UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON REACTOR RADIOLOGICAL EFFECTS

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Nuclear Regulatory Commission
Room 1167
1717 H. Street, N.W.
Washington, D. C.

The Subcommittee met, pursuasnt to notice, at 1:05 o'clock a.m., Dr. Dade W. Moeller, Chairman of the Subcommittee, presiding.

PRESENT FOR THE ACRS:

DR. DADE W. MOELLER, Chairman
HAROLD ETHERINGTON
PAUL G. SHEWMON
WILLIAM KERR
STEPHEN LAWROSKI

ACRS CONSULTANT:

IVAN CATTON
CASPER SUN, ACRS Fellow

INVITED EXPERTS:

WARREN GRIMES
MILO KABAT
DWIGHT UNDERHILL

PRESENT FOR THE NRC:

R. BELLAMY
W. GAMMILL
CHARLES KELBER

DESIGNATED FEDERAL EMPLOYEE

JOHN MC KINLEY

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P R O C E E D I N G S

MR. MOELLER: The meeting will now come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Reactor Radiological Effects. I am Dade Moeller, Subcommittee Chairman. The other ACRS members with us today are, starting on my left, Harold Etherington, William Kerr, and Stephen Lawroski.

Also attending the meeting with us today are Casper Sun, ACRS Fellow; Warren Grimes, Milo Kabat, and Dwight Underhill.

We have also invited Bill Gammill to come, who is here with us, and we have invited Ron Bellamy to join us, and perhaps he will do so later.

The purpose of this meeting is to discuss the accident fission product source term, particularly for iodine, used in the regulatory process for designing, siting and planning for emergencies at nuclear power plants. As most of you know, there has been considerable discussion, both technically and in the public domain, on this subject in the past few months, and as a result of these inquiries and questions that have been raised, the Nuclear Regulatory Commission has initiated the preparation of a State of Technology Report on Fission Product Iodine, and their objective in asking that this report be prepared is to provide the Commission with the best available technical basis for judgments related to the possible exposure of the public to radioactive iodine following a serious reactor accident.

So today we are going to be hearing from the people involved in the preparation of this report, and it will be simply a statement to us of where they stand, what progress they are making, and will give us an opportunity to comment on various facets being covered in their report.

I might say that this Subcommittee meeting and our critique or opportunity to comment on the report is at the invitation of the Chairman of the Nuclear Regulatory Commission.

Our planned approach this afternoon will be to listen to the presentations, to respond and quiz the speakers on what they are doing, and then at the end of that time, it is my hope to poll our consultants and participants here at the front table, to poll them on questions that they would like to have further discussed or portions of the report that they believe should be further elaborated upon.

And so this afternoon at the end of the meeting, then, we will be preparing a first draft of written comments which we will then submit later or use later as a basis for a proposed draft report that the full Advisory Committee on Reactor Safeguards hopefully will prepare and officially send to the Chairman at the end of this meeting, namely, hope to have it finished by Saturday afternoon.

Tomorrow morning the full Committee will be hearing a condensed version of the presentations that we will be listening to this afternoon. Part, again, of our objective today will be to hear what you have to say and to try to select what it would be best to present to the full Committee tomorrow.

The meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and the government in the Sunshine Act. John McKinley is the Designated Federal Employee for the meeting.

Assisting us also in the meeting as a member of the ACRS supporting staff is Garry Young on my right.

The rules for participation in today's meeting have been announced as part of the notice previously published in the Federal Register on January 21, 1981. A transcript of the meeting is being kept, and it is requested that each speaker first identify himself or herself and speak with sufficient clarity and volume so that he or she can be readily heard.

We have received no requests for oral statements from members of the public, and we have received no written statements from members of the public. Let me say, though, each of us has received a considerable amount of written material to use in preparing for this meeting, including a number of referenced documents that have been used by the NRC in its deliberations and which have been presented at various meetings over the past few months.

Let me, prior to calling on our first speaker, mention that Ivan Catton has joined us, who is a consultant to the ACRS and will be participating with us in this subcomittee meeting.

Before I call on the first speaker, are there any comments from subcommittee members or any of our invited guests?

MR. ETHERINGTON: I would like to raise a question, Dade. The question appears not to have been addressed by people who are postulating orders of magnitude reduction over the present criteria, based on the iodine coming out as cesium iodide. I would like to raise the question now in order that the staff may respond to it adequately instead of with a last minute question.

I calculated the iodine-129 inventory at the time of an accident will be augmented subsequently by about 2 3/4 percent from the decay of the I-129 precursors. This iodine will be formed long after the excess cesium has been volatilized and dispersed, and the cesium theory can only account for about a 40 to 1 improvement, not the many orders of magnitude.

Of course, other considerations are quite apart from this, but to claim more than 40 percent order of magnitude doesn't seem possible in view of this delayed iodine that comes out later.

Now, I should confess that these calculations were made on the basis of fission chains that were endorsed by no less an authority than Steve Lawroski but 25 years ago. So maybe my argument blows up, but I have not had a chance to check it.

MR. MOELLER: Very good comment. You are asking specifically about I-129 and the fact, of course, ask you say --

MR. ETHERINGTON: Some of it comes off after the cesium.

MR. MOELLER: The cesium has only a 30 year half life.

MR. ETHERINGTON: No, that comes off by heat. Everything is all dispersed and then you have the tellurium and perhaps the selenium, the precursors decaying and producing the iodine wherever they happen to be.

MR. MOELLER: Okay. I think all of us have heard his statement and his question.

Are there any others?

MR. LAWROSKI: Iodine-129 has an extremely long half life, 15 million years or something.

MR. ETHERINGTON: What is that?

MR. LAWROSKI: It has a very long half life.

MR. ETHERINGTON: Which is this?

MR. LAWROSKI: Iodine-129.

MR. MOELLER: It is 10 million to 15 million years.

MR. LAWROSKI: It has a very low specific activity.

MR. ETHERINGTON: Isn't that the one where you are considering I-129? What is the eight day?

MR. LAWROSKI: I-131.

MR. ETHERINGTON: I meant I-131.

MR. LAWROSKI: The I-131 is an important one.

MR. ETHERINGTON: I figured the I-131 chain. I misspoke.

MR. MOELLER: Ivan Catton?

MR. CATTON: In moving through that stack of documents, I sort of got the feeling that one of the things that we didn't know how to do was make the calculations that tell us where the iodine is going to be, and if you are ever going to make those kind of calculations, a lot more detail, thermohydraulics and flow pictures are going to be needed. And I don't know how this is going to be put together, or whether I am misinterpreting what all those papers are telling me. But I seem to have the feeling that you know enough about the iodine and its chemistry, it is how do you kow the iodine is going toi be there to go through that chemical process?

MR. ETHERINGTON: Well, there obviously is a very big difference between TMI 2 and the ordinary LOCA where everything gets out into the atmosphere directly.

MR. CATTON: In TMI 2 you bubbled it up through a big pot of water and there was a 1970 experiment that said no iodine ought to get out.

MR. ETHERINGTON: My comment was only commenting on something. It really wasn't --

MR. CATTON: I understand. I see a terrible chore in being able to make the calculations that are going to allow you to predict, even if you do know what the iodine is going to do near some surface.

MR. MOELLER: Okay, Bill Kerr had a comment.

MR. KERR: It would be helpful to me if you would explain the time pressure that exists for us to write a report about something of which we are going to be informed this afternoon with this stack of paper. I think I could write a report at this point that would say up to now the estimates have been bounding estimates made on a non-mechanistic basis, and if one wants to be less mechanistic and more procedural, or mechanistic or probabilistic or whatever, a good bit of work needs to be done that hasn't yet been done.

What beyond that can we say?

MR. MOELLER: We may find indeed by the end of the day that there is not a lot that we can say.

MR. KERR: But what is the rush to get a report out?

MR. MOELLER: The rush for us to comment on the report -- and I will let the staff comment also, but it is simply on the basis of the schedule which has been set down for the development of this state of the technology report. The schedule that I was given says that the first draft chapters will be submitted to the Nuclear Regulatory Commission on January 19. They will have to tell us whether that did occur. And then the schedule said the final draft chapters would be received or in the hands of the NRC by February 27, and it said the final draft would be issued for review on March 10.

Now, with that type of a schedule, I can understand in a sense why the Chairman of the Commission asked that the ACRS at this monthly meeting --

MR. KERR: What is it then we are expected to comment on, what the state of the technology is?

MR. MOELLER: No, I think we are to comment on the progress being made in the development of this report, and any voids in it, or any glaring errors, or any places that we think it needs to be -- any subcomponents that need more attention.

I think it is merely to interact with the staff at this point in the process and --

MR. KERR: What is the process? Is the process one of trying to define what we now know so one can see we need to know some more, or is the process one which says that given this report, we are going to change the way we operate reactors next week. I am puzzled as to our goal. Where is it that this report or this procedure is to take us?

I don't mean -- I mean, it would be helpful to me if the staff --

MR. MOELLER: Well, you have heard the question.

MR. KERR: I want to know where it is we are going and what the schedule is.

MR. MOELLER: You have heard the question, and when you speak in a few minutes, cover those things.

Any other questions or specific items of the same nature that we want to alert the staff to at this point?

Okay. If there are none, why don't we move ahead with the agenda that has been prepared for us, and the first item is the NRC Staff introduction and backgrond statement on the technical report on Release of Fission Products, Especially Iodine, and Charlie Kelber will be making that presentation.

MR. KELBER: Thank you, Mr. Chairman.

I appreciate your accommodating us within an already overcrowded schedule. My job today is to try and introduce the context of the report. I believe you are all too familiar with the history of how we came to this particular point, but I would like to introduce what I see as the technical context in which the report is being written, and where I believe that we are going from here.

The importance of fission products release and transport is in two parts: one, its relationship to rulemaking, and I have reference here to the four rules which are under consideration now, siting, emergency planning, which has been issued but in which the implementation is being discussed, engineered safety features, which will come in two phases, and degraded core cooling.

And in all these rules, the radiological source term is a key technical basis for the rule and for its implementation. It is also vital to the adequate handling of the more likely and less consequential accidents, as for example TMI 2, which should have been, in fact, an inconsequential accident. It was not, but it should have been inconsequential, should have been handled, as my boss puts it, like a piece of cake.

But in handling such accidents, current procedures envisage moving many millions of gallons of water in and out of the containment, and this water is likely toi be radioactive, and we have to make sure that we handle it and treat it, its chemistry, properly.

We have a research program under way. There is a significant expansion planned. We will approximately double in size next year, and ramp up somewhat more slowly after that, but I believe we are now forecasting a peak expenditure rate of about $8 million a year.

This report will establish an instantaneous picture of where we are at. The focus of the report is going to be on iodine because that is the way the issue was presented, but in fact, we are concerned with all of the major fission products since it is quite clear that in the regulatory history, that iodine has in fact served as a surrogate for all of the products, tellurium, cesium, ruthenium and rubidium, in particular, but it has served as a surrogate principally because when much of this work was done quite a few years ago, many of the details were not well known.

There has grown up an unfortunate impression which Dr. Etherington keyed on that if you do away with iodine, you do away with everything. I would like to recall to you a viewgraph which was shown to you sometime earlier, and it is not in the package which was given to you, but this was one prepared by Bob Benero and his staff on the isotope contribution to risk. And you can see that indeed the iodine by itself is not a major contributor to risk except in the early fatalities and injuries, and even there it makes no more than a factor of two. And this is based on the models in WASH-1400.

So our report, while it will focus on iodine, necessarily will address to the extent it can the other isotopes, and you can be assured that the research program of course will address the other isotopes.

MR. LAWROSKI: But that table, of course, makes certain assumptions as to how much is the life, does it not?

MR. KELBER: Yes, this is the WASH-1400.

MR. KERR: And it also assumes core melt.

MR. KELBER: Yes, it does address core melt, but you do have also the questions which Ivan Catton touched on, but which are equally important, and that is the handling during the more likely, less consequential accidents which involves a lot of transport of radioactive water and other materials back and forth, degassing of the water, various treatments of it.

MR. CATTON: I meant the comment to cover the whole spectrum.

MR. KELBER: Yes, I know. We agree.

Now, in developing a developing a program, we have to address the question of what are the key outputs. How do we know that we have an integrated program? We need a coherent account of the release and transport of fission products over the entire range of accident conditions. We will try in this report, as Me. Silberberg will tell you, to cover a range of accident conditions. We have to account for at least some accidents, not all, short-lived as well as long-lived products, and that may not be so easy. The behavior of some of the isomers in partaicular may not be very easy ever to substantiate. We may have to go on the best extrapolation we can.

Ivan Catton already has touched on a very important point, the transport description. We do have work under way that deals with some of this. We quite agree that our status there is by no means as good as we would like, and we are considering some form of facility, not an in-pile facility, but something more accessible, to study some of these processes. It might be something like semiscale, and we have to make a technical determination of what kind of a facility would be best, but something which is fairly accessible where we can in fact track the transport of radioactive tracers, at least, in the various thermohydraulic modes of transport.

MR. KERR: Charlie, again to give me a better idea of where we're headed, is the principal thrust of the discussion this afternoon going to be on a report of some kind that is being prepared?

MR. KELBER: Yes. I'm trying to set the context in which I see that report, because I don't think that report is an isolated product.

MR. KERR: And the report will in effect say here is what we know about fission product release and transport, and here are your areas of uncertainty.

MR. KELBER: We'll try to do that, yes.

MR. SILBERBERG: Yes.

MR. KERR: And so what the presentation is mostly going to be this afternoon is how you go about putting this report together.

MR. KELBER: The scope and objective of the report. I am trying to direct --

MR. KERR: Your most recent comments really sort of have to do with given the report, here are the things we already know we are going to need to do.

MR. KELBER: Yes. I would say I don't know what other individuals and the Commission in particular expect from your report. I would appreciate your comments on whether the scope of our work is correct and whether our objectives are clearly framed and are technically realizable. And there are some problems here which may be very difficult to attack and which it may not be cost effective to do.

MR. KERR: Are you talking about the report?

MR. KELBER: You raised the question of what is the objective of the letter you are to write.

MR. KERR: But when you use language of the kind you just used, I got the impression that you were describing our research program.

MR. KELBER: The report itself has a certain scope and objectives.

MR. KERR: That is the reason I asked. I thought it was going to tell us what we now know. Does one have to do research in order to know what one now knows?

MR. KELBER: Let me just say we're not doing so much research as calculations and things of that sort just to tie up some loose ends. No, we're not doing any research. We're now in the context of writing the report.

We would like your comments on whether the scope of the report is right.

MR. KERR: It is the scope of the report and not the scope of the research problem.

MR. KELBER: No. I think you have an opportunity to comment on the scope of the program itself in your comments on the plan and on the budget.

MR. KERR: Now, are you also going to talk about the research program that is going to result after the report is written, or are we going to talk primarily about the report?

MR. KELBER: We're going to talk primarily about the report, that it is in the context of a larger research program.

MR. LAWROSKI: You mentioned something about getting ready to expend $8 million a year. That is the research program?

MR. KELBER: That is about the peak planned expenditure now. That is not this coming year.

MR. LAWROSKI: May I ask whether or not the outline that has a lot of scribbling on it, dated 12-2-80, and which was transmitted to Chairman Ahearne through Mr. Dirks on 7-22 is still the outline?

MR. SILBERBERG: Dr. Lawroski, there has been a revision as of the 11th of December which I'd be happy to pass on.

MR. LAWROSKI: The 11th of December.

MR. SILBERBERG: But it is not that much different.

MR. KELBER: It's substantially the same, but Mel Silberberg will go over it.

MR. MOELLER: Let's wait until you go over it.

One question --

MR. LAWROSKI: I'm a little bit disturbed. You said since the 11th of December, and we got a package just late last night. I got mine late yesterday afternoon only because the Research Committee's meeting adjourned, and it is missing something that is already six weeks old. Well, that's all right. I'll stop.

MR. MOELLER: The outline that you have, Dr. Lawroski, was I believe sent to us under a covering letter of December the 22nd.

MR. SILBERBERG: Well, I would hope that you would have gotten that.

MR. MOELLER: We may have a better version.

MR. LAWROSKI: I am surprised though that that was not in the package that we got yesterday afternoon in lieu of what I did get.

MR. [illegible]: We're getting a little bit out of sequence. There is no harm in that. But let me ask a question because I gather that there were nods that this schedule has not been met.

MR. KELBER: No. The schedule, I believe -- as far as we know, the schedule is still a good schedule.

MR. MOELLER: You do have draft chapter somewhere.

MR. KELBER: They have not been given any sort of peer review, but we do have draft chapters.

MR. MOELLER: That's better than I thought.

MR. KELBER: The report is going to touch on these topics. We are going to address a number of accident sequences. I don't know what we're going to be able to do about the short-lived versus long-lived products. Probably very little if anything.

We are going to discuss where we are in the transport description and what we can do, and we will discuss the effects of the mode of release from containment.

MR. KERR: What is the integrated program being referred to there?

MR. KELBER: The fission product and release program which is a subelement.

MR. KERR: Is that the report?

MR. KELBER: The report is going to touch on these topics, but these are the key products of the research program.

MR. KERR: This is not describing what is in the report. This is describing what the research program --

MR. KELBER: That's correct. And all I'm saying, the report is going to have material that addresses each of these; so in this respect it will be in fact a good snapshot of where we are in our research program, although it will be, as I say, somewhat out of balance because of the emphasis on iodine to the exclusion of other isotopes.

MR. MOELLER: Perhaps you need to say it again, because I find I have questions.

You have just shown us a vu-graph, and it is describing research that is under way at the present time?

MR. KELBER: We have a research program under way at the present time of a little over $2 million a year.

MR. MOELLER: And you are looking at those components of that research program that are of importance to this topic.

MR. KELBER: That is correct.

MR. MOELLER: Okay.

MR. KELBER: Now, I want to point out that where we are in a very broad way by showing you the following cartoon, if we look at various accident sequences with A as the WASH-1400 symbolism for the large break accident with no ECCS action, TML as something like the TMI-2 sequence, a transient with a loss of main feedwater and auxiliary feedwater, and event V is the containment -- is the risk-dominating event where you bypass containment or lose containment isolation.

Both WASH-1400 and the German risk study identified that as the dominant contributor to risk. It happens in different ways in different reactors, but it is still the dominant mode.

Now, if we look at the sequences, these little boxes here are an attempt to describe where the events are that are important, and there is a certain amount of overlap. And of course this is really a continuous spectrum, and we should have a fancier figure, but frankly I did not have the artistry to describe one in the time available to me.

Basically we filled in this little volume here which is largely concerned with the gap release under LOCA conditions. That has been pretty well described and documented.

The much larger volume here is really concerned more with aqueous chemistry and the release from largely solid fuel, largely solid fuel. Long-term effects may also be important, and these we are just beginning to understand.

Now, when we get to the risk dominant events we get a much larger range of isotopes to consider because we have to consider the high boiling point and possibly the actinides. We have to consider sparging and possibly vaporization from molten fuel, and we have to consider the effects from other aerosols as might come from the interaction of the molten fuel with concrete. So this volume is much larger.

We have actually done some work in this area under the LMFBP program. We are, we think, quite well off, relatively speaking, with respect to aerosol behavior. We are -- and I think you heard presentations in that area.

We have some information on the kind of actinide aerosol chains that might be produced and a little bit on some of the high temperature chemistry; but really most of this volume is unexplored.

Now, with that context Mel Silberberg is going to describe to you the forthcoming report, and it should be kept clearly in mind that it is a snapshot photo. It is not meant to be a finished document, a complete piece of research, and it may of necessity, therefore, be equivocal in some parts.

Where do I expect the major impacts to be? I expect them to be some extent on engineered safety features, partly because of the fact that we are developing procedures, the industry is developing procedures and the NRC is discussing these procedures with the industry, to handle accidents in which you do have feed and bleed modes of cooling and other modes of cooling where large amounts of water are treated.

We are beginning to look at a much wider range of accident conditions, and these may very well call for changes in engineered safety feature specifications, and in particular in the auxiliary building if we treat water out there.

MR. KERR: Are you talking about this report still or are you talking about --

MR. KELBER: I'm talking about what may be the immediate impacts of the report.

MR. KERR: So you are saying we know things which we can now write down in a report.

MR. KELBER: But we don't know a great deal.

MR. KERR: Which are likely to have a significant effect on the way we do safety analysis, just the fact that putting it in the report will --

MR. KELBER: I would like to quality "significant effect." I would say that I expect some impact soon, and you will hear more on that from Wayne Houston.

MR. KERR: Just putting this in the report is going to make the change?

MR. KELBER: I think it is a codification of what we know, and some of it is relatively recent.

MR. KERR: "Codification" to me means writing it down. What does "codification" mean to you?

MR. KELBER: It means not only writing it down but writing it down in an orderly fashion and considering it in the context which has been developing over the past few months. I don't think anybody has been laggard in their study.

MR. KERR: I'm not trying to be critical. I'm trying to understand why the existence of this report, which presumably reports information that we already have, is likely to have a significant impact on something or other. It's just because this information is scattered and is not generally known?

MR. KELBER: Some of it is not generally known. Some of it is relatively recently generated.

Where might other impacts come? There has been significant discussion of emergency planning and its implementation. There may be some impact there in focusing that discussion, but I think frankly the report is going to be equivocal enough that that is going to be an area where a large amount of judgment is going to be called for.

MR. KERR: "Equivocal" to me means the report will say we aren't sure what we know.

MR. KELBER: That's correct. In some of these areas I think that is correct.

MR. KERR: Well, it seems to me one can say here's what we know, and here's what we don't know, but most of it will say we are somewhere in between.

MR. KELBER: That's correct.

MR. MOELLER: Any other questions or comments for Charles Kelber?

There being none then why don't we move on and hear about the status of the report itself.

While Mel is getting ready to speak, Paul Shewmon has joined us, and Ron Bellamy has also joined us.

MR. SILBERBERG: What I have here is the objective of the state of technology report on the release of fission product iodine, which we for short have called SOTRI. So rather than keep repeating that, you will see that throughout my presentation.

What I'd really like to do today --

MR. KERR: Excuse me, Mel. I'd gotten the impression from what Mr. Kelber said that this was going to be a state of technology report on the release of fission products generally, so the title --

MR. SILBERBERG: It is iodine plus what additional fission products we can deal with. You will see when I get to the scope of the report -- in fact, we had made such a statement; in fact, it was in the objective that was handed out to you -- although we are focusing on iodine, where we can in the transport processes and the release processes we'll consider other fission products to the extent that we can.

And I believe we're probably making more progress in that area now than I would have thought so two months ago when I first spoke to this.

MR. KERR: I just wasn't sure that you were talking about the same report that Charlie was.

MR. SILBERBERG: It was. The report started out with that title so administratively I'm keeping it that way.

MR. KERR: Thank you.

MR. SILBERBERG: What I would like to do today is take you briefly through the status of it -- where is it, what schedule remains to completion -- I will say that we are on schedule, and we are making good progress -- and then give you a feeling for the scope of the report and some of the key chapters, what are we trying to come up with, what are we tackling in each of the key chapters.

What I will not give you at this point are results, because some of these results are still in an iterative stage, and I think at this point the people who are most knowledgeable and intimately associated with the results are back at the labs working to complete the report on schedule.

The objective statements that I have here on the first vu-graphs are pretty much what you have in your handout that Dr. Moeller referred to, namely the objective is to provide the Commission with the best available technical bases for judgments involving treatment of the entire range of core damage accidents in the regulatory process so that others can make judgments, use the information for making judgments relative to regulatory requirements, that is, effect on ESFs.

Wayne Houston will be discussing a separate report. What he's going to describe, that deals with the impact on regulatory requirements and the regulatory impact of the subject of accident, source terms, fission products and so forth, and by its very nature a lot of information related to effects on ESFs.

Wayne Houston's people are trying to use the report that is going on.

MR. KERR: Is the report going to include what Wayne will talk about?

MR. SILBERBERG: No. When I get to the scope --

DR. KERR: He's going to talk about what he will do with the report once he gets it.

MR. SILBERBERG: Right. How they are going to outline, attack the apex.

We are providing the data and inputs from analyses for this snapshot in time, what do we see as the accident loads on ESFs based on a range of spectrum of acidents, so that Wayne's people can assess what regulatory impact this might have.

MR. KERR: So he already has a pretty good idea of what the report is going to say in order to know what he is going to do with it.

MR. SILBERBERG: Walt Pasedag, who has the lead on the report, is working intimately with us. In fact, he is the editor of one of the chapters in this report, particularly the chapter that he is concerned with on ESF.

So we think the correspondence is very good there.

MR. CATTON: This first part, best available technical basis, are you going to look at things like the source term, the heating --

MR. SILBERBERG: Yes. Let me get to that.

I want to note that this report is in no way a competition. It is a dispassionate reporting of effects and technical bases and the limitations of the data base as we understand it today, to be used for decisions by others.

We want to in the report, and are attempting with realistic consequences of important accident environments, the realistic consequences based on the state of technology as we know it today.

MR. KERR: I guess I'm puzzled by your statement that this report is not a competition. What would have made me think it might have been a competition?

MR. SILBERBERG: I withdraw the comment. In other words, it's not meant to be a rebuttal of other work or other reports. It is meant to call the facts and the data bases as they are there.

MR. KERR: Well, I thought from that that it's going to be dispassionate.

MR. SILBERBERG: It is.

MR. MOELLER: And it will deal as best it can on a realistic basis.

MR. SILBERBERG: Yes.

MR. MOELLER: It won't be conservative.

MR. SILBERBERG: That is not our job. Our job is to call it as we see it. Okay.

The chapters in the report are listed here and form the basis for the scope. I'm not going to go over each one of these, but I will have in my remaining vu-graphs a number of them.

We will start out -- there will be introductory material in terms of background for the report, but then we will go -- again, we're trying -- the level, the audience level for the report is important, because it is going to be read by a broad range of people from administrators to technical people, technical specialists in the field. And so we are going to have to be concise where we can, but nevertheless, we want to provide as much background as we can to someone going into the report in terms of fission product formation, what are accident sequence characteristics as we discuss them here. Then we will go more to the heart of the report, namely the fission product release from fuel.

I have listed alongside each area those contractors and organizations working who have the main responsibilities for inputs to those chapters. There will be a chapter dealing with the chemistry of iodine and cesium iodide. We will attempt to look at tellurium but only in a limited way.

MR. CATTON: With water and air and so forth?

MR. SILBERBERG: I have a separate chart on that.

MR. LAWROSKI: For the very reason that Mr. Etherington brought out, tellurium is a very important one to look at because that is the precursor to the iodine that represents something like 2.7 percent by his calculation.

MR. ETHERINGTON: It still is a precursor, and then that will change --

MR. SILBERBERG: It is important.

MR. KABAT: Are you also going to consider the possible different behavior of different isotopes of iodine, short-lived and long-lived, in the fuel? For example, 127 and 129 isotopes have a better chance to react with cesium than the shorter ones in the fuel which only reach equilibrium and a state, and concentration states are relatively low, compared with the study of those others.

I think that is quite a significant impact which should be studied, and the isotopes should be so done.

MR. SILBERBERG: My understanding is it will be treated, and I certainly want to make sure of that.

MR. KERR: At some point in this process is it going to be decided whether this is a report on fission products generally or on iodine, or is that still undecided?

MR. SILBERBERG: I think I could say now that the report is chiefly on iodine. There will be, for example, as we go toward the aerosols, as we go toward the accident loadings, there we will be dealing physically with the other materials because that is key, and the chemistry will be, the chemistry, the emphasis on chemistry will be on cesium and iodine.

And as we move out into the transport processes we will be bringing the other fission products into the picture. As far as fission product release from fuel, we will have a spectrum of the release source terms from fuel, from solid fuel to molten fuel, for all the fission products.

MR. KERR: Somebody on the committee might have said if it is concentrating on iodine that it really ought to look more broadly, and at this point I cannot be certain whether it is concentrating on iodine or not.

I heard earlier with reference to a slide that iodone really was a fairly small part of the risk contributor, and hence, this report was going to look at all the fission products.

You seem to be telling me that it really is going to concentrate on iodine, and it will deal with the other fission products peripherally.

MR. SILBERBERG: Let me correct my statement or let me clarify it. On the chemistry it will deal more with cesium and iodine. On the transport processes it will by the very nature, because of the importance of the other fission products, will include the other fission products. And some of my remaining vu-graphs will, I think, explain some of those.

MR. UNDERHILL: Are you going to give upper and lower limits of what can be expected under given conditions, or is this an attempt to find out what the expected behavior would be?

MR. SILBERBERG: The expected. We will try to put where we can some uncertainty bands on it.

MR. CATTON: And this evolution from solid fuel to molten fuel, it seems to me time is important, rate is important.

MR. SILBERBERG: I'm going to cover that or at least I will indicate that it's going to be looked at.

We will look at fission product transport in the primary system to containment. There, although I have noted that we are looking specifically initially at iodine, we will be able to also indicate what other species, vapor species, and solids that might be formed or might be contained in the primary system before release to containment.

When we get into containment, here we will be dealing with analyses -- and by the way, these three chapters are as analytical as we can make them. These are estimated.

The expected transport in containment will be using state of technology calculations that will allow us to determine as a function of time what is airborne in the containment building so that one can then in the next chapter use that information to assess loads on various ESFs within the containment or auxiliary building or what have you.

MR. CATTON: Has there been much work done on the surface chemistry in the primary system, and it is going to be different than it is in the containment. Is that going to be brought out here? I understand there are factors of ten difference.

MR. SILBERBERG: The impact in the containment, the impact of paints and so forth -- and these loads are really very small -- they are really not really --

MR. CATTON: I thought there was data that shows that the difference between a stainless steel container and a painted container was a factor of ten.

MR. SILBERBERG: Those are for processes where deposition or where plating is important, like in a primary system plating is more important, so no stainless steel surface behavior. But in the containment, wall depositions in terms of accident loads are not that important. Plating, as opposed to settling, and where the airborne material might go.

MR. CATTON: Well, surface chemistry, how it gets there and stays.

MR. SILBERBERG: Well, now, when I'm talking about containment, I'm talking a little bit more than iodine, because depending on the form of the iodine, most of it will be tied up with other mass in containment if the release is large enough.

MR. SHEWMON: If something condenses out, that is part of transport.

MR. SILBERBERG: Yes, sir. Well, let me get off the scope and get into a discussion on status. Let me summarize where we are right now.

We have received a first draft, and we have reviewed it. The various participants working on the study reviewed it with RES and NRR people, primarily in terms of was it meeting objectives, did we need to do -- was some additional coordination needed. For example, there are some inputs from the iodine form calculations, the thermodynamic calculations I'm going to mention. Into the next chapter there are inputs from the transport calculations into the ESF loads.

So there was an urgent need, and this meeting was not only to get a feeling for the content of the work and its direction and whether we were meeting our objectives, but what additional coordination did people have to do, what additional interfacing did people have to do to make the report consistent. And we accomplished that on the 22nd and the 23rd. In the following week the remaining data inputs for follow-on analyses were identified.

MR. KERR: Mel, we're talking about a report now, the chapters as indicated here.

MR. SILBERBERG: Yes.

MR. KERR: Thank you.

MR. SILBERBERG: The additional analyses and evaluations needed to bring the report together consistently are now in progress, and we have a race in time between completing those analyses such that one can now get into the substance of the final draft.

Now, the fact that one has a first draft, one might think that gee, all I do is just go and tear some pages out and go to the final draft. That is not the case.

We were quite satisfied with the final draft, with the rough draft, but it needed considerable condensation so that our broad audience would not get lost in details too early. Many of these people will be reading reports, you know, in the evening and so forth; and it's always good to keep reports concise.

And we also felt that what we would do is we would have a summary, an introduction summary for a broad audience. The chapters themselves would be technical but mostly for the non-specialist. The appendices would provide the bases, the backup, if you will, for others as well as specialists as to the conclusions and the results, the principal results in the body of the report.

We have started the final draft of a number of chapters, and as I say, there's going to be a close race to close the analysis and complete the final draft.

Now, let's take a look at the schedule so that I can then go into a few of the chapters. We expect to have final draft chapters to headquarters the week of the 23rd, early in the week of the 23rd. We will be reviewing the final draft and preparing a summary for consistency, preparing summary and conclusions at headquarters. We should be completed with that by the 27th.

We then will have that available for internal management review and whatever other revisions we have to; if we need, we'll have to bring people in for additional help.

A near-final draft, we had promised the Chairman that we would send a report, what we would call a near-final draft, to the ACRS by the 6th of March.

MR. KERR: Is the idea there that we review it in the March meeting? Is that schedule here?

MR. KELBER: It's the closest we could come.

MR. SILBERBERG: It's the best we could. And how that relates to the ACRS process I really can't --

MR. KELBER: It's the closest we could come to the ACRS schedule.

MR. KERR: What is our schedule, Mr. Subcomittee Chairman, do you know? Are we scheduled to review that report at the March meeting?

MR. MOELLER: I do not know. It again, I think, will depend on what happens today.

MR. KERR: Thank you.

MR. MOELLER: It may be that that will be our review rather than today. I don't know.

Have the various groups that are contributing to the report, have they felt a tremendous pressure in meeting your deadlines, or have they been able to do it pretty well?

MR. SILBERBERG: Let me answer that. Actually, considering the pressure I would have to say that the groups have done very well. I have not -- we've really not gotten a complaint that there's no way I can finish this, you know, and I'm sorry I got into this. I think there's a lot of enthusiasm by the people who are working on it, and they understand the importance of it, and they actually feel that they will get an awful lot out of the report themselves.

And I must say that turning to it, as best as I would have expected, a group, a group shall we say, in four different laboratories working on such a short timeframe on such a comprehensive report.

MR. MOELLER: Did you give them limitations on how much material they could each submit?

MR. SILBERBERG: When the final -- I'll give you an example. When the initial draft came in, some chapters were about the right length and in the right context. We had one chapter, which will remain nameless, which was that thick (indicating). It was good information, good material. It just needed this revision that I referred to. Lots of information, no question about it.

There was a question how do you boil it down for a broad audience.

MR. KELBER: Let me add a comment. I think it important to remind you of the decision that this report would be readable in two ways: one as a non-specialist, and that has to be kept relatively concise as well as precise; otherwise it's not going to be read no matter what level it's written at.

Second is technical material in appendix format that is keyed to the front matter, and that, I think, will be as long as is necessary to present the data.

MR. KERR: A number of times there's been reference to a non-specialist. Does that mean a member of the Commission?

MR. KELBER: That's a very wide audience. This material has aroused interest not only in the Commission, the ACRS, members of Congress, the press. I expect that there will be members of the public generally who may well be interested, and I think we have an obligation to produce something which they can read with interest and gain something from, while at the same time making a good techncal product.

MR. KERR: Well, it seems to me you have an obligation to fulfill your objective. It is not clear to me what the objective is. If you are charged to produce a handbook on fission products for public consumption, that is one objective. If you are trying to describe the state of the art to people who are going to plan a research program, that is another objective.

MR. KELBER: If that is all we wanted, it would not have gained that type of publicity, believe me. No one really cares very much about the material we use to plan our research program outside the Commission proper and the ACRS.

The interest lies in the claim that was alluded to by Dr. Etherington that quite possibly the radiological source term in serious accidents has been vastly overestimated.

I believe that was an unwise claim to make on the basis of the knowledge available then, but it may be that there is some merit to it. We shall find out in time.

This report, however, is an attempt to give people who want to evaluate that type of claim the best basis they can, and these people include not only technical staff but the Commission, the Congress, the press and others.

MR. MOELLER: Well, following up though on William Kerr's comment, it would seem to me much wiser to prepare perhaps even two reports or three. You could have the complete technical report, the executive summary, and then something in between for the lay audience.

MR. SILBERBERG: I think that --

MR. KELBER: That is a position we should take under advisement.

MR. SILBERBERG: I think we were going to try to do that in the one report from the introduction summary. I don't want to use the word "executive summary" there. That's not a good word. But introduction summary, you know, I mean a faithful one, then the body, then go through the more detailed, and that would be in the appendix.

The report will be mostly more appendix than it will be the other, so in that respect I think we may be fulfilling your objective.

MR. KELBER: I don't know that we want to pursue the trinitarian versus unitarian argument here, but I think that that is a comment that we should in fact keep in mind as we see how the finished product looks.

MR. KERR: In our efforts to comment on the report it will be helpful to have some idea of what the principal audience is.

MR. SILBERBERG: The decisionmakers would be, in other words.

MR. KERR: What sort of decisions are they making and whether to put out a newspaper the next day.

MR. SILBERBERG: No. Regulatory decisions, regulatory guidance.

MR. KERR: So it is a document primarily for internal usage at the NRC, is that it?

MR. SILBERBERG: Yes.

MR. KELBER: I don't know. I differ in that view, and that's an honest difference as to where it is addressed.

MR. KERR: Well, who's going to decide what the audience is?

MR. KELBER: It has been my decision that the audience is principally the Commission and outside the Commission -- the Commissioners, I should say. You yourself have pointed out that a great many of the materials were available inside the Commission in various forms and bits and pieces here, and what we are doing is codifying it, that is correct.

The staff has in fact been codifying it. I think Wayne Houston can be talking about some of the things in IRR, some of these things. And our pace was speeded up considerably by the Commission, and therefore, I view them as being the audience for this report, plus the people with whom they correspond, which is the Congress and the interested public.

MR. SHEWMON: Let me question a comment you made earlier. I have here a letter, which is the one, I think, Bill Stratton and some others sent, though the last page is missing from my handout.

It says, "Although the Three Mile Island reactor core inventories of xenon 133 and 131 were comparable, between 2.4 and 13 million curies of xenon escaped to the environment while only 13 to 18 curies of iodine similarly escaped."

Do you question those numbers?

MR. KELBER: No.

MR. SHEWMON: Okay. A minute ago I misunderstood you, because you said you thought there was severe questions as to whether or not there was this big difference in the iodine and xenon escape.

MR. KELBER: No, no. It wasn't iodine and xenon.

MR. MOELLER: Go ahead, Mel.

MR. SILBERBERG: After the ACRS gets the report on the 6th and decides what they want to do with it, we will be sending a final draft to peer reviewers on the 10th of March in preparation for a peer review meeting on the 17th and 18th of March. And by that I mean those people from industry that have requested to have somebody attend this, independent reviewers who we are selecting who are not associated with our program or the industry program, whether we can find those people as well as several others.

But it is a meeting primarily focused for the specialist in various areas that the report is treating, because we want this to be a review by specialists in that sense rather than from a broader audience.

MR. LAWROSKI: You expect a specialist to be able to look at that with a limited amount of information as to the conditions under which certain data were obtained that is not likely to be contained, because all this is replete with numbers being indicated without having stated what the temperature was, the duration of the experiment or the accident, as the case may be, and so on.

And that has a lot to do with trying to understand what that number that is quoted means.

MR. SILVERBERG: We will have to provide as precisely as we can as much of that information in the appendix that will help the reviewer get that background.

MR. LAWROSKI: Unless he has it right there and then, the kind of time you have indicated does not allow him to go back to a library and peer through very many documents.

MR. SILVERBERG: I understand. Some of the specialists we would hope would have some of that background, not all of them.

MR. KERR: So in a sense the peer review will be primarily a review of the appendices and not a review of the report, because the report is not written for the specialist.

MR. SILVERBERG: Well, the report will have results in it written as simply and as concisely as we can.

The bases for the results can always be challenged by the reviewer and the details and supporting information is in the appendix. So we are trying to communicate the results as simply as we can. The results will still be in themselves substantive within the body of the report, the conclusions.

MR. LAWROSKI: I could believe that if I hadn't heard that you were planning to mount a program of some umpteen million dollars. That to me does not indicate that things are known with any great precision or accuracy.

MR. SILVERBERG: I understand. As Dr. Kelber pointed out, we will state what we know, what we don't know, and what the level of uncertainty is as best we can. I don't disagree with that. I don't disagree with that, no.

MR. CATTON: Now, will a part of that go into some of the accidents that have occurred in more detail? They just state now, gee, this occurred and there was no iodine, and this occurred and there was. You know, you have temperatures, environments. You know, one of them says 20 percent of the core was damaged and then they give you numbers back to refer to the percentage of the total inventory they got out.

Well, really, what I would like to know is, relative to the amount of damage --

MR. SILVERBERG: Well, let me state something that actually Dr. Lawroski. I know which one you're talking about, two months ago. The problem with some of these things, some of the accidents, is that you have a hard time. They are not controlled experiments per se. You have information and the question is --

MR. CATTON: You could hone in a little tighter.

MR. SILVERBERG: Certainly, I agree. Whatever has been written about the accidents --

MR. KELBER: Mel, I'd like to -- I think it would be unrewarding to try to take a rather poor experiment. The accidents were not planned as fission product transport experiments, let's face it. And I think it would be more productive, at a later stage when we are a little surer of particularly the transport modes, to go back and try and see whether we can reconstruct what was observed.

I doubt that we can deduce much from what was observed about fission product release and transport at this time.

MR. CATTON: There is a little you can get, though. Someone described the core as coming apart in pieces. Well, that's probably not much melting. In another case it melted.

MR. KELBER: But they are highly qualitatitive. They are highly qualitative to address the issues laid particularly by the EPRI report before the Committee.

MR. KERR: I don't think Ivan is asking for something that nobody knows. But I think what I hear him saying is, as much information as is available ought to be there in order that a specialist can make a judgment that says, this is probably reasonable or it's nonsense.

MR. KELBER: To the extent we can, I must say yes. But most of these accidents were not well enough instrumented to really help in this matter.

MR. CATTON: I understand that, Charlie. But your report, as Mel said, is going to be dispassionate. EPRI's was not, and they were clearly selling in that report, and they had something to sell. So when you read it you really don't know where you are at. And I think somebody who is familiar with the experiment could do a better job with not much effort in describing it.

MR. KELBER: You are describing now a somewhat different approach. That might well be worth considering. That might well be worth considering, if not as a part of this report --

MR. SILVERBERG: As a follow-on. I would agree with what you say as a follow-on.

MR. CATTON: Look at TMI. You bubbled it all through two or three feet of water. That is important.

MR. KELBER: Your point is well taken. It's a very useful follow-on activity.

MR. SILVERBERG: For follow-on, yes. You see, we're trying not to get too bogged down in this report with the accidents, because as we pointed out they are not controlled experiments. We would like to try to state what we now -- you get inferences, I know. But we'd like to be able to state what do we know about the state of technology, where measurements have been made, where models have been developed.

MR. KERR: It's hard for me to see how.

MR. CATTON: It still may not be important. You see, if the arguments EPRI makes are correct, and if you read through them, you come to the conclusion that whenever you've got water covering the stuff you don't have a problem. And if of all of the accidents you have to be faced with, only one out of 10,000 is a situation where you don't have water, then gee, EPRI is right.

MR. SILVERBERG: Let me state the following.

MR. KELBER: But you have to evaluate that risk.

MR. CATTON: But that has to be looked at.

MR. SILVERBERG: Let me comment --

MR. CATTON: I'd like to finish.

That to me is sort of the basis, the starting point that you should take.

MR. SILVERBERG: We have taken, for example, like the case of TMI-2, we have one of our sequences that we're going to look through is what we call the TMI-2-like accident, with lots of water around. One of the sequences is where that is at a different situation, like in AB, where there's a lot less, where we don't have the opposite of that type of accident.

In that context, one will get a feeling for transport under those conditions. To the extent that one is going to go back and look at the other accidents that occur, the range of them, I think Dr. Kelber is correct, it might be useful, after coming off of this report, it might be a useful follow-on. Because I agree, the way -- I agree with you, some of the descriptions of how information derived from those accidents leaves something to be desired.

But I think the thrust here, we really didn't want to get too bogged down in going over the past accidents, and I think there have been -- I think in general there was some concurrence from this Subcommittee back several months ago that that made some sense.

MR. KERR: Well now, it seems to me that if one has relevant information, then one would not be bogged down. If one is presented irrelevant information, I agree.

MR. SILVERBERG: My concern is with the latter, getting bogged down with the latter. That is my concern.

MR. CATTON: My interests are irrelevant?

MR. SILVERBERG: No.

MR. SHEWMON: It seems to me if you're dealing with a factor of a million, what your readership is interested in is whether you can make some sweeping statements on what the exceptions are, not a list of all of the things that are known and all of the things that might be known if they quadruple your research budget.

MR. SILVERBERG: That is not our intent in this report.

MR. SHEWMON: We'll see.

MR. ETHERINGTON: Are you covering the effects of spray additives and the duration of the spray?

MR. SILVERBERG: I'll be getting to that. That is covered in the part on the transport processes.

Let me finish the schedule so I can go into the rest of it. We will have a Commission paper on the 24th of March which will be at this point where the end product of the report will first be used.

MR. MOELLER: One additional question on that viewgraph. You say it is going to be submitted to the peer reviewers. Who are the peers?

MR. SILVERBERG: I mentioned that they will represent people who were invited from industry and from the laboratories. But we are trying to get independent reviewers where we can.

MR. MOELLER: And will that include in-house NRC or is it mainly --

MR. SILVERBERG: Yes. By its very nature, review groups do constitute or are constituted to begin with from the NRC employees to begin with. It would be between Standards and NRR, of course.

MR. MOELLER: So it'll be in-house plus industry plus national labs, roughly.

MR. SILVERBERG: Yes.

MR. KELBER: And some universities.

MR. SILVERBERG: And some universities.

MR. MOELLER: And again, trying to get fresh people who have not been involved in the preparation.

MR. SILVERBERG: Where we can, yes, right.

Some of your questions have covered some of this material. But let me briefly go through it. There is a chapter on fission products release from fuel, which will go all the way from solid fuel to molten fuel. And in terms of what information is available on fission product release experiments, fission product release models that have come from those experiments, from in-pile and out of pile tests, irradiated fuel, a lot of information that is already out there will be put together.

Then we will move on to fission product release from molten fuel in various stages, from in-vessel core melt to core melt concrete interactions after melt-through and the core melt sequences. We are right now trying to come up with, and what we believe we are having some success with, is the first semblance of a time-dependent fission product release model for two different types of sequences.

MR. KERR: You mean you've discovered it somewhere in the literature?

MR. SILVERBERG: No. The fellows at Oak Ridge are making a valuable effort to synthesize this information over a course of input information available from the sequence and are actually trying to piece together a time dependence to how the different species might be coming off in what percentages, which is really the kind of thing that we have needed all along.

MR. KERR: What is the difference between the fission products, between fission product release models, which I see as the third bullet from the top, and a time-dependent fission product release model?

MR. SILVERBERG: Okay. Fission product release models, we are just talking about that which have been attempted in the past in solid fuels and whatever is available. That is all.

This is an attempt to synthesize all of this into -- mostly, I would say, from experimental information, what data is available both from this country and the work, the work in the Federal Republic of Germany. So we can go from solid fuel out to core melt.

And I think this is one, may be one highlight of the reports, one of the technical highlights.

MR. KERR: Now, one would assume, if one had such a model, no more research would be needed if it was a well-validated model. So what are you going to say about this model once you get it put together?

MR. SILVERBERG: I think we're going to try to indicate what the uncertainties are on it, are in the model. In other words, in terms of the ranges of release rates or the quantities.

MR. KERR: So you won't have just a model, but you'll have a critique that says, here's where we think it has been fairly well validated and here are the areas where we think it is lousy.

MR. SILVERBERG: That is as best we can what we will try to do.

MR. MOELLER: Paul, you had a question?

MR. SHEWMON: Yes. Before you leave that, in the next to the last bullet there, is that meant to be a sequence? As you go from molten fuel, you're vaporizing aerosol?

MR. SILVERBERG: No, I'm sorry. That's kind of backwards. What I meant was, in fission product release from molten fuel we are considering vaporization and aerosol formation processes, including structural materials, the non-radioactive materials. That really doesn't quite belong in the order that it does.

MR. SHEWMON: I guess if you had the thing hot enough, as a point of information, if you got the thing hot enough so that it has melted all the way down to the concrete, I would have thought you would have vaporized and released most of the fission products already.

MR. SILVERBERG: Yes, an awful lot of it does come out. And I would hope that that information would be borne out by this. In fact, that was one of the reasons why we wanted to do this, because that statement has been made and people have been aware of it, but we have not been able to qualify it.

MR. KELBER: I have a speculation in this regard that we're going to have to look at, and I think it should not be taken out of context by anyone. But I am concerned that in this class of accidents we may not have adequately accounted for the sparging of fission products with high biological dose effectiveness, the ectonite iodoxides in particular, by the gases from the core melt-concrete interaction.

If those are sparged from the core melt, they will likely condense on the aerosols present. And while some of those aerosols will undoubtedly deposit out, others may get transported into the atmosphere outside the containment. So I do think that we will have to, in the coming years, make an assessment of that process as well, simply because of the relatively high biological dose effectiveness of these materials.

I don't want anybody, as I say, to take that out of context, that this is a certainty that that process happens or anything of that sort. But it is the sort of thing that we do want to look into.

MR. KERR: Now, will the report attempt to answer the question I just pointed out as an important issue?

MR. KELBER: If there are any data that are applicable, yes, we will present them. Otherwise we will simply leave them as an unanswered question.

MR. KERR: So it may well need to be an additional -- a significant additional research program in core melt concrete reaction.

MR. KELBER: I hope we are able to scope that, the range of that, and make some assessment, because of, if nothing else, the practical matter that these are very difficult materials to work with.

MR. CATTON: Mel, on these fission products releases in the fuel, if I understand it, if you get cesium iodide very hot it decomposes. So if you heat the fuel fast you're going to decompose it before it gets out. Are you looking at that sort of thing, because that would tell you whether you're going to have the cesium iodide or you're going to have the various --

MR. SILVERBERG: Well, once they get out, that brings me to my next one. We are looking at the water to vapor phase equilibria, given now the number of species, cesium, iodine, or what have you. And they will -- in other words, at the lower temperatures they will recondense and reform. It depends on the stability.

MR. CATTON: Well, there's two parts. If I heat it very fast, I'm going to get them out separate. If they get away, they're not going to get back together. If I do it slowly, even if I do decompose them, maybe they will. So there's kinetics associated with this.

MR. SILVERBERG: We will be discussing something about kinetics.

MR. KELBER: Also the relative transport of vapors. If the hydrogen is in one place and the cesium and the iodine are in another place, we have a different type of equilibrium.

MR. SILVERBERG: What we are doing in one of the chapters is primarily looking at the question which has been raised, and in the context which Dr. Kerr pointed out about looking at iodine, is starting with iodine and cesium, because for the moment it has been an issue of some substance, and looking at the chemical thermodynamics, the equilibrium chemical thermodynamics using state of the art techniques and a method that one calls free energy minimization, which allows you to, given the thermodynamic properties of the various species -- those either that you can get from handbooks that are estimated, those which are not known well, and some which have been imagined -- and attempting to, for a range of accident conditions of interest to the remainder of this report, again with a consistent thread of a variety of accident sequences, trying to assess what we might expect simply the likely form, just based on the thermodynamics. And your question on the kinetics is another separate issue.

MR. SHEWMON: These thermodynamics would be with or without water?

MR. SILVERBERG: That is correct, with various steam to iodine ratios, with various iodine to hydrogen ratios, water to hydrogen ratios, over the range of the types of accidents that are of interest and important to our report.

We will get the relative abundance of the iodine species and in the transport chapter, based on the conditions in the primary system, and then at the point of release from the primary system containment we will go back to these curves of abundance and make an estimate on the basis of these data as to what we think the likely form would be or what percentage of the likely forms.

It's not one or the other. Usually there's some distribution over a range of conditions. We are going to try to look qualitatively, unfortunately, at tellurium and ruthenium, also -- they are important -- and see what we know about them. There's not that much information on tellurium and ruthenium that allows one --

MR. CATTON: Isn't there a compound, tellurium and iodine?

MR. SILVERBERG: What tellurium forms a lot of is, there could be hydrogen tellurides.

MR. CATTON: But looking at iodines, there are compounds?

MR. SILVERBERG: We are aware of it, but the thermodynamic information available on them from my understanding is poor. But we'll make a note of it.

MR. KABAT: In your outline, I was missing one stage, which would be a definition of the physical and chemical conditions typical for accidents. Or are you assuming different conditions? Or will you be defining them?

MR. SILVERBERG: We will be defining them. Chapter two talks about accident sequences. I didn't go into it. But we will then discuss physical and chemical conditions that are associated with those sequences. They will be listed in the appendix.

MR. KABAT: So they will be somewhere in the middle of the outline, before the chemistry of iodine?

MR. SILVERBERG: Before it, chapter two.

MR. KABAT: That would be before that chemistry?

MR. SILVERBERG: That's right. You do need those.

Now, I will make one small statement, which is somewhat in the direction of what has been mentioned earlier by Ivan Catton, namely that one really has to take a look at -- and it is somewhat difficult. The vapor equilibria calculations are no better than the input that it comes from. Not only the thermal dynamic properties of the material that you need, but the thermal hydraulic conditions that you are assuming are attendant at the time these species are interacting.

To that extent, the uncertainties in the thermal hydraulic conditions for many of these accident sequences may override the uncertainties in the thermal dynamics. I use the word "may."

The thermal dynamics by themselves are not really assured. In some of these tables, many of which come from National Bureau of Standards, either the information for many of those fission products -- people have worked with those temperatures with those species to get the thermal dymamic information.

There will be a subsection of this chapter dealing with the aqueous phase chemistry alone, and that's out of this chapter.

MR. CATTON: The aqueous phase, that's a scenario that's been worked on a lot.

MR. SILVERBERG: Yes, there is a lot there. We had quite a thick first draft on it.

MR. CATTON: There was one of the ANS journals devoted entirely to it some years back.

MR. LAWROSKI: Devoted to what?

MR. CATTON: Water and iodine.

MR. MOELLER: As I hear you in your comments, I gather the various labs and contractor groups are preparing the individual chaptes, but you people here at headquarters are going to do the synthesizing or the interpreting?

MR. SILVERBERG: Let me note, one chapter is being prepared here by Walt Pasedag who works for Wayne Houston, on the ESF effects. The individual chapters come from the field with summaries of what they believe the significance that would belong in the summary. We will then try to synthesize.

MR. MOELLER: Fine, okay.

MR. SILVERBERG: Let me now deal, having dealt with the chemistry, let me now deal with fission product transport in the primary system in containment.

MR. CATTON: I am trying to get a feel for this. When you have iodine in the containment volume, what kind of concentrations are they? Is it really very dilute? Is there a lot of it? Are you near saturation?

MR. SILVERBERG: Let me give you a range and then -- I think in terms of dilution. We are looking at in these calculations ranges from molar ratios of iodine to water are from 10^{-2}, if you will, to 10^{-6}.

MR. CATTON: So it is very low.

MR. SILVERBERG: Well, 10^{-2} is getting up there, but it is still low.

MR. CATTON: This is to water, and that is in air.

MR. SILVERBERG: Steam, and -- yes, in air.

MR. KABAT: It is in the containment, so it is very, very low, about 10^{-2} solution of iodine would be low rather than --

MR. CATTON: He said 10^{-2} relative to water, and the water is in the air.

MR. SILVERBERG: This is water in the vapor, in other words.

MR. CATTON: I was thinking in the containment where you have got air, steam and iodine, is there that much of it?

MR. SILVERBERG: It would cover that kind of a -- yes. In other words --

MR. CATTON: So it is low relative to the water.

MR. SILVERBERG: Low relative to the water. But in the vapor phase, as I said, from -- I can't recall the containment ratio, but in the vapor phase analyses, they are going from 10^{-2} to 10^{-6}, but there are some sensitivities that one is finding out about that, and I don't want to go into that now, but there is a sensitivity for iodine to water ratio, independent of the fact that it is a low molar rate. There are sensitivities that one I believe is going to find, but I don't want to go into those now.

Having dealt with the chemistry and the release, if you will, of the source of material, one chapter is going to deal strictly with what is the retention of fission products, starting with iodine, well, cesium iodide, either case, within the primary system based on deposition analyses with the TRAP code, and just to get some feeling for what might -- for the various sequences, what might be the range of retentions.

MR. KERR: Will there be a commentary on the validity of the TRAP code?

MR. SILVERBERG: Yes.

The parameters, again, are accident sequence, the chemical form, and source rates, source rate as a parameter because, as I say, that will vary depending on the sequence and depending on uncertainties.

Having gone through the primary system, we are now going to be looking at the expected transport and leakage behavior of iodine and in this case all the other fission products and aerosols available, depending on the sequence involved.

And we are going to simply be looking with state of technology analysis methods at the extent of fission products and aerosol removal in containment by natural deposition and engineered processes. This is sprays on, sprays off. And we are doing this, as I mentioned, to provide accident loads for the variety of sequences so that one can look at ESF impacts. And again, this is over a range of degraded core sequences.

MR. KERR: What sort of accidents? Where are you going to get your accident sequences?

MR. SILVERBERG: Some will come from, like TMLB' and AB. Others come from -- are what we call TMI 2 like, dry or wet, and in some cases because it is very hard to define the so-called in between accidents, some of these things we would hope ultimately would come out of the SASA program where one starts toward core melt and stops.

MR. KERR: I am talking about this report.

MR. SILVERBERG: This report. What we will have to do, where we can't get the in between, we will have to --

MR. KERR: I mean, if there has already been a draft of this chapter written, I gather, where did the accident sequences come from in that chapter?

MR. SILVERBERG: The core melt accident sequences came from WASH-1400. The other sequences that are in there, that I mentioned earlier in my presentation, we were trying to look at accidents less than WASH-1400 sequences. We have identified some of those, but in order to make up for a range of releases in the sequence that we cannot at this time predict or have not calculated through, we will use as a parameter a range of releases, of expected releases to substitute for varying degrees of core melt without actually saying what it was.

MR. KERR: If you used a WASH-1400 sequence, you always get to 100 percent core melt, is that it?

MR. SILVERBERG: Yes.

MR. KERR: So you were not in this case looking at anything like partial core melt.

MR. SILVERBERG: Yes. I thought I said that. We are looking at -- in order to get the range, we are also looking at those where core melt has stopped, partial core melt, if you will. We spent a lot of time, in fact, up until very recently, just trying to get that aspect of the report in because we did not only want to deal with the core melt accidents, we didn't want to deal with the design basis accident, what about in between?

MR. KERR: Now, where are you getting data for this sort of thing to put in the report?

MR. SILVERBERG: For a partial, you mean in terms of the progression?

MR. KERR: Either a partial or a full.

MR. SILVERBERG: The partial, the Batel Columbus people are trying to make, one, an attempt on a March calculation.

MR. KERR: You are using the March calculation?

MR. SILVERBERG: March calculation to see what they might get up to that for so-called partial melt.

MR. CATTON: Using all three of the different core melt models.

MR. SILVERBERG: I am not sure of the details at this point. But that is one thing that is being actually provided, one of the sequences that we are having to look at, partial core melt.

Now, I might say that the information from this chapter -- let me note that for the core melt accidents, that when one wants to look in the following chapter, which I am going to cover, on ESF effects, the people looking at that can actually, if you will, assume at any point in time, assume that the accident sequence has stopped and perhaps core melt has stopped, or that the accident isn't proceeding, what might be the loads up to that point.

MR. KERR: As predicted by the March code.

MR. SILVERBERG: Yes.

MR. KERR: And you are going to assume that this is information which is reasonably valid?

MR. SILVERBERG: In most cases, no, we are certainly not going to.

MR. KERR: What will be the purpose of this range of calculations?

MR. SILVERBERG: To try to determine for the different -- the range of calculations that we are going to make on aerosol transport processes --

MR. KERR: Let's talk about the March as fission particle release from the core.

MR. SILVERBERG: We are making only one calculation of -- only one of the cases is what we call a 50 percent core melt with the March.

MR. KERR: Okay.

MR. SILVERBERG: The others will be -- we will insert -- we will assume a level of fission product release, mass releases.

MR. KERR: Again, I thought the report was going to be information that you think exists in the literature. Now you are telling me, from what I understand, that you are going to assume a release, you are going to assume a release in order to make calculations of transport?

MR. MOELLER: Dr. Kelber?

MR. KELBER: The attempt is to try to illustrate what are the range of conditions we may have to encounter in dealing with a range of accidents, and that is useful information. If you always have to deal with the very worst, and if you don't get much benefit by using a probabilistic technique, that is one case. If, on the other hand, you get a great deal of benefit by taking into account the fact that some sequences are much more likely than others, that is useful information as well.

Yes, it is relative information, not on an absolute basis, but we think it is useful to know whether or not things are always as bad as they might be, or whether in fact a good portion of the time they are a good deal better than that.

MR. CATTON: You would have to couple in with this certain assumptions like, gee, all the iodine is going to come off as cesium iodide, or it is going to come off in another way, or --

MR. KELBER: I believe that is listed down there.

MR. SILVERBERG: That is one of the variables.

MR. CATTON: There is an infinite number of variations.

MR. KELBER: Not infinite, but large.

MR. KERR: So this report is going beyond what is known. It is given that we know these are fission products, let's make some assumptions about what happens to them and see what the results are.

MR. SILVERBERG: Not quite. What I would prefer to say was that in order to look at the impact of a range of accidents, severity, which give a range of fission products and mass loadings, other than the one case for the 50 percent core melt that I described, and the one that I was going to calculate with the March code -- it hasn't been done yet, so I am not sure how it is coming out -- we were going to assume a range of releases.

We know what the maximum releases are for core melt. We know what they are for a terminated LOCA, very low. We need to get a range of mass loadings, to be studying a range of mass loadings to see what ranges might impact, how that might affect either the deposition processes, the transport processes, so that one can make a proper assessment of impacts of the ESFs.

MR. KERR: Well, I am not questioning what one needs to do in order to design ESFs. I quite agree. But -- and I realize one can't make a sharp separation between what is known and what is uncertain. But it seems to me what is known, with some reasonable expectation of accuracy, is the production of fission products, how many fission products one has in a core.

Now, what I seem to hear you saying -- I am not beig critical. I just want to make sure I understand -- is that given that these are in the core, you would also like to know what effect that is going to have on the nuclear safety features. So as part of this report, you will make certain assumptions about release fractions. Given those assumptions, you then will be able to make some estimates of the loading of engineered safety features.

Now, it seems to me that is going beyond what is known about fission products. It is perfectly okay. I am not trying to define the report, I am trying to understand what it is supposed to cover. This, it seems to me, is not what is known about the behavior of fission products but it says, let's suppose the fission products behave in this way, what would be the result.

MR. KELBER: The title is Fission Product Release and Transport.

MR. KERR: Yes.

MR. KELBER: Given a release mode, how are the fission products transported to the engineered safety features? Many things are known in some detail or the other, but not in a coherent account about the transport process. One will make the best estimate he can of what the transpoet is for releases characteristic of various accidents. In addition to looking at the serious accident sequences, what Mr. Silverberg has been telling you is that they will attempt to make the same type of estimate for accidents of lesser severity but greater likelihood and that they will do this parametrically because of difficulties in specifying set sequences in any detail.

MR. CATTON: You could have a break most anywhere, and with any of those breaks you can have a percentage somewhere between a zero and hundred percent of the core. You are going to have to pick three or four of those.

MR. SILVERBERG: We are picking typical ones, not the whole.

MR. CATTON: The break might be a long way from the core. You would have a different result.

MR. SILVERBERG: We are trying to cover that type of --

MR. KELBER: I think it is of interest. I think it is of interest to know whether that sort of parameter makes a great deal of difference in how you treat the engineered safety features.

MR. CATTON: A lot of it is changing the source term for the containment itself. I am not sure why you would bother with the code, just take different source frames and see what would happen.

MR. KELBER: We are worried about the transport mechanisms as well.

MR. CATTON: To understand them long enough to --

MR. SILVERBERG: In the containment.

MR. CATTON: To find out what is coming out the end of the pipe.

MR. SILVERBERG: Coming out the end of the pipe could be a range.

MR. CATTON: That was the point I was making, is that why not just at the outset look at a range.

MR. SILVERBERG: Yes. Put in a number of the sequences there is very little retention.

MR. CATTON: So you get zero to a hundred percent.

MR. KELBER: Yes.

MR. CATTON: In increments of ten. Now we are back to infinity.

MR. SILVERBERG: The emphasis, though, is certainly in the containment. The emphasis is certainly in the containment because the deposition is -- although the deposition in the primary system for most of the accidents of interest are faiurly low.

MR. CATTON: I guess I am just misled by this old journal. They show factos of ten difference between a painted tank and an unpainted tank. That is a fairly big volume. So I thought that was important, but factors of ten are not.

MR. SILVERBERG: Well, it depends again on the context.

I might note that in order to make the calculations of transport in containment, there are a number of different codes available, some of which are at different states of technology. The CORRAL code which treats sprays but does not treat aerosols as mechanistically as the HAARM code, which at this point does not treat the steam condensation that the NAUA code does treat in the Federal Republic of Germany. We are trying to get some special runs made with the NAUA code. We are -- we will be using the

IMAGE EVALUATION
TEST TARGET (MT-3)

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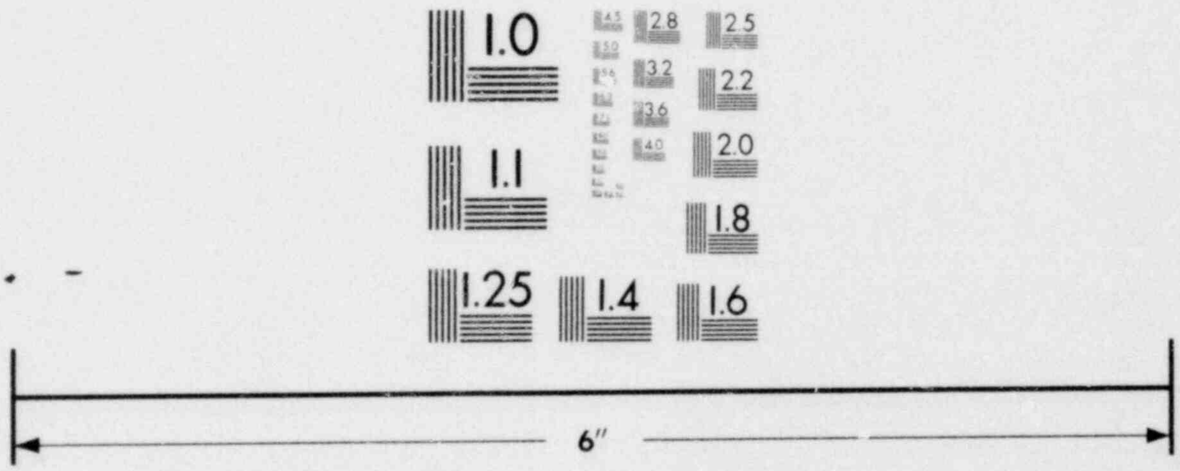
IMAGE EVALUATION
TEST TARGET (MT-3)



HAARM code and the CORRAL code so we can consistently indicate what the different effects might be in terms of the technology of having used these different types of codes, starting with CORRAL and moving on out.

MR. KERR: You will try to run them for the same set of input parameters and see what a different output you get?

MR. SILVERBERG: Yes, where they calculate the same thing, right.

MR. KELBER: Also, one code will illustrate one feature of the transport process, another code will illustrate another feature, and one can try to make a synthetic calculation, admittedly less satisfactory than if you had a comprehensive treatment, but nevertheless, it is the state of technology.

MR. SHEWMON: But you two will certainly be involved in writing the final report. But can you tell me who else?

MR. KELBER: Representatives from NRR, possibly the Office of Standards Development.

MR. SHEWMON: Any of you have an advanced degree in chemistry?

MR. KELBER: Yes.

MR. SHEWMON: Who?

MR. HOUSTON: Jack Reid will be taking a look at it. He is a physical chemist.

MR. SHEWMON: Well, we have one.

MR. HOUSTON: He makes the same point, incidentally.

MR. SHEWMON: I guess what concerns me here is that much of what comes out is that this stuff is water soluble.

MR. KELBER: What stuff?

MR. SHEWMON: Iodine compounds, or iodine reacting with water.

MR. KELBER: Some of them are.

MR. SHEWMON: Well, we can go back and look, but the chemist would know that better than I or better than you is my concern, and the other thing is it sounds like I don't know what all these things are going to bring to you and how they are going to get back to the chemistry of fission products, in what environments, but I hope we don't get so enamored with seeing wha. code can do what to who that we don't get back to the bottom line.

MR. KELBER: Well, excuse me, excuse me. There was a great deal of fuss made at the November 18 meeting and subsequently about the fact that aerosols apparently fall like rocks, and this was made -- this outrageous statement was made by Mr. Levinson to the Commission.

MR. KERR: Wait a minute. Remember, we are going to be dispassionate.

MR. KELBER: I am not going to be dispassionate about the fact that they resolutely refused to talk to one of the world's leading experts on aerosol behavior, Mel Silverberg, before they went ahead and jumped to this conclusion.

Now, this is part of the behavior in the containment, and aerosols do leak, sometimes better than other times, but they are a method of transporting the fission products. We are concerned with the public health and safety. Aerosols can be transported outside, they can be transported into lungs, they can be transported into the ecosystem. It is important to study the behavior there, too. Even if the material is dissolved in the little water droplet that is in the aerosol, it is important to know how that little water droplet moves.

MR. SHEWMON: And combines, and falls, and whatever.

MR. KELBER: That's right, that's right.

MR. SILVERBERG: I didn't say it was easy.

MR. KELBER: There was a great deal of discussion made on that on November 18, and we happened to have one of the world's experts on it right here who was not called upon to discuss it.

MR. SILVERBERG: What we are trying to do -- we didn't say it was easy. What we are trying to do is take the state of technology, provide the balance between chemistry, transport processes, engineered safety features, and do a best efforts job on providing a product that would be useful to someone for decision making, and we are going to try to provide the balance between the chemistry and all the other processes that impact, and we will cover the type of chemistry that you mentioned.

Also, the substance of the report will be written by experts in the field. We are pulling it together. But the substance of the report will be written by specialists in the field, their field.

MR. SHEWMON: That is the substance in the appendix.

MR. SILVERBERG: As well as the conclusions they wish to make, that we will just be collecting.

MR. MOELLER: You, of course, or your contractors in the field, are reviewing not only the U.S. literature but the world literature on the subject.

MR. SILVERBERG: Yes.

MR. MOELLER: And are you calling in the peer review or in any part of the process on foreign --

MR. SILVERBERG: Thank you for mentioning something I overlooked. We are going to be inviting at least a representative expert from the Federal Republic of

Germany. It has not been designated. I don't know what they wish. We will offer an invitation, we will extend an invitation.

MR. MOELLER: Very good.

MR. SILVERBERG: Thank you. Maybe others.

MR. CATTON: What about Japan?

MR. SILVERBERG: Good suggestion. That is a good suggestion.

MR. KERR: A week is too short if you are going to have it reviewed.

Well, I suppose they would have to read English though.

MR. SILVERBERG: Okay.

The last chapter -- basically the last chapter is one that is being coordinated and written by Wayne Hasedag in NRR, and this is not -- basically it is looking at a variety of the ESFs that are involved in various regulatory requirements, various Reg Guides, and some are probably missing from it. This gives you kind of a scope of what they will be dealing with.

MR. KERR: I must say, it didn't give me -- from looking at that, I can't imagine what you would be dealing with.

MR. SILVERBERG: Well, Wayne might be able to help on where we might be going.

MR. KERR: Mostly because that strikes me as being a little bit more than one chapter, maybe more like 25.

MR. SILVERBERG: Well, that is a problem.

MR. KELBER: The intent here was to scope what is a second document which I believe will be the focus of Wayne's discussion.

MR. SILVERBERG: Provide inputs that would be treated in hopefully more depth in the second document.

MR. MOELLER: And is this predominantly the effects of the iodines and so forth on these engineered safety features, or their effects, vice versa or both? I mean, I could see the safety features are maybe obviously altering the chemistry or something, but I could also see the compounds having an effect on the ESFs.

MR. SILVERBERG: More of the latter. Compounds and mass, I mean, in other materials.

MR. KELBER: We are particularly concerned with the question of the proper qualification of the engineered safety features, that they be able to function under the loads that may be imposed on them.

MR. KERR: We already have all these things in operation and we have conservative design parameters that are used.

MR. KELBER: They may be entirely adequate.

MR. KERR: Is the idea here that one is going to look and see how conservative these are, or is the idea that maybe they aren't conservative enough?

MR. SILVERBERG: I would prefer Wayne to handle that.

MR. KERR: Okay.

MR. SILVERBERG: Thank you, Mr. Chairman.

MR. MOELLER: I am sure there will be questions, more questions for you, Mel, but you have been on the stand, let's say, for a long time, and the room is warm. So why don't we take ten minutes.

(A brief recess was taken.)

MR. MOELLER: The meeting will resume.

Mel Silverberg of course had just completed his formal presentation prior to the break.

Do any members of the subcommittee or our consultants have questions, additional questions for Mel?

All right, there seem to be none. Why don't we then move ahead and the next item on the agenda is the discussion of the source term impact on ESFs, the design of ESFs and the licensing process, and for that we have with us Dr. Wayne Houston.

Wayne, the floor is yours.

MR. HOUSTON: I just have one slide, and I will put it on shortly, but perhaps a few introductory remarks might be in order.

The first point I would like to make is that although back in the latter part of November and early December the staff proposed to compile the report which you have heard about that has been referred to by its acronym as the SOTRI report, State of Technology Report on Iodine, the lead for which was picked up by the Office of Nuclear Regulatory Research, and much of the writing, as you understand, is being done by other contractor organizations. Along about the middle of December a group of people on the staff had about the same kind of concerns or, not misgivings, really, but considerations that have been expressed by Dr. Kerr approximately an hour ago. It wasn't quite clear that the outline of the SOTRI report would address some of the questions that seemed to be associated with the issue that had been raised, and that has to do with tying the matter together into the context of the regulatory process and the licensing decision process, past, present and future.

So that this gave rise to the formation of a small task group headed by Walt Pasedag, who is in our Office of Nuclear Reactor Regulation, but there are three members of that group in addition to Walt, and a representative from the Office of Research with the probabilistic analysis and risk assessment group, Roger Blond, and a third from the Office of Standards Development, a fellow by the name of

Jankowski. The three of these are preparing a separate and distinct report from that which you have heard about so far, but which is intended to be completed on the same time schedule as the SOTRI report, and submitted as part of the Commission paper; where you saw the schedule for a March 24th submission, we are on the same deadline for the completion of this report.

It will not be nearly as thick, I think, or as technically oriented a document, but will address the general question of the impact on the regulatory process and the licensing decision process.

It might be of interest to read some words from a memorandum that sort of created this task group, and this was done actually by another group within the staff which is called the Staff Steering Group on the Degraded Core Rulemaking Activity. Dyer Allotta is the Chairman of this particular group, and it was indicated that that steering group believes that an in-house report, that is, within NRC staff, report of the impact of fission product iodine and fission product aerosols on past licensing practice, present regulations, and possible future licensing application, in particular for core melt accidents, should be prepared in parallel with the proposed contracted State of Technology Report. The in-house report is necessary so that the contracted State of Technology report conclusions, in particular, possible changes in our technical understanding, can be quickly evaluated in their licensing context.

Now, one, I think, line of logic that was mentioned briefly here would be that after the SCTRI report is finished, we can pick up from that point and then develop an impact report on the licensing decision process, for example. We are not trying to do that. We are trying to do them in parallel, and this has created some problems.

So what it means is that the impact report as I referred to, and I don't think is has an official title or an acronym yet, is in preparation but is being done in parallel with the SCTRI report, and therefore has to a certain extent a hypothetical character to it, if this, then that kind of reasoning. But the object of it is, as I read in that paragraph, such that by the end of March we at least in the staff ought to be in a better position than we are today to see just what parts of the licensing process are potentially affected by the findings and conclusions of a technical or scientific character that come out of that report which, coupled with the observations that have already been made to us by other groups --

MR. KERR: Wayne, let me see if I understand what you are talking about in your example.

In the present licensing process, I think it is still true that we use as a source term in the containment

25 percent of the iodine, and associated with that is a calculated dose outside which is, what, 25 rem whole body, now, something like that.

Now, I think everybody involved knows that that is arbitrary. The Germans, if I understand correctly, use about a factor of ten roughly lower calculated dose, and they also use about a factor of ten lower source term. They have exactly the same fission product data that we have, and so they simply arbitrarily chose to use a different source term.

Now, what is there about this report, about what is now known, that is going to change our attitude toward the source term? You already know clearly -- I mean, clearly the people in Reg already know as much as is going to be in this report about the fission product generation, how much iodine there is. I am puzzled as to what it is you are going to do with the information in this first report that will have an impact on the regulatory process. It is almost as if new information were being developed when it seems to me new information isn't being developed at all, it is just that the information that exists is being collected.

For example, the Germans already know enough so they use a significantly different source term. I think the results also turn out to be about the same because they also use a different dose calculation.

MR. HOUSTON: I would like to try to answer your question n the balance of what I have to say. If I haven't answered it satisfactorily, maybe I can come back to it. I won't guarantee that I have an answer to it, but I think I do.

It seems to me that in order to address the question of the impact of accident source term considerations on the regulatory process, the licensing decision process, it is important to understand what we have been doing in the past, where we stand now with respect to our understanding not only of the release mechanisms as they relate to that process -- and that is my purpose for having them up there -- but also the fairly dominant role, rightly or wrongly, that considerations of radioiodine have in current licensing treatments, including the effect they have or the extent to which they appear either explicitly or implicitly in our regulations, the extent to which they affect technical specifications, procedural impacts, if you will, and the extent to which they affect certain specifications for engineered safety features, some of which are listed in Item 3, and then in Item 4 down there, we go on towards the tail end to talk about future potential licensing requirements, or the problem of implementation of some of our current and recently revised licensing requirements, particularly in emergency preparedness.

Going back to the beginning there, I have a listing there in a particular sequence, perhaps mechanisms I guess is the right term to put there, but considerations for the release of fission products that ultimately have a potential for getting out into the environment and the atmosphere, whatever.

At the lowest level one might look at fuel clad imperfections, and these are things which give rise to the appearance of radioactivity in primary coolant, to a certain extent in secondary coolants in pressurized water reactors, responsible, presumably, to a large extent for the phenomenon of spiking which has been observed in the operation of nuclear power plants, and sudden increases in iodine and presumably some cesium activity, which subsequently decays and all but disappears, is following a certain transient operation of the plant.

MR. MOELLER: Wayne, can you be a little louder? We are having trouble.

MR. HOUSTON: I'm sorry. Standing in the middle here it is hard to face all different ways.

In the next sort of an order of degree of severity is the matter of actually getting ruptures of fuel clad which gives rise potentially, as we normally view it, to the release of radioactive material which actually accumulates in the gap between the cladding and the fuel matrix and the fuel elements.

Going on up, when one treats or considers accident in which the temperature of the reactor core gets higher and higher, you get into a fuel melting mode. If it gets high enough you begin to vaporize materials that are relatively more volatile at higher temperatures. And then of course, one can have the physical phenomenon of an explosion effect. The last four of those things are of course release mechanisms which are treated in the reactor safety study.

MR. CATTON: Is there an intermediate category between fuel clad rupture and fuel melting, just if the fuel is hot?

MR. HOUSTON: You can put it in any subdivisions you wish. This is not intended to be, you know, a perfect description.

MR. CATTON: There are interpolations between these.

MR. HOUSTON: My point is here that in the normal licensing process, as it has been in the past and is currently for the most part, the considerations of the fission product release mechanisms are to a very large extent within what we frequently refer to as the design basis envelope limited to the first two of those mechanisms. To a certain extent we get into the third, consideration of the third, but not in a mechanistic sense.

This is the thing that Dr. Kerr was referring to a little while ago, when we deal with what could be called the maximum credible accidents, or has been or used to be called the maximum credible accident. Sometimes you refer to it as the most serious design basis accident or the limit of the design basis accident envelope from a consequence point of view, that which appears to be required to be considered by Part 100 are siting criteria and which, as you recall the footnote makes reference to the fact that the accident hypothesized or postulated in order to satisfy or test the criteria for reactor siting, and one typically assumes that the release is that kind of a release which one would expect if you get substantial melting of the fuel. It is a non-mechanistic treatment, however, in the current licensing process.

In risk assessment activities, stemming largely from the Reactor Safety Study and those of the type that te staff is engaged in, and others, at the present time, the release mechanisms of dominant importance are the last four. In the relatively recent past, as a sort of an aside, the staff I think has concluded that the mechanisms giving rise to explosions in the core are such that the likelihood of that occurrence is believed to be even considerably smaller than was judged to be the case in WASH-1400.

But at any rate, to again summarize, my main point is that with respect to the current licensing decision process, the first two, and to a limited extent the third, are the mechanisms which have been involved in the process of setting criteria, and radiciodine has played a dominant role with respect to the application of the consequences of those release mechanisms.

Going now toi the second item and the role of radioiodine in current licensing treatments, it is probably pertinent for me to point out that in our present regulations, at least in Part 50 or Part 100 regulations, you will not find any mention of iodine. The question has been raised, for example, by some of our Commissioners, iof all of these observations about iodine are true, do we have to change our regulations? It is not immediately clear that any immediate change in regulations is necessary to accommodate that.

However, I would point out there is at least one part in Part 100 with which I am sure you are quite familiar that is implicitly tied to radioiodine, and that is the fact that the two dose guideline values that are given in Part 100, the whole body and the thyroid, the thyroid dose guideline there is there for the purpose that it deals with the radioiodine question. So it does give rise to the question as to whether it makes sense to continue to have the thyroid dose limit guideline either of that magnitude or of any magnitude in our siting criteria.

MR. MOELLER: In that, Wayne, which is controlling, or does it flip flop back and forth, the thyroid or the whole body?

MR. HOUSTON: In the normal analyses that are done by the staff, it is the thyroid dose that is believed to be controlling, or it has been believed to have been controlling.

(General laughter.)

MR. KELBER: Very well put.

MR. MOELLER: So that makes any change that you might make would be significant, or could be.

MR. HOUSTON: In that sense, yes.

MR. MOELLER: And is it controlling by a factor of two or ten or what?

MR. HOUSTON: I think in terms of it being controlling, one would have to measure it in terms of the relative percent of the dose guideline limits, and quite typically, some of the analyses which are done for the, let me call it the siting criteria accident, the maximum credible or the maximum hypothetical accident, typically show percentages a dose computations, typically show percentages of 300 rem, ranging anywhere from about 25 percent to nearly 100 percent of that number.

In contrast, calculations of whole body dose tend to be on the order of one to ten percent of the 25 rem whole body number.

MR. MOELLER: Thank you.

MR. HOUSTON: Another part of our regulations which I should I think mention at this point, which bears on the question but again does not specifically mention radioiodine, is one of the general, I think one of the general design criteria that deals with the criteria for atmospheric clean-up systems. In other words, there is a general recognition in the general design criteria of the potential for having substantial quantities of radioactivity released into the containment, for example, into a containment building, for example, and that this material should be cleaned up in some sense and prevented from getting out to the extent possible. Again it is not specific with respect to any particular radioactive isotopes or nuclides, not specific with respect to aerosols or vapors or gases or solvents or what have you, but it is relevant and implicitly so to the discussion.

But it does appear that with the one possible exception of th 300 rem figure, there would be really no question about a need to make revisions in our regulations based on this.

It then becomes a question of implementing the regulations as well as the, to get down to the bottom, possible future changes in regulations.

In the area of the technical specifications which, you know, become conditions on licenses, there are specifications which are directly traceable to and related to the typical staff and to the past to a certain extent industry attitudes, although they may be changing now, about the importance of radioiodine. Typically, for most operating plants there are technical specification limits on the amount of iodine activity that can be tolerated or that should exist as a limiting condition of operation, in the primary coolant. For PWRs this is commonly but not in every case, one microcurie per gram. Under certain conditions they are allowed to exceed this to accommodate the iodine spiking phenomenon, but the considerations that have led to the adoption of those numbers have depended to some extent on assuming that the radioiodine present in the reactor coolant is for all practical intents and purposes in a volatile form, such as the chemistry of elemental or molecular iodine would produce.

If that is not correct, there may be no need for these technical specifications, or they may need to be modified considerably and presumably relaxed in this respect. That is a possible impact.

I should have said at the outset -- and I am supposed to be talking about a report which is in preparation that others than myself are doing. These are some of the things that are supposed to be addressed in that report. This is the context of what I am trying to say.

MR. KERR: Wayne, referring to the tech specs, one of the considerations in writing tech specs is conformance to Appendix I.

MR. HOUSTON: Yes.

MR. KERR: And this does not speak specifically of iodine, although iodine may turn out to be a significant contributor to the gamma dose, and to the thyroid dose. Even if you didn't have any iodine, would there be a significant change in the impact on Appendix I calculations, or have you looked at that? If you haven't looked at it --

MR. HOUSTON: We have some experts in the audience on that. I don't know the answer to that.

MR. BANGART: Most of our calculations are based on measurements of activities and measurements of amounts of radioiodine in effluents. So we don't look at the chemical species.

MR. KERR: You have a model that is required for calculation of source term. Now, is that model based on some assumption about iodine?

Suppose you discover some significant difference in iodine behavior? Would that model change significantly?

MR. MOELLER: Could you identify yourself?

MR. BANGART: I am Dick Bangart with Effluent Systems Branch.

I don't think so because the bases for the model are based on the actual concentrations of radioiodine and other isotopes that are measured both throughout the plant and through the effluent streams themselves.

MR. LAWROSKI: Measured when?

MR. BANGART: Measured in actual effluent pathways.

MR. MOELLER: Well, his point, the iodine is for routine releases where they have data, and here we are trying to estimate an accidental release.

MR. KERR: Well, the tech specs are for regular operation.

MR. BANGART: They are different specs we are talking about.

MR. HOUSTON: They are different parts of the tech specs. You are talking about what we refer to as radiological effluent tech specs.

MR. KERR: Yes.

MR. ETHERINGTON: I had a double take on SOTRI. I had a feeling the emphasis there was on the Part 100 type of incident, and you seem to be covering Part 50 and Part 100.

Am I wrong?

MR. HOUSTON: I would phrase it somewhat differently. I would say that the emphasis you have seen in the SOTRI report is on the Part 100 and worse accidents.

MR. ETHERINGTON: That's what I thought.

MR. HOUSTON: What i am trying to do is broaden that spectrum a little bit to include the lesser accidents that we traditionally look at and consider in the licensing decision process.

As you are well aware, we analyze and sometimes there are consequences of these analyses or impacts on licensees, certain discrete scenarios such as steam line break accidents, steam generator tube rupture accidents, these are two examples of accidents where it is very relevant what kind of activity and what chemical form it may be in the primary coolant when such an accident occurs.

If it is elemental molecular iodine which gets out, which is what we traditionally assume, we calculate certain consequences of that, generally potential doses to persons' thyroid glands. If the iodine in fact cannot get out either at all or to the extent that the chemistry of molecular iodine would suggest, then we should perhaps modify our practices in this. This is one of the potential impacts.

And this report will indicate that this is one of the things that we need to look at. It is identifying those areas.

I don't know whether we have finished the question on the effluent tech specs and the Appendix I.

MR. KERR: I have finished my question if you have finished your answer.

MR. HOUSTON: Finally, there are, I would say, in a sense, the first two of the items under No. 2 there are what one might think of as procedural impacts whereas the third is a potential equipment impact. All of them might be potential economic impacts of making significant changes n our treatment of fission products, particularly iodine release assumptions, if you will.

Because that is a special category which has been highlighted, which is obvious, I think, from an engineering point of view, but i has also been highlighted in the observations which have been made to the Commission regarding the importance of this question, the observation is made that it is not clear that because the traditional treatment or what I might call conventional wisdom of the situation in dealing with radioiodine in molecular form appears to have led to the setting of certain standards or specifications on engineered safety features which may be wrong, because if it isn't elemental iodine that we are dealing with, we should go back and look at those engineered safety features systems or specifications to determine whether or not the specifications on them are valid, are correct, are excessively conservative, are excessively

Liberal.

Yes.

MR. SHEWMON: To back up, you have got the regulations in Part 100, I came away with the impression that since -- that you didn't feel that if none of the iodine got out it would change, need change the reg guides at all.

MR. KERR: He didn't say reg guides, he said regulations.

MR. SHEWMON: The regulations, and I didn't know whether that was because you felt comfortable because we still had it bounded, or because that was why we didn't need to change the regulations, or what the basis for the statement, because the iodine was insignificant in the shortest term or what?

MR. HOUSTON: What I meant to imply was that because the 300 rem thyroid dose that is mentioned as a guideline value in Part 100 is directly tied to radioiodine, it raises the question as to whether -- and that is the only part of the regulations where one can I think legitimately raise a question as to whether or not the impact of making a significant change in an iodine release consideration, assumption or postulate or hypothesis, whatever you want to call it, based upon the evidence, whether such a change in the regulations would be necessary or warranted.

MR. SHEWMON: Why is it the only one? Is it because the iodine that might be released is such an insignificant part of the radiation?

MR. HOUSTON: No, the answer to your question of why is because that is the only place in the regulations that you can tie to the question of radioiodine. I am not saying it should be larger or smaller; there or not there, that is the question.

MR. KERR: Mr. Houston is being appropriately legalistic. He is distinguishing between regulations, which Part 100 is, the Regulatory Guides, which 1.4 and 1.3 are.

Now, nobody can today get a reactor license without making use of the suggestions, let me put it that way, in Regulatory Guide 1.3 and 1.4, and those suggestions are that you consider 25 percent of the iodine as being immediately available in containment. However, it is not a regulation, as the Regulatory Guide is quick to point out. It is a suggestion, and it says if you can satisfy the intent of the regulation any other way, you are free to do so. For all practical purposes, it is a regulation now in the sense that people have to follow it.

So if it is decided that iodine wasn't a contributor, at the very minimum, the Regulatory Guides would have to be changed.

Does that make things clearer or less clear?

MR. SHEWMON: Well, some.

(General laughter.)

MR. SHEWMON: I get the impresson that since the regulations don't call out iodine, that the physical reality of whether or not the iodine is there is irrelevant, and therefore we are happy with the regulations because nobody explicitly --

MR. KERR: Are you saying you could do the sensible thing without the regulations, without changing the regulations?

MR. MOELLER: Let me say what I thought I heard Dr. Houston say. As I listened, you said among our regulations the portion that most relates or in fact directly relates to the study, the report that we're talkin about being prepared, is 10 CFR 100, specifically where it refers to the offsite iodine dose, our thyroid dose.

And you're saying that if any part of the regulations would be subject to change, it would be this portion. You 've not said you're going to raise it, lower it or twist it sideways. You are just saying it is there and we have to look at it. Okay.

MR. SHEWMON: But the rest are okay.

MR. HOUSTON: No. What I'm trying to do is describe the things that are supposed to be addressed in this companion report to the SOTRI report. The report has not been written. There are no chapters drafted yet. They are in the discussion stage. They're working on chapters, but it hasn't been written yet.

And what I am trying to describe are some of the things that I expect to be addressed there and which are supposed to be addressed in that report.

MR. MOELLER: But this would lead almost

immediately to a complete revision of Reg Guides 1.3 and 1.4, would it not?

MR. HOUSTON: It could, yes.

MR. MOELLER: It could.

MR. HOUSTON: Some would say it should.

MR. SHEWMON: It seems to be statements like that that got us started on this exercise. People said fairly strongly that it should.

MR. HOUSTON: That's right. I am trying very desperately to avoid any conclusions here and now.

MR. KERR: This report is going to be dispassionate and not competitive.

MR. HOUSTON: It may have some recommendations in it. I don't know yet.

MR. SHEWMON: I hope so.

MR. HOUSTON: I don't know.

MR. MOELLER: Could you help us a little bit with this companion report that you are developing? Is it on the same time schedule as the state of the technology report?

MR. HOUSTON: Yes.

MR. MOELLER: Will they be bound in the same volume, or will you always get the two of them together?

MR. HOUSTON: They are both being prepared to be put into a Commission paper and go to the Commission on March 24th.

MR. MOELLER: So they will both go to the Commission. Fine. That's all.

MR. LAWROSKI: You say at this time you don't even have an outline or a draft?

MR. HOUSTON: There is in existence an outline but no draft.

MR. CATTON: Who's putting this together?

MR. HOUSTON: A group of three people -- Walt Pasedag, who works for me, Roger Blond, the Office of Research, and a fellow whose first name I'm sorry I can't remember, his last name is Jankowski with Standards Development. Three people from the NRC staff, three different offices.

MR. KABAT: And the effluent monitoring guidelines are considered in this project or it is a separate story?

MR. HOUSTON: Effluent monitoring/

MR. KABAT: No.

MR. HOUSTON: I don't think that would be covered here, no. I can't say that specifically, but that might be toward the bottom end of the list. It might be when we get down to the bottom line on item 4 that we might raise that question.

MR. KABAT: Shouldn't you consider this as a part of the safety ESF systems?

MR. HOUSTON: Monitoring systems?

MR. KABAT: The plant monitoring?

MR. HOUSTON: That is not typically what we think of as an engineered safety feature.

MR. KABAT: Okay. But maybe that the ESF function would be conditioned by data from the monitoring system, so in a certain way the data is necessary for engaging the ESF system.

MR. MOELLER: Dr. Kabat, can you be louder for the people over here?

MR. KABAT: I discussed the effluent monitoring of radioiodine under local conditions or emergency conditions, if actually the effluent monitoring should be considered so in as part of the relative actions in the whole program.

MR. HOUSTON: I'm not sure that I really understand.

MR. KERR: A possible answer is the way things are done here that would be part of the emergency procedures but not part of the engineering safeguards, I think.

MR. KABAT: Okay.

MR. HOUSTON: I could say this. We require absolute monitoring systems. One, if the effluent monitoring systems that we require depend in any way on the particular chemical form in which radioiodine exists, for instance, if such monitors depend upon the use of charcoal to absorb radioiodine which is then looked at by some sort of a counter or simulation spectrometer or such, it could make a difference.

If we conclude that the item that is going to be there, if any, is not going to be absorbed on the charcoal, it could have an impact on the monitoring system.

Is that the kind of thing that you mean?

MR. KABAT: Yes, because it was actually measured that the different chemical species have very different deposition rates on grass or vegetation generally. It means the intake rate of the same curie of iodine in different chemical forms would be different, so it means in emergency situations where there are thousands of curies of iodine, it could have the same effect on preparation as one curie of metal iodide, so that would make a difference in the actual environmental rates.

And so that is why I suggested that it could be considered as a part of the regulatory requirements, actually included in the regulatory requirements to measure eventually the species, the chemical species, because of the different deposition rates, very, very different deposition rates.

MR. HOUSTON: Okay. Going on to item 2 quickly, I have tried to list here some -- and this is by no means a necessarily complete list -- engineered safety feature considerations that are involved in questions of impact of changes in the iodine source term.

One can reasonably raise the question does this have any effect on containment systems or containment leakage characteristics or specifications? I don't have an answer to the question. It is not immediately clear that there would be a significant impact there.

In spite of the fact that the traditional practice in dealing with this in the evaluation of an application, the evaluation of a plant, the containment leakage is treated as if it is predominantly radioiodine in elemental form. If that changes, it could conceivably change our concern about the extent to which containments leak, but something else may crop up to take its place also.

With respect to liquid leakage pathways, it might be a little bit more of an impact; and one of the concerns we've had for some time are for those kinds of liquid systems which are water-carrying systems for which the lines pass through the containment perhaps to pumps or heat exchangers, what have you, that might be in an auxiliary building, for example.

And under conditions of the type, let's say, that occurred in the TMI-2 accident, to the extent that or if the systems can contain water that is heavily contaminated, it has been leaching or extracting fission products from the core because of its association with the primary coolant system, we are concerned about then the possible subsequent release of radioactivity from liquids that are transported into, say, an auxiliary building.

One of the things that we did typically look at is the emergency core cooling system pumps; our concern about leakage of valves and seals, etcetera, and here typically we do calculations which again makes the assumption that the thing we are concerned about is radioiodine in elemental form.

We did those calculations at the exclusion area boundary based on certain information or assumptions about leakage rates one might have in emergency core cooling systems through leaky valve stems, for example; and this in turn can give rise to certain design considerations impacting on the design of the plant in terms of, for example, the question of whether or not that material should be contained in some better fashion, or whether there should be an ESF-grade ventilation system with filters in the auxiliary building. These are not inexpensive, so the impact there is considerable.

I guess I already mentioned the charcoal in the HEPA filter systems. If we're not dealing with them, we're not likely to deal with them or should not have to deal with them.

With radioiodine in elemental form one can obviously raise the question whether there is a need for charcoal filters which are now virtually required in many parts or some parts of a plant.

Questions of the use of additives to containment spray systems, is this necessary. This depends upon the chemical form of radioiodine.

Do we need to inquire --

MR. LAWROSKI: Would you expect to get the same kind of range of behavior if the iodine and the containment were there as iodide, as if it were elemental iodine?

MR. HOUSTON: No, I would not.

MR. LAWROSKI: I wouldn't either. So shouldn't those results be a tipoff, though, because I think the experiments are based on the use of elemental iodine.

MR. HOUSTON: The postulates of what iodine is there as a source term in the first place are not necessarily clearly based upon experiments. Our treatment of what happens to the iodine as we consider they are passing through or into the systems is based upon experimental evidence of elemental iodine in aqueous chemistry.

MR. SILBERBERG: Let me add a point, Wayne, if I might. The data on effective containment sprays on elemental iodine have been done, of course, but during the same time some experiments were done on effects of particulates. This is in the old CSC experiments. And the mechanism, the transport mechanism by which the way the containment sprays scrub out the particulate iodine or the vapor are different; but it turns out that it has been modeled, and the containment sprays are quite effective in getting particulates also.

In Chapter 6 of our report we will discuss iodine removal depending on which form it is.

MR. KERR: But you would not need the spray additives.

MR. SILBERBERG: But I would not need the spray additives for cesium iodide, that is correct.

MR. UNDERHILL: How much iodine got to the filter at Three Mile Island?

MR. BELLAMY: It was about 120 curies. One hundred and twenty curies reached the filters, of which approximately 10 percent was transmitted through the filters into the environment.

MR. MOELLER: The containment sprays are needed for temperature and --

MR. HOUSTON: I think you could say they're primarily there for a heat removal system, but they have also been given sort of double duty to also help scrub the containment atmosphere

MR. LAWROSKI: But I think -- I believe in that case somebody has mentioned the Germans use different source terms and so on. But I believe, if my memory is correct, that they do not use additives in their spray systems.

MR. MOELLER: That's right.

MR. HOUSTON: I've heard that.

MR. MOELLER: They just use water. At least that's what we've been told.

MR. HOUSTON: Finally I mentioned control room habitability systems. To a certain extent our evaluation of the effectiveness of the arrangements, the design arrangements for ventilation systems for control rooms from a habitability point of view have also depended very crucially on the assumption that it is radioiodine in vapor form that is the hazardous material to be considered. And again, that requires a look-see to determine whether something there needs to be changed.

There are other ventilation systems in the plant that are not mentioned. One I might mention simply because iodine-129 was mentioned a little while ago, even though inadvertently, in the case of dealing with fuel handling accidents, for example, with spent fuel pools on a site where the fuel has been in storage for a considerable length of time, most of the shorter-lived iodine activity has gone away, we still have iodine-129.

And here again we treat this traditionally, and it has been conventional wisdom in spite of the fact if you, let's say, drop a fuel assembly and you crack it open, and you've got 20, 30, 40 feet of water for the stuff to come through, we still assume that it won't pick up all the iodine. I think we do assume something like 90 percent but not all of it, or maybe none of it comes out as molecular iodine. Maybe none of it will come out the surface of the pool. That could affect our dealing with ventilation systems and the storage buildings.

Finally, I'd like to say a few words about the current rulemaking activities and activities which have recently passed through a rulemaking, emergency preparedness. We clearly recognize the potential impacts of our state of knowledge about release mechanisms on creating a new Part 100 and new siting rule. It is more involved in this context now than just the question of whether the 300 rems should be there or not.

There is in process some proposed rulemaking activity on minimum engineered safety features requirements which clearly could be affected very much by this. Degraded core rulemaking is in the early stages of the process, and could be very much affected by these considerations. And there are certain questions now not relating, I think, so much to the present state of our emergency preparedness requirements in the form of our present rules, but questions relating to the implementation of those requirements which could depend in some circumstances on the forms of radioiodine we might be dealing with.

Probably the best example of that is the policy question regarding the use of potassium iodide. If there is a very little amount of radioiodine out in the environment following an accident, there is obviously very little need to give people potassium iodide tablets. So that is a consideration that has to be addressed.

I think that concludes my remarks essentially.

MR. MOELLER: Do we have questions for Dr. Houston, additional questions?

MR. KERR: What does one expect, given that this goes up as a Commission paper, will recommendations go along with it that say hey, here's what we ought to be doing?

MR. HOUSTON: I'm not sure whether the paper that is now in process will actually contain any specific recommendations, let's say to the Commission or a strong, clear suggestion that something needs prompt and immediate change. It may; I don't know.

It also may produce recommendations that here is an area that warrants further study, but the information that we have now would suggest that it shouldn't take very long to make a decision with respect to this particular matter. And this may change the way we do a certain part of our application reviews and may result, for example, in the immediate withdrawal of a reg guide or standard review plan or something of that nature.

That could happen, but the report right now is not far enough along for me to be able to project exactly what form any recommendations will take.

MR. KERR: A draft does not yet exist?

MR. HOUSTON: No.

MR. KERR: And the final form will be available by?

MR. HOUSTON: In final form the target date is March 24th as a companion piece with the Commission paper. I would expect a draft would be available, for example, for transmittal to the ACRS at about the same time that the SOTRI draft, which was, I think, March 6th.

MR. MOELLER: And following current policy I imagine the implementation aspects that you forward to the Commissioners would present to them the various alternatives available. It seems to me most of the recent reports have been in that mode.

MR. HOUSTON: Many reports are in that mode, that is correct. I'm not sure that this one is very likely to be quite that clearcut in terms of presenting alternates in the sense of here are alternative decisions that are available. It is just not clear to me that it will be quite that far along by March 24.

MR. MOELLER: Any other questions?

MR. HOUSTON: I might add here, I believe it is my perception that this Commission paper is what we would call an information paper, not a paper requesting that they make a decicion or recommending that they make a decision, which then would require choosing among alternatives.

MR. KELBER: I think we are aware of what the Commission's immediate concerns are. If we feel that on the basis of work done in Research and NRR and to a smaller extent I&E we can make a recommendation with regard to those needs, then of course we will do so. And there are some, at least, who are pushing us very hard to do just that. But I think it may well be that we'll be able to, on the basis of information developed at that time.

MR. MOELLER: Okay. Mr. Kerr?

MR. KERR: I would have thought from what I have seen in correspondence that one of the missions of one of these reports would be to answer some of the questions raised by the NSOC letter to Mr. Carter. And as I remember -- I can't quote the letter -- it said something about, on the basis of information that the Committee had obtained, there appeared to be some likelihood that a source term that had been used was much too big.

Now, I guess if one reads this report that has been described to us carefully, one might be able to reach a conclusion -- and I think the kind of work you have described is certainly work that needs to be done -- which is we need a better idea of source term.

But it seems to me that the Chairman of the Commission and others might have to look carefully to find a response to the NSOC. Is part of the objective of the report to provide an answer to their comments?

MR. KELBER: To the extent we can, yes. I might say, it is certainly conceivable that the comment is one of those questions which is ill put and is not answerable in their terms. In other words, if we are going to pursue a mechanistic description of accident consequences, then there may be no such thing as the source term.

There will be source terms for different types of accidents. Some will be bigger and others will be smaller.

MR. HOUSTON: Let me add to that if I may. I guess I didn't really totally answer your earlier question, where you referred to Reg Guide 1314. What we referred to as the TID source, 25 percent of the inventory of radioiodine.

MR. KERR: The TID source is 50 percent.

MR. HOUSTON: But half of that is cleaned it. So that leaves you 25 percent. In later revisions of the reg guide we just dropped it down to 25 percent.

Its basis is to a certain extent, of course, shrouded in the mystery of time.

(Laughter.)

MR. HOUSTON: We believe it to be suitably conservative. At the time I believe there was a fair representation and a consensus among knowledgeable people that it was not unreasonable to do that. With respect to the concept of --

MR. KERR: It was also meant deliberately to be conservative, wasn't it?

MR. HOUSTON: Oh, yes, yes. It was not essentially part of the TID source term to specify what the chemistry of the iodine should be. That sort of came along and evolved.

One thing I wanted to say, however, it appears to me as an individual that it's a simplistic question to think that all of the NRC does its business on the basis of a single source term or something. That is not true. That is a very distorted view, I think, of our procedure and our process.

That source term of reference from some points of view is what I would call, I think for clarity, the Part 100 source term. But from other points of view -- and this is, I think, particularly relevant to the observations from EPRI and from the industry -- I think, although it is not quite as direct a focus, it appears to be more on WASH-1400 and the staff's, the NRC's risk assessment efforts, not so much on the siting source term per se.

MR. KERR: But the implications of this hypothesis would be equally important to a WASH-1400 source.

MR. HOUSTON: Absolutely, absolutely.

MR. KERR: I guess you can say to the Commission by inference, we think the NRC asked the wrong question and we're not going to answer that, but here is the one we are going to answer.

MR. SILVERBERG: We need to do both.

MR. HOUSTON: We are aware of the NSOC's letter to President Carter and it should in some sense be addressed. But it's not clear to me that an attempt -- it was addressed to him and not us.

MR. KERR: This was the original impetus for this investigation, however, wasn't it.

MR. HOUSTON: The NSOC letter? Not to my knowledge, no. I don't believe so. That just came along. That just came along.

MR. KERR: What do you mean, two weeks later, a month later?

MR. HOUSTON: At least a month.

MR. SILVERBERG: At least a month.

MR. KERR: But the discussion that led NSOC to write this was the thing. It seems to me if you don't want to respond to it, maybe one shouldn't respond to it, but --

MR. HOUSTON: My impression was that the whole thrust of it, of that NSOC letter was that the NSOC was responding too slowly to the implications made.

MR. KERR: But when one says "by implication," it's expected on the part of the people that write the letter that there are some important implications. Otherwise, it wouldn't matter whether you responded slowly or rapidly.

Now, if you ignore that it's okay with me, I guess. But I am sort of puzzled that you can ignore it.

MR. KELBER: I am sort of puzzled that the NSOC could ignore the NRC efforts in this direction. They did not ask the Commission nor its staff to appear. And so we could have perhaps directed the question a little bit more precisely.

I can't help it if another agency's going to ask imprecise questions because of imprecisely written papers. I think if I were to forecast certain recommendations -- we will try and forecast what recommendations we can.

MR. KERR: I would say the questions are fairly precise. It may be difficult to answer them.

MR. KELBER: I think the point is that anybody who was familiar with WASH-1400 would recognize there is no such thing as a source term in WASH-1400. There are in fact something like nine categories of release identified with different types of accidents.

So the whole issue has been bound up in knots because people have confused Part 100 and its use in the regulatory process wit risk analysis and its use.

MR. HOUSTON: I believe, first of all, to answer your question, I am not sure that we have yet focused sharply on your question, namely here is a section of the report which specifically addresses the Nuclear Safety Oversight Committee's comments. Maybe they should be in and we ought to consider that.

As we perceive the report, it would be my believe that somehow or other their comment is being addressed.

MR. KERR: Let me say that I think what you are addressing is the more important of the two questions. But if I were the Chairman of the NRC I might also want the other question addressed.

MR. HOUSTON: We'll go back and take a look at that. I think that is a good point.

MR. MOELLER: Mel?

MR. SILVERBERG: I just want to note that I believe -- I think that is a good comment, an excellent suggestion. I think we can accomplish both.

MR. KERR: I would expect you could.

MR. HOUSTON: If you're willing, I have a couple of other observations I can make that I think are relevant to this.

MR. MOELLER: Fine.

MR. HOUSTON: The observations that have been made to the Commission on this subject over the past five months or whatever have been partly technical and scientific in character, but have been partly allegations of the impact in terms of people's perceptions of the risks associated with the operation of nuclear power plants, in a sometimes explicit and sometimes implicit stated concern that a major part of that impact relates to the current Commission's activities in emergency preparedness.

So a key question, one of the key questions here -- and I really didn't spend too much time at it -- was would this change in a source term have a significant effect on the Commission's regulations on emergency preparedness and implementation.

Now, I did mention potassium iodide. What I didn't talk about is what I think also is a very great concern to some people, which has to do with the extent of the program. The present staff response to that question is basically, it is not clear at all that it has any impact, because the considerations that led to the establishment of these 10-mile and 50-mile zones did not crucially depend upon it.

MR. KERR: With all due respect to the jargon engineers and scientists use to talk to each other, to make a statement that it is not clear at all that it has any impact doesn't really say much. It seems to me one has to say either it does have some impact or it doesn't have any impact, or we don't know whether it has any impact or not.

MR. HOUSTON: It would be very nice if everything was so cut and dried.

MR. KERR: But those three cover just about everything. I don't know whether you're telling me you don't know or you don't want to say or you think it doesn't have any impact or its impact is --

MR. HOUSTON: I can answer the question directly if it is for my own personal decision, but it isn't and therefore I can't. We arrive at regulatory decisions by something akin to a consensus process, which is not predictable.

MR. CATTON: We saw that this morning.

MR. KERR: But I thought you told me you were giving me your personal opinion and your personal opinion was it was not clear at all that it has any impact. Now I don't know what that statement means.

MR. HOUSTON: All right. Let me try to explain what I think it means.

If you go back and read the literature that led up to the creation of the concept of the 10-mile emergency planning zone and can come back and tell me that radioiodine played the dominant role in that consideration, then the answer to the question is yes, there was a big impact. But I know that that was not the case.

MR. KERR: Then it seems to me you might have said to me, I don't think it has any impact.

MR. HOUSTON: I don't think I said that.

MR. KERR: No, you said it is not clear that it does.

MR. HOUSTON: I'm sorry. I meant that.

MR. MOELLER: Now, I guess so another aspect you are going to mention is the report could have implications in terms of whether evacuation is a sound protective action. I mean, you have mentioned it can influence the importance of KI pills. You have mentioned it could influence the distance for the EPZ's.

But from what I have read, it could also influence the degree of usefulness of evacuation versus sheltering versus other kinds of things.

MR. HOUSTON: It could in the following sense. If one takes the position that radio iodine cannot get out, period, in any physical or chemical form, the only thing that can get out is noble gases, then the matter deserves reconsideration. But that is not clear.

MR. MOELLER: No.

MR. HOUSTON: I think what I was trying to say, I doubt whether reconsideration of the source term will have an effect on much of the emergency preparedness requirements. But anything that depends on the chemistry of radio iodine should be looked at.

MR. SHEWMON: Was the milk suppression efforts around windscale based on iodine, or was that strontium?

MR. HOUSTON: That was iodine, and that did not depend on the chemical form. It was basically the difference processes that got it into the air.

MR. MOELLER: All right. We have, as anyone who has the agenda can see, we have the EPRI presentation remaining. And thinking of that, let me sort of propose a unilateral suggestion, and that is that the NRC staff wants to know -- I mean, we've invited you back in the morning to appear before the full Committee. There are probably a few other things you could do other than sit here for several hours with us.

Let me suggest the following. In the morning we do want you to appear before the full Committee, and in just a moment we'll make some suggestions to you.

Secondly, in the morning, if you can be there by 8:30, you can hear the Subcommittee reporting and you'll know what we decided tonight or what are some of the conclusions we've reached or some of the comments we offer. So there's no reason to stay and listen to that. And if we have any questions remaining, we can ask them of you tomorrow.

Does that sound all right to the Subcommittee? What I am proposing is to try to release the NRC staff.

MR. KERR: That is a statesmanlike proposal.

MR. LAWROSKI: How much time do we have to ask those questions tomorrow?

MR. MOELLER: We've got from 8:30 to 11:00, and we've even got some time after lunch. But I'm hoping maybe we can do it between 8:30 and 11:00.

MR. LAWROSKI: I'd like to ask a couple, so if they don't have the answer tonight --

MR. MOELLER: Fine. And then let's also mention what we'd like to hear from them in the morning.

MR. LAWROSKI: I'll later probably have more, when I finish reading this stuff we got yesterday. But one approach in trying at least to reach, I think, a decision whether the source terms have been grossly exaggerated, we have to use them by factors of 100 or 1,000, would be to look at what the information is and what can support it, what was sent in in support of this position that maybe the term should be changed.

For example -- and I have reference to a document that is from EPRI to Chairman Ahearne -- well, to the Commission. It is dated November 10th -- I'm sorry, it's from NSOC. It's from Dr. Zubrosky, I believe -- yes -- who appended a paper that is titled "Fission Products and Aerosol Behavior Following Degraded Core Accidents," by Morowitz, NSOC again.

And if we're going to talk about the source terms being wrong by factors of 100 or 1,000, then I would think one, in sending in something like this to the Commissioners, would have tried to help reconcile some of the information contained. I reference in one case, for example, to a statement that is a part of this paper: As a result of a failure of an intentionally defected fuel rod in the plutonium recycle test reactor, a pressure tube also failed and released fission product iodine from the reactor coolant water to the containment.

Out of a total of 773 curies of iodine-131 in the fuel, 7 curies were released to the containment atmosphere, and 205 were found in the water caught in the waste water tanks. That 7 curies in the containment, that is one percent. That is not a tenth of a percent, it is not a hundredth of a percent, if these numbers mean anything. So that is .1.

I think the arguent is whether or not we should use a term like 20 percent of the iodine inventory or whether it should be two-hundredths of two-thousandths of a percent.

I turn to the very next page of the very same document, this new one. And by the way, this document, it says nothing, though, by way of reconciling that this -- you know, the temperatures were wrong, anything whatever on the conditions.

But anyway, it says one percent. The next page says Witherspoon and Postma, and they give the reference legend here, performed laboratory experiments on the condensate from a steam fission product atmosphere, and found that when the solution was evaporated to dryness less than 4 percent of the dissolved iodine and 1-1/2 percent of the cesium contained in the liquid was released to the gas phase. It says less than 4 percent. I don't know, maybe it's 3.

But again, now I am getting up higher and higher. So I don't know. And I just wonder. I suspect if I read through some more of these things -- I haven't had time, but one could find more examples.

So the question I'm going to ask the staff, has anybody looked at that, either the staff or you? You asked the EPRI people to reconcile this, because you have to. It's like saying, you know, I don't want to consider a vigorous reaction between aluminum and water because the two times I put the two together I don't get anything, but the two times that somebody else has done it he's gotten a real good one, but because I can't seem to get it.

Well, one more. I have a recollection -- maybe my memory is wrong, but I don't know whether I saw it in writing or whether in the almost endless number of presentations we've had since March 1979, that a statement was made that shortly after the TMI-2 accident that in order to reduce the volatile iodine, the volatility of the iodine in the water -- I don't know whether it was in the aux building -- that somebody said that they did and I understand they put in an additive in that water.

If that were really -- the iodine was there as cesium iodide. Unless the thing broke down with radialysis, I shouldn't have thought that something whose boiling point is 1280 Centigrade would have needed much to keep the volatility low. Maybe it was added for the wrong reason. But I heard that it was added. I forget whether it was thiosulfate or some hydroxide.

MR. CATTON: I have a number like that. I looked at the number on the core melt and they found a little less than one-half a percent.

MR. LAWROSKI: ... Mr. Silverberg will remember, although these are not reactor-type experiences, but in connection with the processing of spent fuel, the behavior of iodine and the dissolution of fuel, whether it is oxide or metallic fuel, has been a considerable concern ever since 1944, when sizable quantities of spent fuel were processed. And I wonder if somebody has looked at that, because there you could find some pretty quantitative -- you know, you should find some better materials, because that's a better place to think of it.

The material balances leave much to be desired, let alone the fact that there aren't enough statements about the conditions.

I also would say my copy did not have the table that was mentioned of reactor accidents, but I do note that some in support of the fact that, gee, you didn't get much iodine out -- you know, like these destruct tests -- I also note there wasn't a lot of the noble gases released. So if the noble gas didn't get out, I wouldn't expect the iodine would.

MR. KELBER: So far as the material balance, I would also wonder where the other 500 curies went. But I think that is beside the point of your question.

MR. LAWROSKI: Maybe if they want to think about it until tomorrow. I don't care who answers it.

MR. KELBER: I think perhaps we could deal with some of that tomorrow, but I think that one point that has come up, and that is the aqueous chemistry in particular -- we didn't mention we do in fact have the Oak Ridge people in consultation with some of the people in Savannah River and the Sandia people as well, and are drawing heavily on the experience in the reprocessing, because as you correctly point out that is the most quantitative experience that we have in this field.

And I think that we're setting the stage there for what I believe is the correct thing to do, and that's a lot of work on aqueous chemistry.

MR. LAWROSKI: So these were not -- not all of these were dry conditions. I mean, TMI-2, I mean, heck, that may be really unique and we shouldn't get a mindset, not right away.

MR. KELBER: Where have I heard that word before?

MR. SILVERBERG: I couldn't agree with you more.

MR. LAWROSKI: At least I would like to see these other things reconciled before I buy really low numbers.

MR. MOELLER: Thank you, Dr. Lawroski.

Are there other questions or comments along similar lines?

MR. LAWROSKI: In addition, I reiterate, the question Mr. Etherington raised at the very beginning is another one that ought to be looked at.

MR. MOELLER: Ivan Catton?

MR. CATTON: I just have a quick comment, and that is back to this accident scenarios. The number that I mentioned earlier was wrong. I just took a look at my notes and it turns out that the preliminary look says the number of sequences that leaked to core meltdown dry is one-tenth those that you get wet.

And from my view of the reliability, that means they are the same.

MR. SILVERBERG: In other words --

MR. CATTON: They're about equal. I think that should be looked at.

MR. SILVERBERG: Okay.

MR. KELBER: My experience is that that varies from at least plant type to plant type. I wouldn't want to make a categorical rule, but they are roughly comparable.

MR. CATTON: Analyst to analyst, it varies even more.

MR. KELBER: But they are certainly comparable.

MR. SILVERBERG: And because of that, basically we have addressed those types, that range. We have spanned the dry and the wet in our sequences, using that as a guide. That is a well taken point.

MR. MOELLER: Okay. In terms of your presentation tomorrow, I believe personally that you could do pretty much what you could do today, always shortening it a little bit.

At the beginning, though, if you could possibly do so, clearly spell out what the objective of the report is and tell us very early that it is on schedule; and specifically, also explain -- it would have helped me if you had explained earlier today -- Wayne Houston's report, and that it is a complementary item to the technology report.

And as I say, I think certainly the full Committee should hear from each of the three of you. And as I say, perhaps anything you can do to shorten it will be helpful.

Do the Subcommittee members have any other suggestions, contrary suggestions?

(No response.)

Well, why don't we go along, then, with that.

Dr. Shewmon?

MR. SHEWMON: We have been here for three and a half hours, and you said they should go over the same thing they did today, but do it a little shorter, is that it?

MR. MOELLER: Do it a little bit more quickly.

MR. SHEWMON: Do you think that'll get us down to two hours or one hour?

MR. MOELLER: We have -- and I don't think we want to necessarily fill the entire time, but the full Committee schedule calls for, I believe, from 8:30 until 11:00 and from 1:30 to 2:30, or something. Hopefully, we can do it in the morning. Let's try to do it between 8:30 and 11:00 and get it out of the way.

MR. KELBER: I would appreciate that.

MR. MOELLER: Okay. That is our goal.

MR. LAWROSKI: Is the full Committee also going to hear from Mr. Rahn?

MR. MOELLER: I stand corrected. The full Committee will hear that also.

MR. LAWROSKI: He may answer my question.

MR. RAHN: I think I can answer some questions.

MR. MOELLER: Okay. Well, we are hoping to aim to finish here by 6:30 at the very latest. We have been going quite a session, so let's take ten minutes, and then we will resume with the EPRI presentation.

(Recess.)

MR. MOELLER: The meeting will come to order. We will proceed on now then with the presentation on the work and reports that have been done under the auspices of the Electric Power Research Institute, and we have for that presentation Frank Rahn.

MR. RAHN: Thank you, Mr. Chairman, gentlemen. My name is Frank Rahn. I'm with the Electric Power Research Institute.

By way of background I want to mention a few reasons why we brought some of these substantive issues up at the November 18th meeting to the Commissioners and subsequently on December 16th to NSAC.

I think TMI certainly had a lot to do with it, the instance of having left out what was predicted that might come out from an accident such as TMI and subsequently what did come out, specifically the iodine, I think it was very striking. And in fact, when we talked with a number of people in the industry, it is clear that a lot of our ideas were not unique in any way, that in fact there were people at the national laboratories, overseas, and at the NRC that had ideas that were very similar to the ones that we had put forth.

We feel they're very important, and we view what we have done as mainly shaking the tree on which the fruit was already ripe. And in fact, when the fruit fell it was quite a tree indeed.

The question also comes up why do we raise these questions now. In fact, there are a number of reasons, the first of which, there is new evidence to be presented, including the accident at TMI and a number of experiments that have been done since the last in depth look at the issues. But more important, we are getting into new areas such as siting and evacuation policies of WASH-1400.

Now, WASH-1400 was originally designed and the study originally done looked at on an absolute basis what the risk and the consequences would be from a nuclear accident and compared that against some perhaps arbitrary criteria as to what was safe.

Today that is changing. When you talk about evacuation, you are not looking at absolutes any more, but you're going into the area of relative risk; that is, you're asking yourself in reality the question does a nuclear accident pose a greater risk than the evacuation? And indeed we see we are now in new territory.

We conclude, and we concur with the staff, that what is important are the following isotopes, namely as was testified earlier today, iodine, cesium, tellurium, ruthenium, and rubidium.

Now, as was also mentioned earlier today, you see that the iodine only constitutes roughly 50 percent of the consequences for the acute fatalities and relatively less when you talk about long-term fatalites and also property. So we like to put forward that we're a little bit concerned that the single emphasis of the staff has been on iodine when in fact it is the other isotopes, including the aerosol behavior, that constitutes the vast majority of the risk.

In the interest of time I have considerably cut down the presentation I planned today, because a lot of these facts that I was going to be talking about have already been mentioned in the earlier presentations. So you have a packet that can go into the record, as it will, so if you're following along, I'll be starting at approximately page 8 of that material.

MR. SHEWMON: Two things. One, would you tell me what it is that makes you feel that the staff has given this particular emphasis to iodine? I certainly didn't get that impression from the discussions earlier.

MR. RAHN: Well, excuse me. Let me pull out some of the earlier slides presented by the staff, and I noted in a statement that they will consider the other aspects as time permits; that is, the handout from the staff presented earlier today.

MR. SHEWMON: Is that Mr. Silberberg's stuff?

MR. RAHN: It was Mr. Silberberg's.

MR. CATTON: That was one of the handouts from Mel

Silberberg, not from the licensing people.

MR. RAHN: That is correct.

MR. CATTON: Silberberg and his group don't license.

MR. RAHN: That is correct.

MR. CATTON: Well, a conclusion based on that is not correct.

MR. RAHN: We get the impression that the emphasis is -- "impression" is perhaps not the correct word -- that that is indeed the case.

MR. SHEWMON: I have a fair amount of paper here. Could you hold up page one of what you are starting on page eight of?

MR. RAHN: The first slide I'm going to use is threshold levels on source term reductions. In terms of overview I was simply going to make a few observations on this particular diagram.

Now, we use this diagram with some caution. In fact, there are three cautions we have to be very careful of. The first is these are basically aqueous diagrams at low temperature. Secondly is that it does not take into account any complexing items that may occur, and thirdly that these are equilibrium charts.

The central point I wanted to make in terms of the iodine and other things enumerated is the fact that under normal operating conditions a reactor will be on this line here, which is the dashed line on the diagram which is the hydrogen over the hydrogen ion line, normally down at pH 7, 8, or 9 roughly here on the diagram.

And unless you get a very oxidized enviroment, unless you get a fairly low pH, the chances are you will not produce a great deal of molecular iodine, which is indicated in this area here on the diagram and indicated to be non-aqueous by the fact of the bold letters. That is the only observation I was going to make.

So does that answer your question?

MR. SHEWMON: Thank you.

MR. RAHN: Would you like a further discussion?

MR. LAWROSKI: That is equilibrium.

MR. RAHN: That is equilibrium, and that is important, but it does give you an overview. As you get away from equilibrium those lines move, but still it indicates that you need a very oxidizing environment, and you have to have relatively low pH before you start getting into significant molecular iodine.

MR. SHEWMON: Would you expect an intense radiation field to change that line at all?

MR. RAHN: Yes. The reason is you start producing a number of free radicals, including peroxide and what not, so those lines will bounce around. The only point I was trying to make is that some of the questions, the reasonability of some of the data that has been presented on the question of iodine relative to a Porpaid diagram I think comes out relatively clear, rather than when we present a number of equations which are difficult to follow. And again to be used with care with the number of cautions that I mentioned.

MR. LAWROSKI: This is without any hydrogen.

MR. RAHN: This is with hydrogen in water.

MR. LAWROSKI: This is with hydrogen in water at some relative pressure.

MR. RAHN: That is correct.

MR. LAWROSKI: I don't see any number. There should be, depending on the overpressure of hydrogen, there should be some influence on that.

MR. RAHN: The overpressure of hydrogen pretty well will lock you on this dashed line which is labeled A, dashed line A in the diagram. As far as threshold levels on source term reductions are concerned, we raise the question because we feel it is an important question, that in fact relatively small reductions can have important safety repercussions.

The easily identified factors on iodine and particulate matters, source terms, and particulates can be reduced by a factor of ten or more with probabilistic analysis such as WASH-1400, and I'm going to come back to that point in a minute. If fact, if you didn't get a tenfold reduction in iodine and particulate components, particulate component and source term in a study such as WASH-1400, that implies that you will have no early fatalities. And I think this is the key point in terms of our thinking on reactor accidents and what we might do about it.

We spoke about WASH-1400. Indeed we feel that WASH-1400 is an excellent study, that it was done under some severe time constraints and money constraints, and as a result there are certain parts of it that now since we have moved into these new areas of consideration such as siting and evacuation policy, we have to go back and relook at it again.

And some of the areas which WASH-1400 does not include in areas of attenuation are, for instance, in the primary system. There is an assumption that there is no water or surface sorption of volatilized species. As far as the containment is concerned, there is no deposition along leakage paths, there's no trapping of any species during water flow through saturated pools, and no retention of any species in auxiliary buildings or structures outside containment.

In addition, there are a number of areas of conservatism that are listed on this chart. For instance, you use 100 percent release for volatiles. It assumes fuel oxidation very effective in releasing ruthenium, various chemical forms, aerosol behavior and so on. I won't read it to you. I think you can go through that rather quickly.

We looked at WASH-1400, and we have looked at the five most dominant accident sequences. These include the check valve V, TMLB'. Check valve V, essentially direct path outside containment. TMLB' is a transient with auxiliary feedwater, also loss of AC power and so on. S_2C is a small LOCA with failure of the containment spray.

When we do so, we have looked at various areas of conservatism which we have listed on the left. The black dots indicate those areas which we feel were not adequately treated in WASH-1440, each one of which is significant and each one of which we believe can get more of a factor of two with attenuation of the source term.

If you look down the list, all the significant sequences have at least five or more areas in which significant reductions can be achieved simply by going back and including in the model some of the questions that we've been raising.

MR. LAWROSKI: Excuse me. On this diagram, which is the one before this, I see where you have RuO_4.

MR. RAHN: Yes, sir.

MR. LAWROSKI: What temperature is this?

MR. RAHN: The diagram you're looking at now? I did not show it. But the one you are referring to is essentially a low temperature.

MR. LAWROSKI: How low?

MR. RAHN: Twenty-five degrees Centigrade.

MR. KABAT: How do you want to oxidize ruthenium under these conditions?

MR. RAHN: Again, we were just looking at what possible chemical forms we had to consider. As far as ruthenium is concerned it is solid, and in fact we believe it will mostly come out in terms volatilizing gases and aerosols, and also with particular aqueous chemical forms you might have.

MR. LAWROSKI: What status -- once you get over 100 Centigrade it dec mposes violently.

MR. RAHN: No question about it.

MR. SHEWMON: But that is only up on a part of the diagram.

MR. LAWROSKI: I know, but Mr. Kabat asked you how could you under the conditions we were just shown have RuO_4. That's not the easiest material to have.

MR. SHEWMON: But the line for the reactor is down here in the ruthenium.

MR. RAHN: As long as we are in an aqueous condition it is much different, and you have to look at what you are.

MR. KABAT: You can oxidize ruthenium only in high oxidizing conditions.

MR. SHEWMON: That is what the diagram says.

MR. KABAT: I'm sorry. I didn't see the diagram. But it means in the reactor accident conditions you wouldn't expect any conditions like that? In reactor accident conditions you would expect highly oxidate solutions?

MR. RAHN: Quite the opposite. Quite basic, because generally you have sodium hydroxide in another base which is injected with the ECCS system.

MR. KABAT: So that the diagram shows that as far as ruthenium oxide, it's practically impossible to be produced under these conditions.

MR. RAHN: That's right.

MR. KABAT: Okay. I misunderstood.

MR. RAHN: Well, so what are some of the impacts of smaller releases? Again referring to WASH-1400, in the early injury case we put down WASH-1400 as being immunity. If you reduce the iodine particulates by a factor of five, the early injuries are reduced to .03. If you reduce the iodine particulate to a factor of 10, you reduce the early injuries to 1/50th of what WASH-1400 is currently projecting.

In addition, this is not taking into account the fact if you have an individual who is irradiated to, let's say, 300 rem and subsequently only gets one-fifth of that, that is very important in terms of what the health effects for that particular individual might be.

MR. SHEWMON: Sir, you in your presentation have iodine and particulates as one phrase here like "Damn yankee" or something down south. Are you assuming that most of the radioactive material in the particulate is also iodine, or why do you choose to group these together?

MR. RAHN: Just for convenience. We don't necessarily mean that if you reduce both iodine and particulates they would necessarily be reduced the same amount. We used iodine and particulates together because for ease of presentation we considered what would happen if you took both of those groups and reduced them by five or some similar magnitude, if you reduce one by five, another by ten, vice-versa, you get some differences.

MR. SHEWMON: Okay. But then you feel in going through these various walker baths and whatever you have on one of these disagrams I can't find, primary system containment leaks, saturated water pools, aux buildings, that indeed the particulates and iodine would be trapped in much the same way?

MR. RAHN: No. They behave very differently. In fact, there are a number of physical and chemical processes which exist, some of which act on iodine in the aqueous form, others which will act with iodine on the molecular form, still others which act on particulate matter, aerosols, which should be factored into WASH-1400.

MR. SHEWMON: Okay.

MR. RAHN: Now, the question of timing had come up earlier in some of the presentations, and I would like to make a few points of some of the things which are not readily or currently recognized in some of the models.

I think all of us recognize that these happen. They just have not been built into the models. In fact, if you have a major accident, you're going to have loss of water from the primary system, and if you do so, you're going to have a lot of water some place. That means either in the fuel cell, or in containment, or dripping off the walls. So there will be in even a so-called "dry accident" a lot of water some place.

As far as fuel melting is concerned, this is where the bulk of the fission products will be released, but in order to get this fuel melting, this melting will precede by some time the penetration of the pressure vessel so that in fact the aerosols which are generated during this process will have to be present in the volume of the pressure vessel before there is any possibility of the core melting.

And during that brief period of time, whether we're talking about minutes or hours, there will be significant physical and chemical processes going on which will very dramatically affect the nature of the source term.

MR. SHEWMON: Sir, let me interrupt once more. The staff have all left so they can get home before 5:00, I guess, but we can ask them tomorrow. They had an alphabet soup of various computer codes which they were going to exercise on this problem. Do you know whether any of those are designed to take into consideration some of the things you were talking about with regard to the solution or hold up in the water?

MR. RAHN: The answer is I know, and the answer is no.

MR. SHEWMON: They won't bring it up tomorrow. Thank you.

MR. RAHN: I will come back to that point a little bit later as to what I consider to be a good experiment and what is a good computer code.

Now, as a result of the last point, the density of fission product aerosols should be based primarily on the free volume of the pressure vessel and not the containment building. Pressure vessel, typically you're talking a few tens of thousands of cubic feet versus the volume of a containment building itself which runs up over 1 million cubic feet. So there's a very severe disconnect without the densities and concentrations of aerosols we should be talking about.

MR. KERR: Well, now, there are some containment structures that don't have a million cubic feet.

MR. RAHN: Half a milli-- cubic feet, whatever. It's the difference between several te of thousands, several hundreds of thousands or millions.

MR. SHEWMON: Your point is the agglomeration of aerosols goes up at some power of the density, is that right?

MR. RAHN: That's right. A very fast power density.

MR. CATTON: It would take place before it gets outside of the vessel?

MR. RAHN: Yes.

MR. CATTON: So it won't take place at all?

MR. RAHN: A very large fraction will not get out. It doesn't mean that it won't often.

The last point on this slide that I want to make is fuel melting will not start under the fast blowdown stage is over. In fact, until you have most of the water outside the primary system, there will be sufficient heat transfer to prevent severe melting from occurring.

MR. KERR: What fraction of the iodine do you expect to be in the gap between the pellet and the clad?

MR. RAHN: I don't know the answer to that, but if it's between the pellet and clad, if it's during the blo.down phase, it'll be in the aqueous solution. It will end up in the water wherever that water happens to reside after the accident. It will not be available in the aerosol.

The point is here it's not approprite to use the speed of the escaping steam to calculate the fission product transport into containment.

MR. KERR: Fission products can be transported in containment other than aerosols. It seems to me that is a good mechanism for transporting say iodine into containment.

MR. RAHN: Okay. I guess my point here -- and I stand corrected -- that for blowing aerosols into the containment it will carry. If there is transport of iodine in solution into the water, that iodine will remain in the water and as a result be carried into containment.

In addition, here is a typical PWR containment building, and in fact if you have a hypothetical LOCA loss of coolant accident, you have a pipe break let's say roughly at this position, immediately you get a blowdown phase. You may get some of the iodine, if it is ionic form, carried out in the water into the containment.

But as far as the aerosol is concerned, first of all you go into a phase prior to or just the start of fuel melt where you have a very dense aerosol on top of the pressure vessel, and to get out it first has to interact with all the surfaces -- that includes the port plates and various other control drive mechanisms -- as well as having to proceed down the path, during which a number of important aerosol played out mechanisms are concerned, various played out, various agglomeration, etcetera, during that particular travel down the pressure vessel and the piping. And none of this has been taken into account in most of the mechanistic studies concerning source term release.

This is a diagram which is in part taken from the study at Park, it comes from some of the German work at Karlsruh, and is an estimate of what amounts of aerosols are we talking about.

Typically you have steel on the order of a thousand kilograms -- that is a metric ton of steel -- almost a metric ton of uranium. You can read that.

As far as the radioactive fission products are concerned -- it is this little bar here -- something just less than 200 kilograms at most.

Now, what we are talking about is 2 1/3 to 3 metric tons of aerosols, and I don't think it takes very much of a genius to realize that if you have that much aerosol running around in containment, whether it is confined to the pressure vessel or confined to the entire containment, that in fact it's going to fall out rather quicky.

Let's look at what some of the predictions show.

MR. KERR: Are you telling us that there isn't any way or any feasible way that one could have mostly the fission products and not this other stuff?

MR. RAHN: I don't see how it's possible. In fact, let me go back a couple. Well, it depends on various things. Certainly you come off on stages depending on the volatility of various of the isotopes; but by and large the ones most likely to go first, for instance, are the silver, the ignium, and the cadium -- the ignium and the cadium. In fact, just from that you can see there's roughly 500 kilograms of that material which is likely to exist.

MR. KERR: It seems to me, for example, that steel might go last.

MR. RAHN: Steel might go last.

MR. KERR: So I could, for example, maybe get rid of a thousand kilograms if I ignored the steel.

MR. RAHN: Perhaps. It depends. It is very dependent on which scenario you are calculating. I only put this up as to be indicative of the relative amounts that we are talking about. Even if we are talking about the silver and cadmium which you agree is likely to go first, you still have 500 kilograms of material which is likely to be plating out, interacting with whatever fission occurs.

MR. KERR: I imagine the fission products might go first, and I don't know what would follow them since that is where the energy is that's going to produce this process. I don't know in what order other things might.

MR. RAHN: That is still a rather significant amount of other things at the same time, especially for some of the solids. The ones that are likely to volatize first like iodine, there is good evidence to believe that in fact it will come out not as IO_2 in the molecular form but rather as iodide.

MR. LAWROSKI: Any others?

MR. RAHN: Coming out early?

MR. LAWROSKI: Not in the form of aerosol but just because of the high vapor pressure.

MR. RAHN: You have to go through the listing as far --

MR. LAWROSKI: I thought maybe you had.

MR. RAHN: Excuse me.

MR. LAWROSKI: I thought maybe you had and could tell us. You said iodine and what?

MR. RAHN: Iodine is certainly one of the lower ones. You can go through things like tellurium and what not. There is no reason to believe that -- well, we like to concentrate on the five or six most important radioisotopes as far as consequences are concerned. When you do that you're looking at iodine, cesium, tellurium, vidium -- which one did I forget -- tellurium.

Those are really the significant ones, but at the same time you also get a lot of other things coming out which have much less consequences, which add to the total aerosol behavior and in fact cause things to fall out very quickly.

Studies done in Germany -- this comes out of Karlsruh -- this was a study of a PWR, and this study was for a particular condition in which there was no water present, the so-called dry accident.

MR. CATTON: Is this based on their experimental work where they heated it?

MR. RAHN: This is based mostly on their experimental work.

MR. CATTON: You know, the heating method stirred that so much some of it was literally thrown out.

MR. RAHN: In fact, it may come off even slower than is indicated here.

MR. CATTON: Yes.

MR. BAHN: But in fact there are a couple of points I wanted to make here, the first of which -- as you can see from the bottom, it says time after blowdown. So in fact, it was indicating that it's not until you get something like an hour or more after blowdown that you start getting a significant amount of aerosols coming out.

The second thing that they did here was, they assumed that the aerosol concentration was not that of the pressure vessel, but rather an aerosol that was dispersed throughout the entire containment building. So this is conservative. In fact, if you had a denser aerosol it is likely to fall out even faster.

So that in fact you see that it is only in the period of a couple of hours in here which corresponds to this peak of this curve at which time you are getting a significant amount of aerosol that is coming out. And then it very drastically falls off. So that in fact as far as leakage, what this means by falling off is that in fact you're getting the agglomeration processes operating, and you have settling processes.

Again, this is a calculation of dry containment. So that the time over which you have a significant risk associated with these aerosol fission products is only a matter of a few hours. The accident may go on for many days. But in fact, the period of risk is confined to several hours.

In fact, if you do get an overpressure condition from the lack of the containment being able to contain the pressure generated from overpressurization and steam, that probably, according to the German study, could not occur for a period of several days, let's say 50 or more hours. By that time the amount of aerosols likely to be bouncing around the containment are so low as to be negligible in terms of risk.

I'd like to go back --

MR. LAWROSKI: Is there apt to be any fractionation?

MR. RAHN: Of aerosols?

MR. LAWROSKI: Yes.

MR. RAHN: More than likely, what will happen is they will agglomerate together without very much detail.

MR. LAWROSKI: You don't think decomposition --

MR. RAHN: There may be some small chemical reaction, but I doubt whether there would be much differentiation.

MR. LAWROSKI: Fractionation, not differentiation.

MR. RAHN: Fractionation.

MR. LAWROSKI: I just want to know.

MR. RAHN: Especially at densities which are really of interest, and by that I mean densities in excess of 100 grams per cubic meter, maybe even exceeding a kilogram per cubic meter. These are very impressive densities.

I would like to go back to a study that was done by Battelle Northwest Laboratories in 1970. It was referred to earlier today by some of the people from the NRC. This is the containment systems experiments, the so-called CSE experiments done by Bob Hilliard and others. This is a fairly large-sized containment building. You can see the diameter of 7.6 meters, 150 cubic meters volume.

And what this is showing is an experiment or a series of experiments that were done back at this time, where various fission products were injected into the containment and driven by a substantial amount of steam throughout the containment, circulated throughout this volume, and measured by a variety of measurement techniques indicated by these squares as to what the concentration was and the behavior of these fission products.

Now, at this point I would like to specifically call to your attention the fact that there were two lower chambers, called the middle room, which was this one here, and the lower room, which was this one here, which really haven't been paid very much attention to, although measurements were made down in those areas. I'm going to come back to that point in a few minutes.

One of the significant points is that there is an opening between these chambers, specifically this opening here, which is a four-foot diameter opening; another four-foot diameter opening down here, which effectively connects the two chambers.

MR. CATTON: That is a well-mixed chamber.

MR. RAHN: That is a very well-mixed chamber, because of the driving power of the steam.

MR. CATTON: Where was the steam condensing?

MR. RAHN: Basically in the pools.

MR. CATTON: In both pools?

MR. RAHN: Some of it was condensing back in here because this was a closed vessel, sort of trying to simulate a pressure vessel. The rest of it dripped down the walls and ended up in the sump.

MR. CATTON: Was there a cooler in the sump?

MR. RAHN: No cooler in the sump. In fact, the entire pressure vessel was heated and thermally insulated to keep it at a warm temperature.

MR. CATTON: So just driving the temperature up caused the condensation.

MR. RAHN: I was going to make a comment on the fission products. In fact, back in those times nobody was really thinking too much about cesium iodide, so we decided to do this test using elemental iodide, cesium oxide, UO-2 melter. And in addition, just to make sure that everything was not in a reducing atmosphere, but rather in an oxidizing one, you can see that air was used to transport the elemental iodine and cesium oxide over the heater.

In fact, the whole tube here was trace heated in order to keep the temperature very high, so that -- in an attempt to deliver all of the iodine or all of the cesium and all of the uranium to the chamber. And they produced iodine in molecular form, iodine particles, cesium particles, uranium particles.

But what is significant is that in fact, in spite of all of the efforts taken to deliver 100 percent of the iodine and 100 percent of the cesium to the chamber, nearly 35 percent of the iodine never was able to get out of the generator and over two-thirds of the cesium never made it out of the apparatus -- something that is always overlooked when people look at these types of experiments.

MR. KERR: What is the significance of that result?

MR. RAHN: I'll tell you one direct significance. We talked a few minutes ago about check valving as being a significant scenario in terms of WASH-1400. Check valving in fact is almost a direct analogue in many ways to this, where you have a relatively small line, which is an ECCS line going outside containment down a long length of pipe. In fact, there is almost no attenuation in the WASH-1400 for that type of scenario.

In fact, if you get a very oxidizing condition, which would not be necessarily the case, you would have significant playout of the iodine and the cesium down that line, which was never recognized in the study.

MR. KERR: Was this experiment examined in enough detail so that you determined that was the reason the iodine was not getting out, and it wasn't just a failure to heat it hot enough or something?

MR. RAHN: They tried their darnedest to do whatever needed to be done.

MR. KERR: Did they actually look and find play-out?

MR. RAHN: They actually looked at a mass balance and did a rather good mass balance in this instance.

MR. KERR: I am not asking the question very well, I guess. If the iodine doesn't get into the chamber, it seems to me it could be because it never did leave the original receptacle or because it got taken out somewhere along the way.

MR. RAHN: The mass balance only was the amount of iodine that left the receptacle or the amount of cesium that left the receptacle.

MR. KERR: You did have a way of finding that it was out of the receptacle?

MR. RAHN: It was out of the receptacle. It was between the receptacle and the wall of the chamber.

MR. LAWROSKI: The receptacle being over here on the left?

MR. RAHN: Here and this and this.

MR. CATTON: Somewhere in the pipe?

MR. RAHN: Yes.

MR. CATTON: Did they look?

MR. RAHN: Yes.

MR. CATTON: And they could see it?

MR. RAHN: Yes.

What happened in the chamber -- now, remember again, it was a highly oxidizing environment.

MR. CATTON: One thing. Did they mention the temperature of the pipe?

MR. RAHN: I don't know the answer to that.

MR. CATTON: What was the steam temperature?

MR. RAHN: They trace heated the pipes.

MR. CATTON: That still doesn't tell me what the temperature of the pipe or the steam was.

MR. KERR: They should have measured it.

MR. CATTON: Right.

MR. RAHN: In fact, I don't personally -- possibly it's in the report. I could go back and ask them, but they did go to substantial lengths to try and maximize the amount of iodine and fission products that were delivered out down in that system.

Now this is the type of thing that never gets factored into any of the models, and in fact it's highly significant that you cannot do something like that.

What else did they find in this experiment? They found, for instance, that in the gas phase, again iodine being produced and generated as molecular iodine, not as cesium iodide or some other form of iodine, but in the gas phase within a couple of hours the gas phase concentration dropped down by a factor of roughly 100.

The iodine went into two places. Most of it went into the surfaces and the liquid form that formed on the outside of the containment -- I'm sorry, the inside of the containment building -- and dropped down eventually into the vessel sumps. As you can see, over a period of time the iodine in the vessel sumps was building up and the iodine on surfaces and in liquids tends to be tailing off.

MR. KERR: How many times was the experiment repeated?

MR. RAHN: There were roughly 15 different experiments in that series at different concentrations.

MR. SHEWMON: Do all of those three lines show there were 100 percent in each?

MR. RAHN: Yes. I haven't personally checked that, but I believe that was it.

Questions?

MR. SHEWMON: I just wondered whether surfaces and liquid films are still out of the pipe, but on the walls someplace.

MR. RAHN: That's right. Now, what this diagram shows, it adds up to 100 percent. But that means 100 percent of what was actually delivered outside the pipe.

What is more revealing -- and this is something that no one has ever taken into account in their modeling -- is the fact that -- remember those bottom rooms? That is, the middle chamber and the lower chamber that we spoke about before. They also took some data down there, being good experimentalists. And here is some data of the concentration of total iodide in various of the rooms. And perhaps this one down in the corner may be typical. That is perhaps the one I can best read. The others are not all that different.

MR. LAWROSKI: Which corner?

MR. RAHN: I was looking specifically at this, but I think the rest show the same thing, that in fact there is at least a factor of ten difference in concentration at any time between what appeared in that upper room and what appeared in the middle room, and even a higher attenuation as to what happened in the lower room.

Now, just gravity settling, which is one of the primary mechanisms for the plate-out, you would have expected much more to have ended up in some of those lower chambers. They have data which is similar to that for cesium, cesium in the gas space.

I won't run this too much longer. But you can see basically the same type of thing, that in the lower rooms you never get to within a factor of 20 or so of what the concentration was in the main chamber in the top.

This goes to show that any aerosol concentration type calculation that one were to do, you had better take into account that there are multiple chambers in any reactor containment building, and it is very important that you not take the containment as being in one room, but you have to take into account the fact that you have various concentrations in various rooms.

Again, that is not usually accounted into various calculations.

MR. CATTON: Were these sprays on?

MR. RAHN: No. There were two series, one with sprays on and one with sprays off. I have the results here somewhere. I'll have to go back. I don't have the paper with me. It's in my hotel room.

MR. LAWROSKI: Where it says cesium, is that elemental cesium or is that cesium oxide?

MR. RAHN: Cesium oxide.

MR. SHEWMON: I think maybe you can settle a point for me. Is it going through the door that it gets trapped, given it's here?

MR. RAHN: The point I'm trying to make is that there are significant concentration differences between chambers, and this is not usually taken into account in mechanistic models that are used. And it makes a big difference, factors of ten or more.

Well, some additional selected conclusions of this experiment. There are many other conclusions which you will read in the report, which I think most people are aware of. These are some of the surprising ones which I pulled out, which I feel are very relevant in some ways, some of which we've already talked about.

The first one we talked about, that in spite of attempting 100 percent release, an average of 28 percent of the iodine and 67 percent of the cesium were retained in the release apparatus and injection lines.

The next point we haven't spoken about yet, and that is the leakage tests show that the containment atmosphere leaks diminish significantly in steam-air atmospheres. One of the things they tried to do is to see what will happen if you had a leakage in the containment building, where they deliberately introduced a leak path and saw what came out.

And in fact, what happens is at the point where the leak path or the penetration through the containment building exists, you get condensation of moisture, which in fact or in essence acts as a scrubbing mechanism for taking out whatever iodine in molecular form or cesium in molecular form, aerosol form, might be coming through that penetration. Again, a conservatism which does not appear in most of the safety studies.

They found that 15 percent of the cesium remained on the paint. 85 percent was in the condensate. In a typical reactor building, you have 60 tons of paint covering various surfaces. You only have a few kilograms of cesium.

Coming back to a point that was a question to, I believe it was, Mel earlier today, what they did was, at the leak path they collected the condensate, they took this condensate, they put it on a hot plate, boiled it dry. When they did that, in spite of the fact that again you are introducing molecular iodine into the chamber, you found out that 94 percent of the iodine remained behind at the bottom of the beaker; 99 percent for the cesium.

So what that is indicating is that whatever happens inside the chamber, the iodine and the cesium are no longer in volatile forms.

MR. UNDERHILL: What temperature was it heated to?

MR. RAHN: It was condensed and it was heated to 100 degrees Centigrade, just boiled away.

MR. CATTON: All of this is relatively cool.

MR. UNDERHILL: That is the point I wanted to make.

MR. RAHN: If you get up to several hundreds or thousands of degrees Centigrade, again you might revaporize it. But the fact is, in a reactor accident if you had penetration of containment building, those surfaces are going to be cool.

MR. CATTON: They're going to get cool.

MR. RAHN: They will be cool.

MR. CATTON: Not immediately.

But also, if you boil the water off after you get the iodine in it, it has to be in it some time or else apparently you release it as you boil it.

MR. RAHN: Say that again?

MR. CATTON: There's some sort of a process that takes place. Don't you form hydrides or something? And these don't get boiled off. The molecular iodine does, and that takes time, and apparently it takes hours.

MR. RAHN: Well, they did this relatively soon after they finished collecting it. It was a matter of a few hours.

MR. CATTON: There is a paper in the same journal you were referring to that discusses that.

MR. LAWROSKI: You told me that this was not by difference. Getting back to your figure 8, either when this is Xeroxed the data points disappeared -- but I see no data points.

MR. RAHN: I believe I made a correct statement, but maybe I better go back and check it.

MR. LAWROSKI: Well, they should have showed it. They might have wandered around a little bit. I would understand that. But I see none.

MR. RAHN: It may have been a good point. I may have misstated it.

MR. KABAT: The 94 percent of iodine which remained in that phase, that was established under equilibrium conditions or you were venting the space?

MR. RAHN: It was vented. It was a large beaker in which the condensate was placed. It was put on essentially a hot plate, brought up to boiling conditions. All the water was boiled away. A residue remained in the bottom of the beaker and they measured.

MR. KABAT: For how long a period of time?

MR. RAHN: How long was it boiled away? I don't know exactly, but on the order of an hour or so.

MR. KABAT: On an order of an hour? You confirm that because it pretty well agrees with the results of our measurements?

MR. UNDERHILL: I don't think there would be any compound of cesium that would be volatile at these low temperatures, would there?

MR. RAHN: No.

Some other aerosol experiments were done, this time at HEDL. This is the HTCA, which is the basic facility, HTCA standing for high-temperature, high -concentrate aerosol experiments. And what happened here is essentially a crucible of uranium oxide was heated to the high temperature, producing a dense aerosol. The aerosol conditions were such that the concentration down here was .23 kilograms per cubic meter. That's 230 grams per meter.

And this is the result. Now, what you see here is essentially a distribution curve. The fact that you have one component of the aerosol which seems to be decaying very rapidly, and another component of the aerosol which seems to come out in a very much longer period of time.

Now, this type of behavior you don't normally see in experiments. The reason you don't see it is that all of this is occurring within 12 seconds, and it is not normal to sample aerosols in such a rapid time frame. In fact, the sampling was done every three seconds, and you saw behavior like this.

What this is essentially saying is that within ten seconds or so everything is over concerning roughly 90 percent of the aerosols. You start off with an initial concentration, very quickly drop down to a very low concentration.

The question is, why does that happen? Well, the reason is that they looked at some of the samples, and this is what they saw. This is the aerosol collected, very clearly bimodal in the sense that you have one very large particle, which exceeds 300 to 500 microns in diameter, and a whole bunch of other particles which are relatively small, in the range of 10 or less microns.

Now, as far as the mass is concerned, most of the mass is in this single particle. The rest of it, a rather small fraction of the mass, is in the small particles. Again, those large particles dropped out in the first ten seconds.

MR. SHEWMON: What was in the tank?

MR. RAHN: Essentially it was a crucible of uranium oxide very rapidly brought up to much in excess of 2,000 degrees Centigrade, just to see what would happen.

MR. SHEWMON: And that is the boiling point of uranium oxide?

MR. RAHN: Well, uranium oxide boils at in excess of 2800 degrees.

MR. SHEWMON: Well, then what, this is just evaporation?

MR. RAHN: Essentially evaporation. They used an arc to produce the high temperatures.

MR. SHEWMON: So it splattered big pieces and the rest vaporized in the arc and condensed, maybe?

MR. RAHN: Well, by and large, I don't think there was very much splatter.

MR. CATTON: The arc splatters.

MR. RAHN: The arc splatters, but this was away from the arc, or otherwise they would have destroyed their samples.

MR. SHEWMON: Okay.

MR. RAHN: Well, in conclusion -- the hour is getting late. I'd just like to say that we agree with the staff that there are a number of significant isotopes and aerosol behaviors which are important in the source term contribution, and in fact things like tellurium, ruthenium, et cetera, are equally important as iodine. And we want to call people's attention to the fact that iodine is not the entire story that affects the aerosol behaviors; the other isotopes are very important to consider, and they represent roughly 50 percent of the total risk and I should say the consequences as far as early fatalities are concerned, and a much greater fraction in terms of late fatalities.

The second point we want to make is that there is significant experimental data which exists, the details of which are overlooked very often when people put together various of the computer models which then go on to estimate what the consequences of risk are.

What we feel should be done and is most important is to go back and look at these experiments in some detail and pick up these points and put them in the codes. Now, this is relatively easy to do in the sense that it does not take a very large experimental program that one has to crank up to assemble all the data. Just simply putting what we know into the codes will make very large differences as far as what we perceive the risks and the consequences to be.

This does not necessarily mean that we will answer all the questions. It will in fact uncover a number of questions. But simply the reduction in consequences while putting in what we know will be quite significant in terms of what our actions are likely to be in terms of evacuation, siting policy, et cetera.

The last point I wanted to make is, if additional research is to be done, what shall we look for in terms of what you would have for a good experiment or for a good computer code? I have put down a couple of the criteria.

The first one for the experiments, the first one might be surprising: The instrumentation must handle particle sizes greater than 10 microns. It turns out that most of the experiments, most of the apparatus can only handle relatively small-sized particles. And if you have a single particle of several hundred microns which contains moset of the mass, which is not able to be measured, in fact you are missing very important experimental data.

The second is the aerosol density should extend the range upwards from 100 grams to one kilogram per cubic meter. It is very important that high concentration experiments should be done.

The next point is that the measurements should be made immediately after the start of the experiment. As you can see from a couple of graphs ago, the first ten seconds are extremely important in terms of aerosol behaviors. And the experiments on which the models are based have not made measurements in short time frames. It is very difficult to do, but it is very important to do.

The next point I think is widely recognized now: that no quartz be used in fission product release experiments. In fact, there is an interaction between iodine and quartz and cesium iodine and quartz which can produce things like cesium silicate, and you get molecular iodine out.

MR. LAWROSKI: As well as a few other materials.

MR. RAHN: And a few other materials. But the quartz is a no-no.

And the last point is that compartment data is required. It is not enough to have an experiment in a single compartment. In fact, you saw by the HEDL experiments that in fact we can get two orders of magnitude difference in what happens in adjacent compartments, even with rather large penetrations.

Now, codes. The codes must treat high concentrations correctly up to one kilogram per cubic meter. No code that I know of today does this.

MR. SHEWMON: How far do they go?

MR. RAHN: If you get up much beyond ten kilograms per cubic meter, then you start to stretch most codes.

MR. CATTON: Don't most codes treat the aerosol without the affect of the aerosol on the flow, or is that a problem?

MR. RAHN: That is another problem.

MR. CATTON: They don't treat it with an effective density. If it's air, they solve the air problem, and then they put the aerosol in and then look at where it goes. Is that a problem?

MR. RAHN: No, that is another problem. The mere fact that you will have a high flow field to drive the particles together and they would agglomerate imperfectly. But just the fact that you had a relative quiescent system and there's not a lot of gas -- if you had concentrations of around one kilogram, you are getting into different behavioral regimes in terms of the way the aerosols interact and time scale is important, which is the last point, you know, which none of the codes currently treat.

MR. UNDERHILL: Did you mean ten milligrams or ten grams per cubic meter?

MR. RAHN: Ten grams.

MR. UNDERHILL: You said milligrams.

MR. KABAT: Is it feasible to evaporate so much material as to get one kilogram as a practical consideration?

MR. MOELLER: You couldn't walk through that.

MR. RAHN: That is exactly the point. The codes predicted this, and in fact it never happens. When you start arriving at these high concentrations, they fall out so rapidly. You are not talking about -- Mr. Kelber disparagingly talked about what we referred to as rocks, but in fact you're talking about rocks, they would fall out so rapidly.

MR. LAWROSKI: You want a code that'll treat such concentrations.

MR. RAHN: We want a code that'll treat aerosols' behavior in high concentrations.

MR. SHEWMON: Call it sand the next time and maybe Charlie will be happy.

MR. RAHN: Again, the code should reproduce the experiments correctly, including multi-compartment tests. And another important point is that the code should handle bimodal particular distributions. That is, the large particle sizes as well as the small particle sizes.

At best, what is happening today in some of the codes like TRAP is that in fact they try and handle this by using a single modal distribution, which puts too many particles in the intermediate size and not enough in either end. And this is a serious mistake.

MR. LAWROSKI: You all are talking about the cubic meter there being the gas phase.

MR. RAHN: That's right, aerosol and the gas phase.

MR. SHEWMON: Sir, I think you have many points. My personal opinion is that that bimodal business is probably just particulate stuff being splattered out, unless you have good ideas as to where it comes from. I don't think it does your case really much good. That is a personal question for you to consider.

MR. RAHN: Well, let's go back and look. In fact, I'm not the world's expert on this. I'm just bringing to your attention various points. But if you inspect --

MR. MOELLER: Either way is okay.

MR. RAHN: You can see it's unlikely that this would be a splatter particle, because if it were it would tend to be much more spherical than it exists here. And this reproduction isn't particularly good, but you can almost look through it in terms of -- it tends to be more like a spiderweb rather than a solid coalesced particle.

So in fact the process that's occurring is much more likely to be an agglomeration with very filmy arms coming out, rather than a splatter particle.

MR. ETHERINGTON: The UO-2 is at 2,000 degrees and then an arc was struck; is that how it was produced?

MR. RAHN: At 2,000 degrees.

MR. ETHERINGTON: And then you struck an arc?

MR. RAHN: The arc was used to heat it above the aerosol temperature.

MR. ETHERINGTON: Well, that took it way above 2,000 degrees.

MR. RAHN: That's right.

MR. SHEWMON: You might go ask somebody to give you some pictures of what is called "splat cooling."

MR. RAHN: You mean like in solder?

MR. SHEWMON: Well, somebody down at Cal-Tech made a career out of it and got several prizes out of it.

MR. RAHN: It gets thin, but it doesn't tend to be very splattery. Again, this is the type of point we're raising that we think should be investigated.

What we are suggesting is that in fact the first thing to be done is to go back, examine the existing data, rather than embark on -- I would think that if you do so, just looking at the experiments that are done and very closely scrutinizing the conditions under which they were dne, you will get some rather surprising results, which if they were then factored into some analyses such as WASH-1400 would produce reductions in consequences an order of magnitude, two orders of magnitude lower than what we have today. And these are very important for policy considerations.

I just wanted to finish up with a rather facetious point, if I might. We're all familiar with the story about the Dutch boy who, on walking by the dike one night, hears the rushing water coming out. And the first thing you know -- this particular Dutch boy wasn't the most intelligent one, but he rushed over and put his finger in the first hole he saw. Unfortunately, it was a hole in a tree and didn't solve the problem.

The point here is that if you want to solve the problem, first you have to know what it is.

Mr. Chairman.

MR. MOELLER: Thank you.

Are there any questions for Mr. Rahn?

MR. LAWROSKI: Do you have any comment about some of those high numbers that were in that attachment of Mr. Zebrowski's to Chairman Ahearne that I referred to earlier today?

MR. RAHN: Well, one of your comments was about the aerosol leaking out.

MR. LAWROSKI: I didn't call it aerosol. Just the fact that four percent of the iodine was in the containment. It was not a dry situation.

MR. RAHN: Simply, if you reduce it from 25 percent to 4 percent, that's almost an order of magnitude right there. I really don't want to comment.

MR. LAWROSKI: Yes, but gee, that's like picking my accident in a way, isn't it?

MR. RAHN: The other thing we suggest is you go back and look at all of the accidents. There's a myriad of data from the accidents that exist.

MR. LAWROSKI: But you can't keep changing the design.

MR. RAHN: Some of the accidents give you quantitative data, some only qualitative. You can go back. You know, you're suggestion about the new processing plants, that's excellent, because there's any amount of data that shows the behavior of various fission products during reprocessing. This is something that can be done.

So the point to start at is going back and looking at the existing data.

MR. LAWROSKI: My point was that, you know, just taking it at random from a document that is supposed to support a case to get the thing reduced by a factor of 100, when I see something that are just two pieces of data that limit it to a factor of 5 to 20 -- you know, a few more examples.

MR. SHEWMON: That is going through one step, and his point is it has to go through several to get out.

MR. LAWROSKI: No, this is in the containment, I recognize that.

MR. RAHN: You have to look at all of the details of the particular accidents, go through it and then see what you can extrapolate to a real situation.

MR. MOELLER: Mr. Sun?

MR. SUN: In your paper you say instrumentation must be able to handle particle sizes greater than ten microns. I presume you must be counting the particle size. Can you be more precise? What is average sizes, diameter, and what is the standard deviation for that kind of measure?

MR. RAHN: It depends on the experiment. You can see from that chart I showed, where you have the one large particle of several hundred microns and the others are much smaller sized. In fact, the standard deviation and the average are meaningless in that situation.

MR. SUN: Okay, thank you.

MR. MOELLER: Are there other questions or comments?

Dr. Bellamy, do you have any questions or comments at this point?

MR. BELLAMY: No, sir. The only thing I'll do is I'll note that I will take an action. I will make sure that I myself review the two staff reports before they're issued.

MR. MOELLER: Do you all -- did you have a question?

MR. WALKER: Yes, I really do, more a comment.

MR. MOELLER: It's D. Walker.

MR. WALKER: Yes.

I think before we criticize the way the data has been handled, we ought to be familiar with how that data has been handled. You know, I find it rather disturbing to note that the data that was illustrated was the CSE natural circulation data. Those data in fact were the basis for the models that were used in WASH-1400.

There is a fairly extensive review paper published by Postman on how the data was used, about four years ago. In addition, the stuff in the lower compartments -- I think it is important to recognize that the coral models do indeed take into account those compartments.

One of the problems in the WASH-1400 calculations is it was difficult to get exchange data, the gas exchange data between the compartments. As a result, a very high exchange rate was assumed, and if anything that is one area that the WASH-1400 calculations are not conservative in. So that is the very data that was used in the WASH-1400 models.

MR. RAHN: I might make a comment on that --

MR. SHEWMON: Let me clear up for clarification --

MR. LAWROSKI: You are referring to his CSE data?

MR. WALKER: CSE, the next picture over.

MR. SHEWMON: His point was that experimentally they found there was a substantial difference between the concentrations in the successive chambers. Now, high exchange rates I guess means that there's a fair amount of turbulence in the gas?

MR. WALKER: They mix very rapidly. That was what was assumed in WASH-1400. Very high exchange rates were assumed.

MR. SHEWMON: Did WASH-1400 also reproduce the data that there was an order of magnitude drop from one chamber to the next?

MR. WALKER: I don't think WASH-1400 would do that. The way the WASH-1400 calculations were done, the concentrations between the compartments were callibrated very rapidly. There was probably a nonconservative error in WASH-1400.

MR. SHEWMON: Okay. I didn't know how to interpret conservatism or nonconservatism. You are saying WASH-1400 would not reproduce the data and the trapping that he pointed out?

MR. WALKER: No, it puts the stuff into those extra compartments more rapidly.

MR. SHEWMON: Thank you.

MR. RAHN: The only other point I was going to make, I spoke to Bob Hilliard from HEDL a few days ago and asked him specifically what use that he made of that lower chamber data. And he said I was the first person who ever asked him about it since the experiment was run. So since he was the principal experimenter, I doubt whether that factor ever entered into --

MR. WALKER: I agree. But the upper compartment did.

MR. RAHN: But the other points about what remained behind in the injection system or a number of other points in fact were not.

MR. MOELLER: Dr. Campbell, did you have any questions or comments? We didn't mean to ignore you.

MR. CAMPBELL: Well, I might comment on the same point, because I've also talked to Hilliard about it. The point that you were making on the 96, 94 percent business, I think that you're trying to get far too much information out of a very qualitative test.

What he was simply trying to do was to show that it wasn't the same kind of iodine that went in. It wasn't molecular iodine, which went in, which was volatile. And I think he just took the water and boiled it down and determined the activity left in the beaker, and it came out 96 percent. That is probably plus or minus several percent.

He didn't trap what was lost; he measured what was left. So there could be a material balancing. So I think it splattered out, a little bit of it.

I think it is a very qualitative test. You shouldn't try to interpret what you are trying to interpret out of it.

MR. LAWROSKI: I agree. But on the other hand, I would have thought that sending something up to a Commissioner, who really doesn't have the time to go and look at the conditions of the experiment, let alone even the staff --

MR. CAMPBELL: The purpose of it was to show that the iodine wasn't volatile, like molecular iodine would be.

MR. RAHN: That is a different point.

MR. CAMPBELL: And that is all the purpose was.

MR. LAWROSKI: I don't make a case that it's got to be molecular iodine. If certain iodine gets in the containment, whatever form it's in, that counts. We should, of course, though, ascertain if we're going to use the term molecular iodine, that it is that.

That's the trouble with some of the papers I've read. The authors who have drafted papers have used "iodide" and "iodine" very loosely in what purports to be a scientific paper. It has to be one or the other, you know.

MR. CAMPBELL: Could I also --

MR. LAWROSKI: He has the best chance to know, the writer.

MR. MOELLER: Go ahead, Dr. Campbell.

MR. CAMPBELL: I would like to also very briefly comment on I believe the first question raised, going back after lunch, about the precursors, namely tellurium. The conclusion drawn from that, I believe, is not correct, namely that since two or three percent of the iodine is in the form of precursors it is only a maximum of a factor of 40 change, whichever form the iodine is.

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

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in the matter of: ACRS-SUBC. ON REACTOR RADIOLOGICAL EFFECTS

Date of Proceeding: February 5, 1981

Docket Number: ____________________

Place of Proceeding: Washington, D. C.

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

Alfred H. Ward

Official Reporter (Typed)

Alfred H Ward

Official Reporter (Signature)

INTRODUCTORY STATEMENT BY CHAIRMAN

Dr. Dade W. Moeller

SUBCOMMITTEE MEETING

REACTOR RADIOLOGICAL EFFECTS

The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Reactor Radiological Effects.

I am Dr. Dade W. Moeller

The other ACRS Members present today are: Dr. Stephen Lawroski, Dr. William Kerr, Dr. Paul Shewmon, Mr. Harold Etherington.

Also attending will be ACRS Consultant, Dr. Ivan Catton and Invited Experts Warren Grimes, Milo Kabat, Dwight Underhill, ACRS Fellow Mr. Casper Sun and R. Bellamy and W. Gammill of the NRC Staff.

The purpose of this meeting is to discuss the accident fission product source term, particularly for iodine, used in the regulatory process for designing, siting, and planning for emergencies at nuclear power plants.

The meeting is being conducted in accordance with the provisions of Federal Advisory Committee Act and the Government in the Sunshine Act. Mr. John McKinley is the Designated Federal Employee for the meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on January 21, 1981.

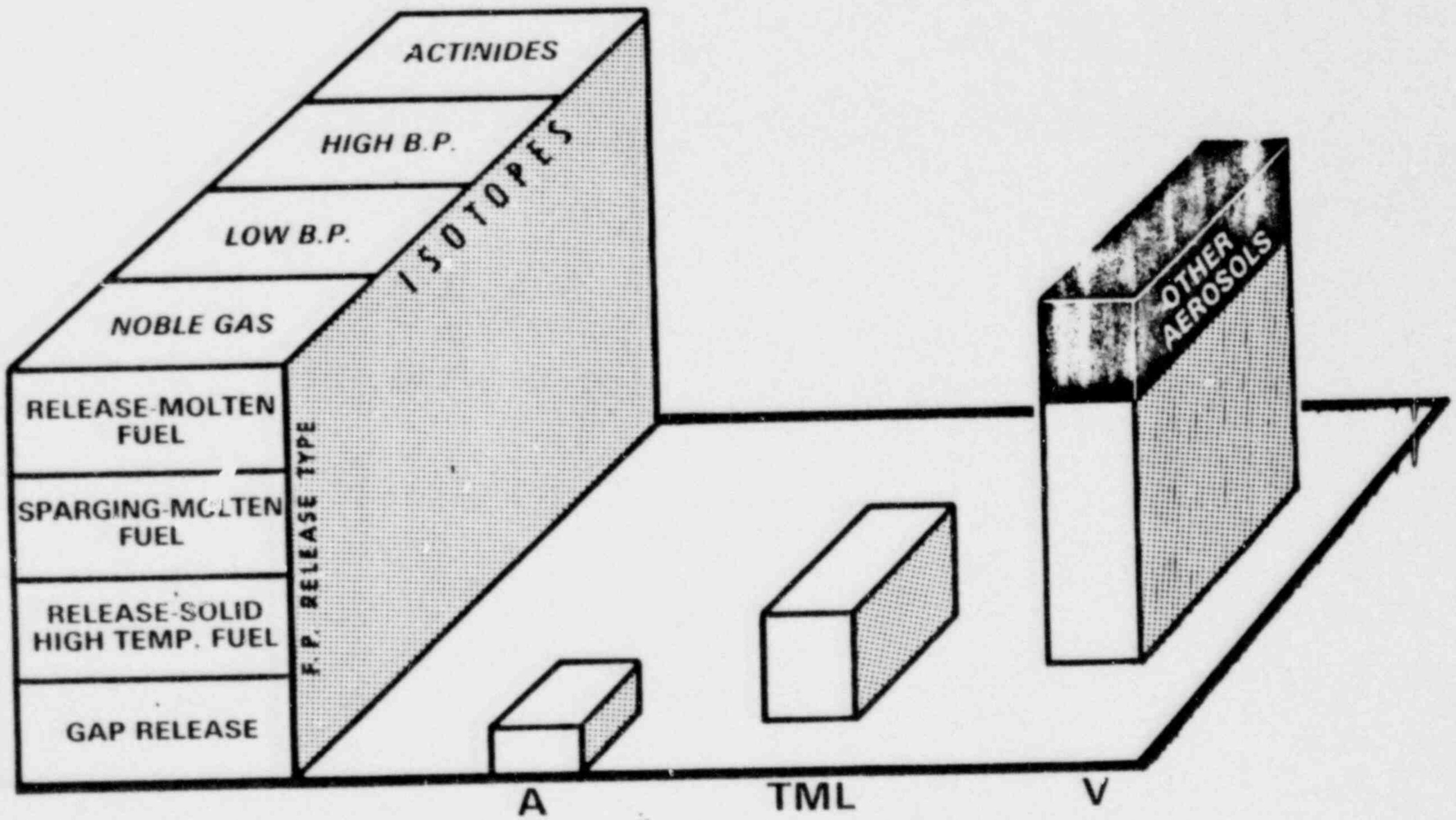
A transcript of the meeting is being kept, and it is requested that each speaker first identify himself and speak with sufficient clarity and volume that he can be readily heard.

We have received no requests for oral statements from members of the public. We have received no written statements from members of the publ .

We will proceed with the meeting, and I call upon Dr. Charles Kelber of the NRC Staff.

KELBER

ACCIDENT SEQUENCE



STATE OF TECHNOLOGY REPORT ON RELEASE OF FISSION PRODUCT IODINE

(SOTRI)

OBJECTIVES

- PROVIDE COMMISSION WITH BEST AVAILABLE TECHNICAL BASES FOR JUDGMENTS INVOLVING TREATMENT OF ENTIRE RANGE OF CORE DAMAGE ACCIDENTS IN THE REGULATORY PROCESS
    - REGULATORY REQUIREMENTS (EFFECT ON ESFs)
    - REASSESSMENT OF ACCIDENT SOURCE TERMS
    - RULEMAKING (DCC, EP, MESF, SITING)
- DISPASSIONATE REPORTING OF FACTS AND TECHNICAL BASES (AND THEIR LIMITATIONS) TO BE USED BY OTHERS FOR DECISIONS.
- REALISTIC CONSEQUENCES OF IMPORTANT ACCIDENT ENVIRONMENTS

STATUS REPORT

STATE OF TECHNOLOGY REPORT ON RELEASE OF FISSION PRODUCT IODINE

M. SILBERBERG, RES

FEBRUARY 5, 1981

December 11, 1980

STATE OF TECHNOLOGY REPORT ON RELEASE OF FISSION PRODUCT IODINE

OBJECTIVE

The objective of this report is to provide the Commission with the best available technical basis for judgments related to the possible exposure of the public to radioactive iodine following a serious reactor accident. Such judgments are needed with respect to features of emergency plans and assessment of current sites, in the Siting rule, in the interim Minimum Engineered Safety Features rule, in Enviornmental Impact Statements, and in the Degraded Core Cooling Rule.

The perception of need for this report was precipitated by recent expressions of industry concern that the methodology of TID 14844 is very old (1962) and does not reflect near-term experience. On behalf of potential applicants, EPRI claims that recent experience, especially at TMI 2, indicates that iodine is a much lower potential hazard than current Guides and Standards indicate.

Past regulatory staff practice has treated severe accidents involving the potential for core damage from three distinctly different aspects:

1. The release fractions for Part 100 analyses were based on a presumption of substantial core melt to define a single limiting case accident as a basis for a highly stylized analysis on which to make a judgment of site acceptability. Since Part 100 provided for offsetting unfacorable site characteristics with engineered safeguards, these release assumptions came to be used as the design basis for some, but not all, safety-related systems. As this practice evolved, the assumed iodine releases into the containment atmosphere were recognized as being highly conservative but this was felt to compensate for the uncertainty in, and possible nonconservatism of, the release fractions assumed in for fission products other than noble gases and halogens.

2. Independently of the foregoing, a design basis was established for control of hydrogen evolved by metal-water reaction based on an assumption of localized overheating of the core, but not melting. This basis was modified (reduced) some years after the issuance of Appendix K to Part 50, but still assumed localized overheating.

3 The increased thermal margins provided by Appendix K led to the definition of design bases for many systems, particularly for auxiliary systems, which by assuming no core damage down played the safety significance of those systems or understated the service conditions for which they should be qualified.

The Commission, in its degraded core cooling and related rulemakings, has undertaken to address and rethink in a systematic manner the basic issue of how the whole range of accidents involving core damage is treated in the regulatory process.

This report is to be a dispassionate reporting of facts and available bases for informed judgment; the judgments themselves will be made by others.

ENCLOSURE 1

OUTLINE

STATE OF TECHNOLOGY REPORT ON RELEASE OF FISSION PRODUCT IODINE

CHAPTER	TITLE	LEAD ORGANIZATION
SUMMARY		RSR, NRR

Are there clear indications that iodine is always or predominantly released in aqueous solution with Cesium as CsI? Are there different release characteristics for different plants or different accident sequences? If so, what are they? What actions are indicated with respect to ESF's? That is, is any change indicated to current ESFs so they may function better as intended? If iodine is not likely to be controlling, what are reasonable candidates for controlling features, taking into account effects of aerosol depletion? *

1. Fission Product Formation — BCL

   Describe briefly the fission product formation in fuel, and the mode of release from fuel. Put boiler plate, detailed tables in appendix. Describe biological effectiveness of key fission products.

2. Accident Sequence Characteristics — RES/SRR

   Develop details of accident sequences that determine the iodine environment, rank according to likelihood for various plants. May require help from SASA. A plant layout diagram such as that used in the Rogcvin report will be included as background and for use with sequences. Physical and chemical environments for the sequences will be included.

3. Fission Product Release from Fuel — ORNL (ANL, EGG)

   Describe past, current evidence and modes of analysis for F.P. release from fuel. Is the release a function of the accident sequence? E.G., in high pressure sequences with little clad oxidation, much eutectic formation, is release expected to be different from low pressure failure with much oxidation, ballooning? (See NUREG/CR-1715.) Include: (I) release vs. Temp. Time; thermochemical data within the fuel and input from ANL and EGG f.p. related work.

4. Chemistry of I, CsI — SNL (ORNL)

   Describe basic chemistry of I and CsI as in Malinauskas, Campbell talk to staff, treat aqueous chemistry of I in light of expected

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* To the extent that time permits, information should be included on release (Chapter 3), transport and distribution (Chapters 4, 6), and ESF loads (Chapter 7) for other significant isotopes (e.g., Cs, Te, Ru, etc.)

water conditions in primary, secondary, aux. bldg. systems. Input on aqueous chemistry from ORNL and possible input from contact with Savannah River Lab.

5. F.P. (I) Transport in Primary System to Containment BCL/Sandia

Briefly describe TRAP-MELT Code, perform sensitivity analyses (TRAP) on I_2 vs CsI in primary and report results. How sensitive to sequence characteristics (Consider TMLB', S_2 D, AD, for example)? Are there differences between plant types? Most probable physical and chemical form of I entering containment for sequences (Sandia expedite tests on CsI in Air + Steam, Reducing).

6. Expected Transport and Leakage Behavior of Iodine ORNL/BCL

BCL analyses of aerosol effects in containment for likely sequences (HAARM/QUICK). Use Sandia results as available to determine iodine form term available for behavior in containment and for leakage via air from containment. Different w/wo core melt? Determine I distribution in containment (airborne, settled, slated, deposition in ESF, sumpwater) vs. Time. Are aerosol effects important ex-containment? Comparisons with CORRAL will be included for cases involving I_2. Thermochemical behavior of CsI during H_2 burn will be addressed.

7. Effect of Accident Loads on ESF's NPR (BCL/ORNL)
ESF's include: containment leakage, control of aux. bldg. leakage via liquid systems, secondary containment systems, charcoal and HEPA filter systems, containment spray and spray additive systems, and MSIV leakage control systems (BWRs).

8. Summary of Areas of Major Technical Uncertainty

9. Conclusions

Appendices.

SOTRI COMPLETION SCHEDULE

o FINAL DRAFT CHAPTERS (HQS.)	02/23
o REVIEW FINAL DRAFT, PREPARE SUMMARY AND CONCLUSIONS (HQS.)	02/27
o INTERNAL MGT. REVIEW	03/04
o NEAR FINAL DRAFT TO ACRS	03/06
o FINAL DRAFT TO PEER REVIEWERS	03/10
o PEER REVIEW MTG.	03/17, 18
o COMMISSION PAPER	03/24

SOTRI STATUS

- FIRST DRAFT REVIEW/COORDINATION MTG. (01/22/23)
- REMAINING DATA INPUTS FOR FOLLOW-ON ANALYSES IDENTIFIED
- ADDITIONAL ANALYSES/EVALUATIONS IN PROGRESS
- FINAL DRAFT STARTED

SOTRI SCOPE/OUTLINE

- FISSION PRODUCT FORMATION (BCL)
- ACCIDENT SEQUENCE CHARACTERISTICS (RES, BCL)
- FISSION PRODUCT RELEASE FROM FUEL (ORNL, ANL, EGG)
- CHEMISTRY OF I, CsI (SANDIA, ORNL)
- F.P. (I) TRANSPORT IN PRIMARY SYSTEM TO CONTAINMENT (BCL, SANDIA)
- EXPECTED TRANSPORT AND LEAKAGE BEHAVIOR OF IODINE (BCL, ORNL)
- EFFECT OF ACCIDENT LOADS ON ESFs (NRR, BCL, ORNL)

INFORMATION WILL BE INCLUDED ON RELEASE, TRANSPORT AND DISTRIBUTION OF OTHER SIGNIFICANT ISOTOPES - AS TIME PERMITS

CHEMISTRY OF IODINE AND CESIUM IODIDE

- VAPOR PHASE (SANDIA)
  - EQUILIBRIUM CHEMICAL THERMODYNAMICS
  - OBTAIN RELATIVE ABUNDANCE OF IODINE SPECIES FOR ASSESSING CHEMICAL FORM IN TRANSPORT CHAPTERS
  - SANDIA / ORNL CROSS-CHECK
  - TE, RU (QUALITATIVE)
- AQUEOUS PHASE (ORNL)

FISSION PRODUCT RELEASE FROM FUEL

- BEHAVIOR OF CESIUM AND IODINE IN FUEL
- FISSION PRODUCT RELEASE EXPERIMENTS
  - OUT-OF-PILE / IN-PILE
  - IRRADIATED
- FISSION PRODUCT RELEASE MODELS
- FISSION PRODUCT RELEASE FROM MOLTEN FUEL
  - VAPORIZATION AND AEROSOL FORMATION
  - IN-VESSEL CORE MELT
  - CORE MELT / CONCRETE INTERACTIONS
- TIME DEPENDENT F. P. RELEASE MODEL
  - ENTIRE SEQUENCE

EXPECTED TRANSPORT AND LEAKAGE BEHAVIOR OF IODINE

SCOPE

- EXTENT OF F.P., AEROSOL REMOVAL IN CONTAINMENT BY NATURAL DEPOSITION AND ENGINEERED PROCESSES
- PROVIDE ACCIDENT LOADS FOR ESF IMPACTS
- VARIOUS AEROSOL TRANSPORT CODE ANALYSES

PARAMETERS

- ACCIDENT SEQUENCES
- CHEMICAL FORM OF I
- F.P. AND AEROSOL RELEASE RATE
- INTERCOMPARISIONS OF CORRAL, HAARM, NAUA

FISSION PRODUCT (I) TRANSPORT IN PRIMARY SYSTEM TO CONTAINMENT

SCOPE

- EXTENT OF F.P. RETENTION IN PRIMARY SYSTEM
- TRAP CODE ANALYSES

PARAMETERS

- ACCIDENT SEQUENCE
- CHEMICAL FORM (CsI, I_2)
- SOURCE RATE

IMPACTS OF ACCIDENT SOURCE TERM CONSIDERATIONS

1. FISSION PRODUCT RELEASE MECHANISMS
   - Fuel Clad Imperfections - coolant activity, spiking
   - Fuel Clad Rupture - gap activity
   - Fuel Melting
   - Fuel Vaporization
   - Explosion - Oxidation
2. ROLE OF RADIOIODINE IN CURRENT LICENSING TREATMENTS
   - Regulations - 10 CFR Part 100
   - Technical Specifications
   - Engineered Safety Features Systems
3. ENGINEERED SAFETY FEATURE CONSIDERATIONS
   - Containment Leakage
   - Liquid Leakage Pathways
   - Charcoal and HEPA Filter Systems
   - Containment Spray and Spray Additive Systems
   - Main Steam Line Isolation Valve Leakage Control Systems
   - Control Room Habitability Systems
4. CURRENT RULEMAKING ACTIVITIES
   - Siting
   - Minimum Engineered Safety Features
   - Degraded Core
   - Emergency Preparedness

EFFECT OF ACCIDENT LOADS ON PERFORMANCE OF ENGINEERED SAFETY FEATURES

- CONTAIN. SPRAYS
- CONTAINMENT RECIRCULATING FILTER SYSTEMS
- AUXILIARY BUILDING FILTER SYSTEMS
- PRESSURE SUPPRESSION POOLS (BWR)
- STANDBY GAS TREATMENT SYSTEM (BWR)
- PRESSURE SUPPRESSION BY ICE (PWR)
- CONTAINMENT LEAKAGE REQUIREMENTS

ACCIDENT SEQUENCES

- SEQUENCES WITHIN DESIGN BASIS ENVELOPE
- SEVERE CORE DAMAGE SEQUENCES
  - DEGRADED CORE SEQUENCES
  - CORE MELT SEQUENCES

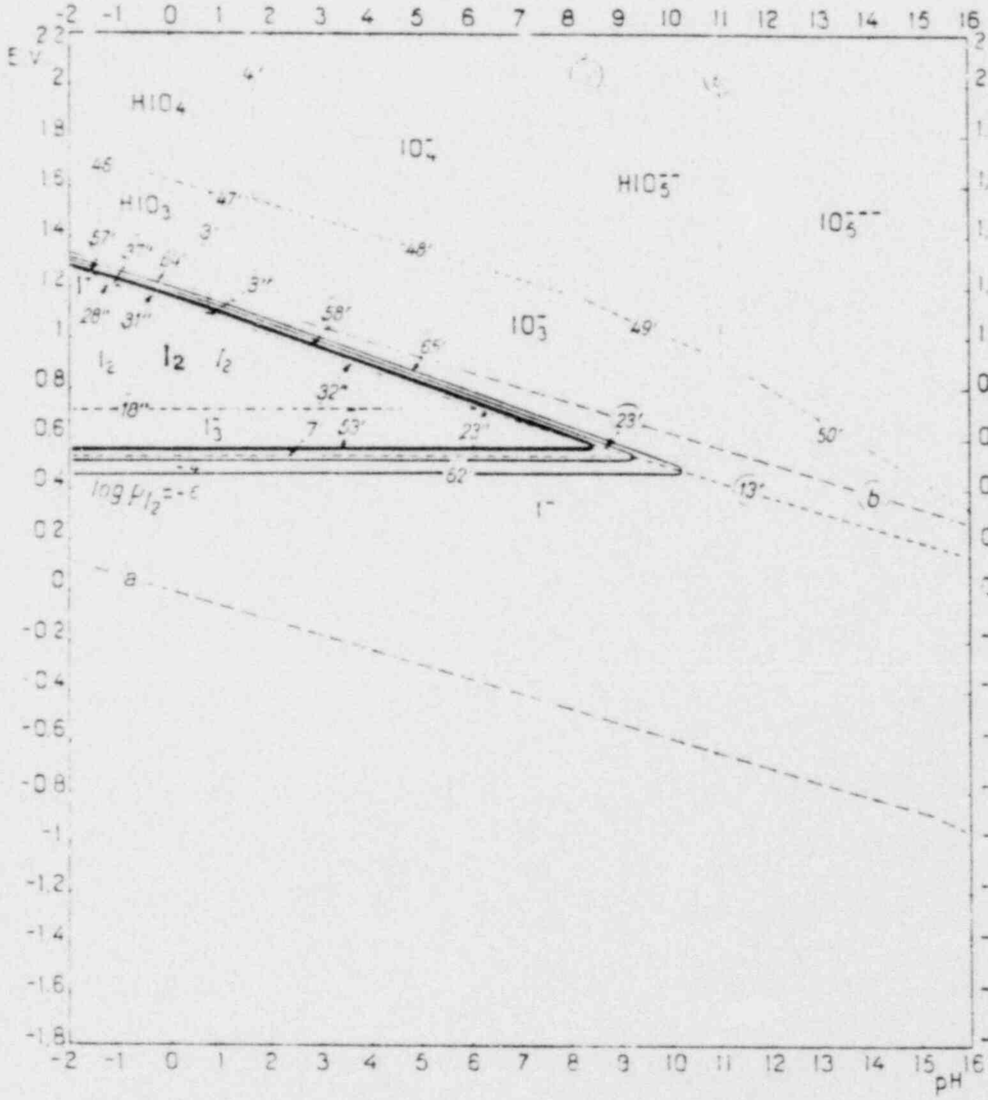
FISSION PRODUCT RELEASE AND TRANSPORT

- VITAL TO RULEMAKING:
  - SITING
  - EMERGENCY PLANNING
  - ENGINEERED SAFETY FEATURES
  - DEGRADED CORES
- VITAL TO ADEQUATE HANDLING OF MORE LIKELY, LESS CONSEQUENTIAL ACCIDENTS
- RESEARCH PROGRAM UNDERWAY, SIGNIFICANT EXPANSION PLANNED
- STATE OF TECHNOLOGY REPORT WILL ESTABLISH A SNAPSHOT OF WHERE WE ARE, WHAT WE NEED TO DO THAT WE ARE NOT YET PLANNING TO DO, WHAT WE NEED NOT DO

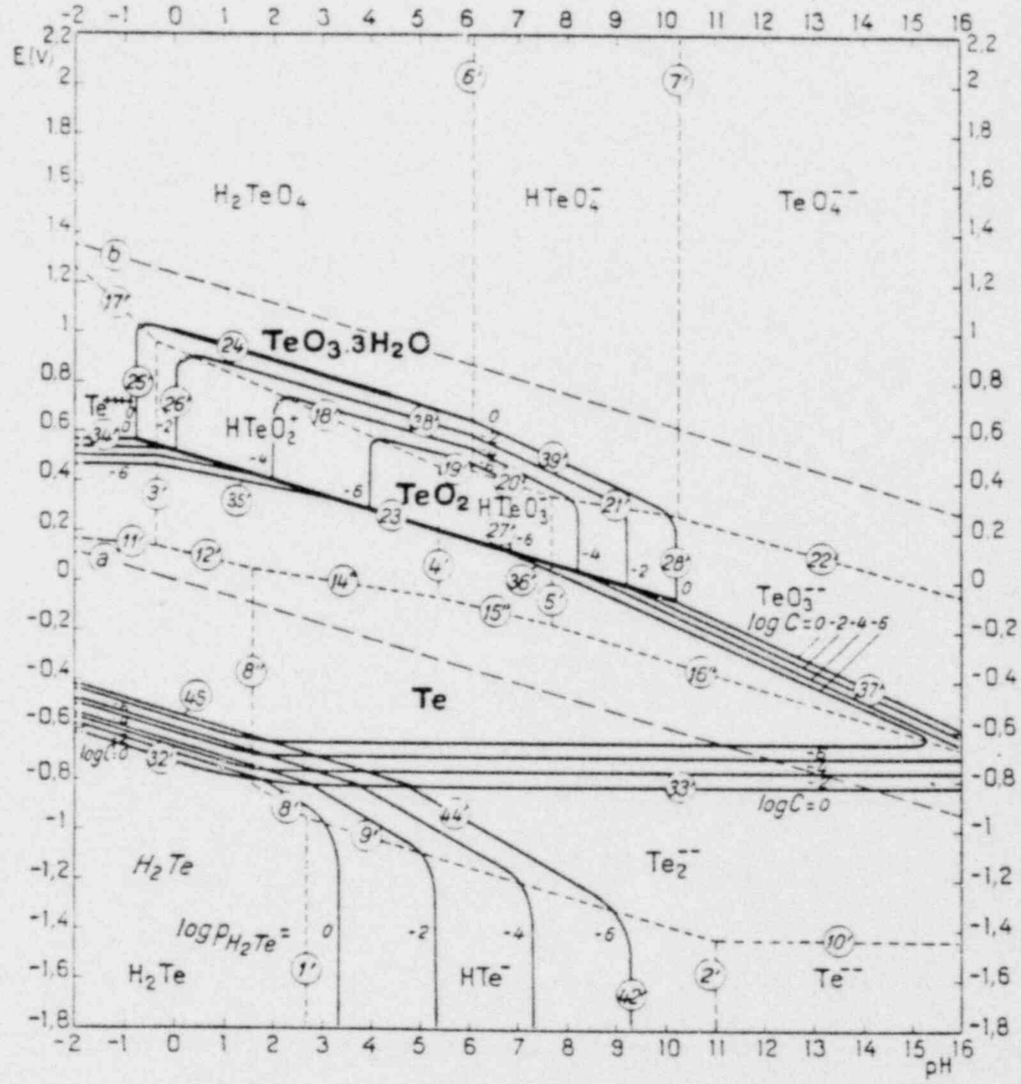
KEY OUTPUTS OF AN INTEGRATED PROGRAM

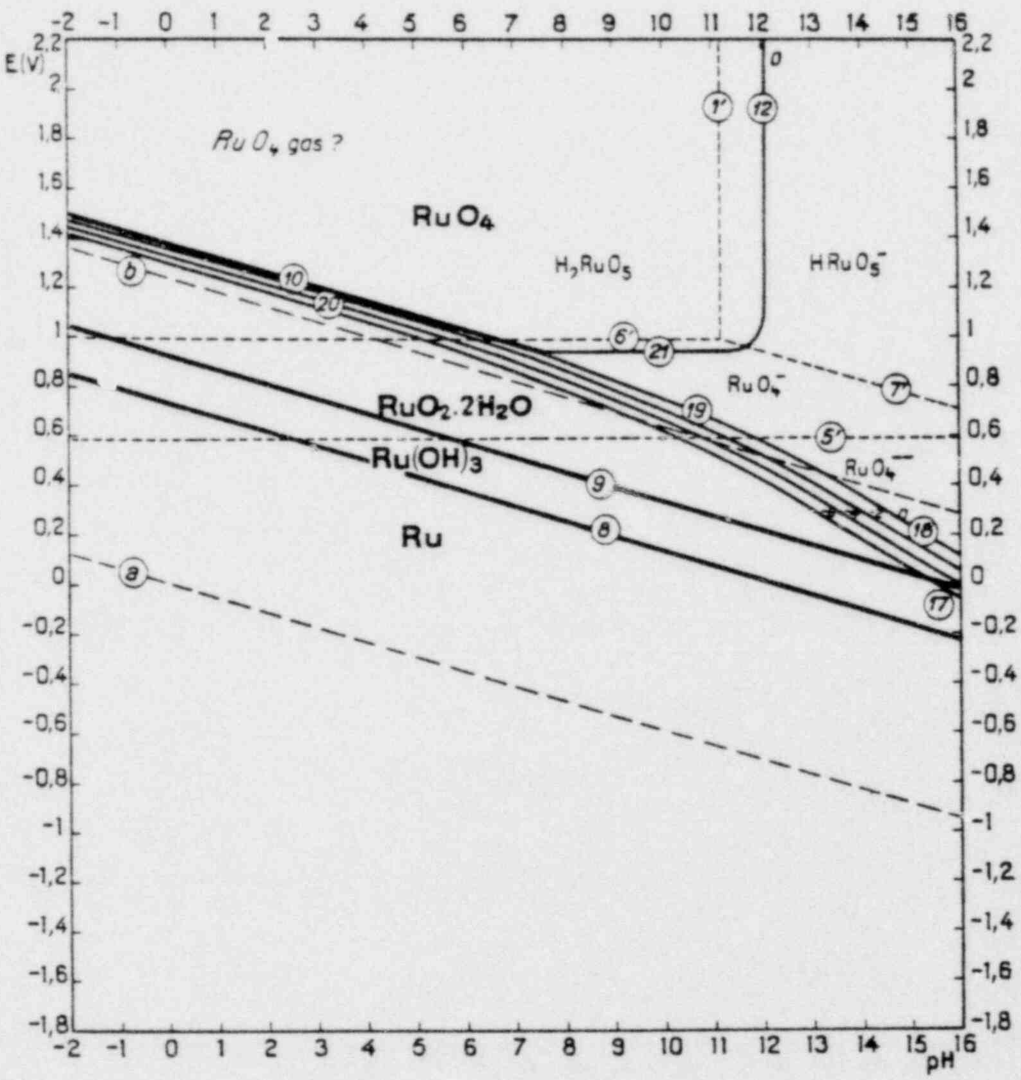
- COHERENT ACCOUNT OF THE RELEASE AND TRANSPORT OF FISSION PRODUCTS OVER THE ENTIRE RANGE OF ACCIDENT CONDITIONS
- SHORT LIVED AS WELL AS LONG LIVED PRODUCTS ACCOUNTED FOR
- TRANSPORT DESCRIPTION ACCOUNTS FOR MAJOR PHYSICAL AND CHEMICAL PROCESSES
- EFFECTS OF MODE OF RELEASE FROM CONTAINMENT ACCOUNTED FOR

EPRI

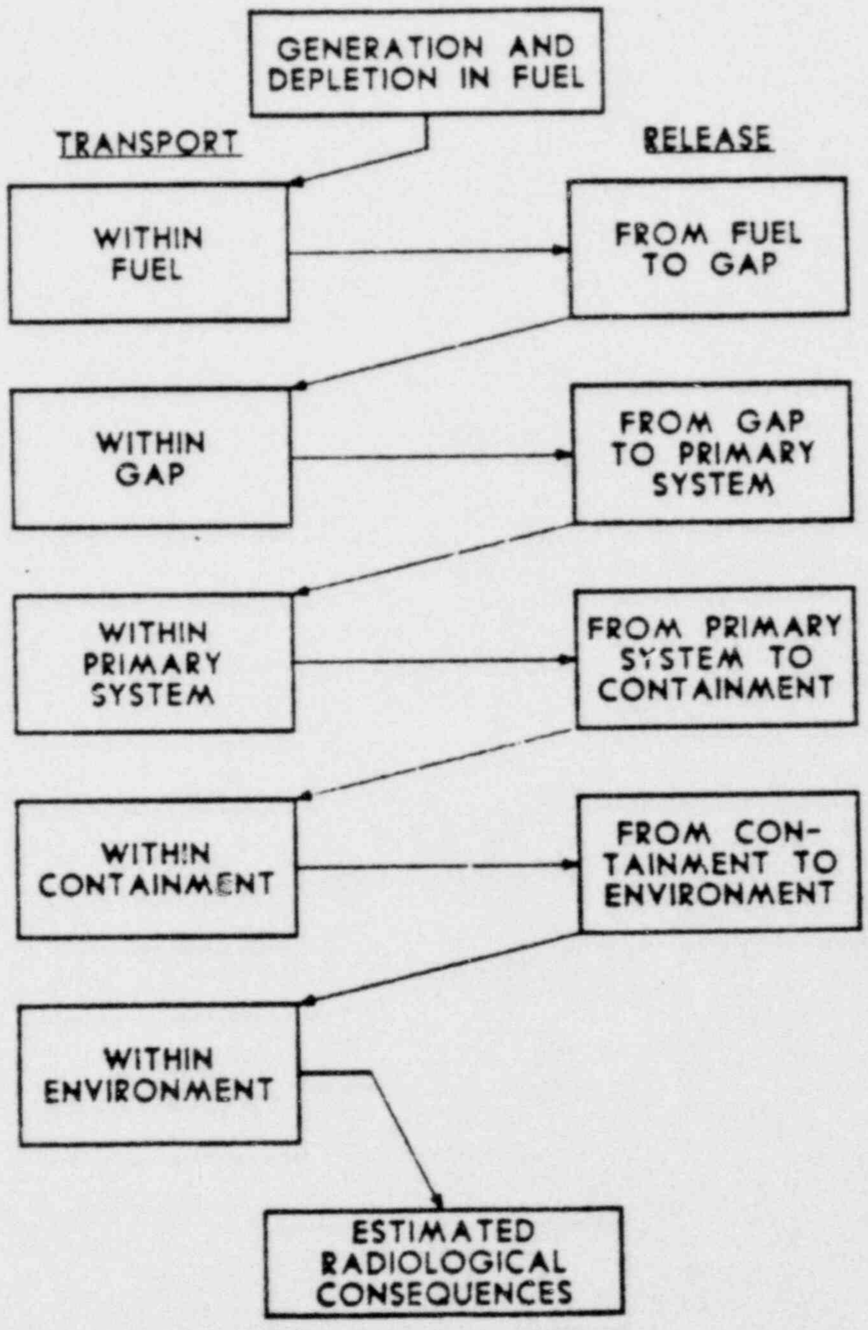


POOR ORIGINAL

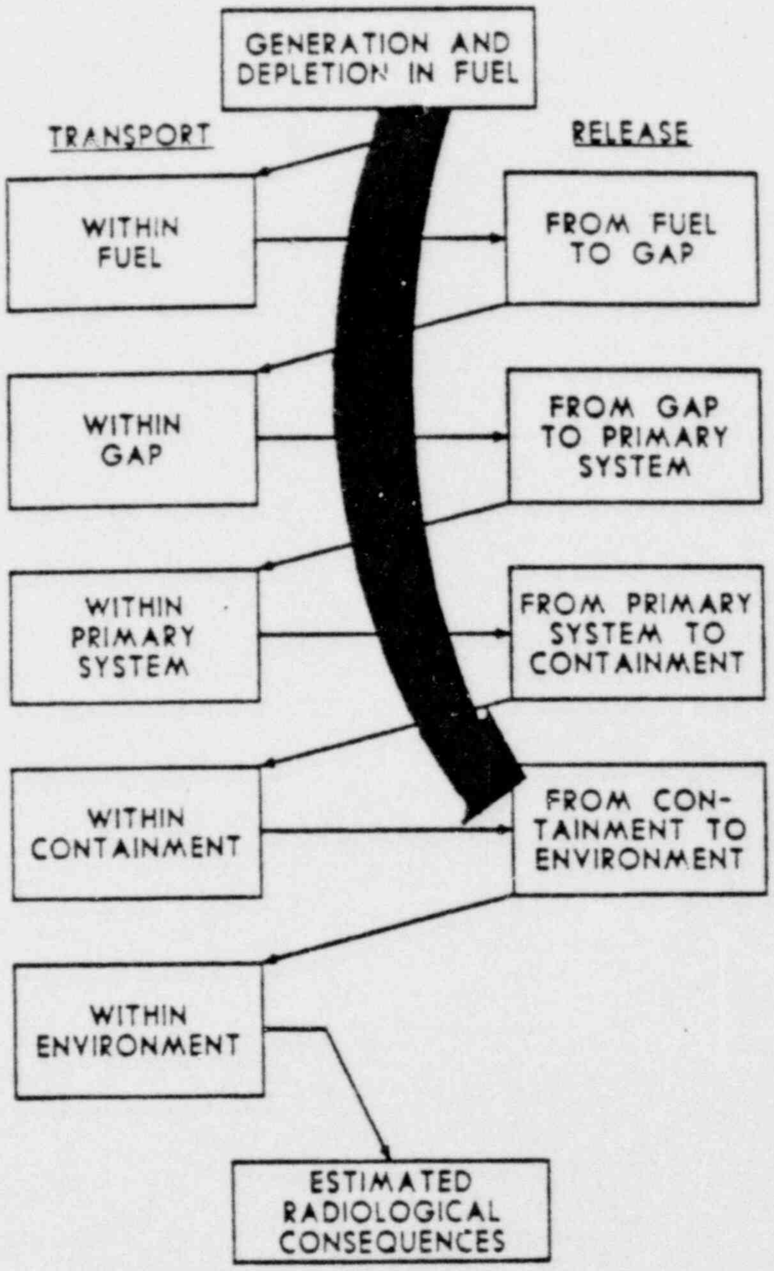

E(V)
pH
H_2TeO_4
$HTeO_4^-$
TeO_4^{--}
$TeO_3.3H_2O$
$HTeO_2^+$
TeO_2
$HTeO_3^-$
TeO_3^{--}
log C = 0 -2 -4 -6
Te
H_2Te
Te_2^{--}
log C = 0
$log\ p_{H_2Te}$ =
HTe^-
Te^{--}


E(V)
pH
Ru O4 gas ?
RuO4
H2RuO5
HRuO5-
RuO4-
RuO4--
RuO2.2H2O
Ru(OH)3
Ru

FISSION PRODUCT PATHWAY



REGULATORY GUIDE ASSUMPTIONS



FACTORS AFFECTING TECHNICAL SOURCE TERM

Aerosols (nongaseous particulate fission products)

- Stable, dispersable aerosols difficult to create
- Agglomeration
- Condensation of steam on aerosols
- Plugging phenomena
- Densification and settling out

Iodine — and other potentially volatile species

- Chemically reactive
- Formation of CsI in fuel
- Various species
- Hydrolysis
- Adsorption/absorption on surfaces
- Incorporation into aerosols

FACTORS AFFECTING TECHNICAL SOURCE TERM

Mechanical effects

- Moisture and steam condensation (fog, mist)
- Heat capacity of building (continuing condensation)
- Most RCB penetrations don't lead to environment
- Filter action of soil
- Water in containment (even in "dry melt")
- Plate out

THRESHOLD LEVELS ON SOURCE TERM REDUCTIONS

- Relatively small reductions can have important safety repercussions
- If easily-identified factors included, iodine and particulate source terms reduced by factor of 10 or more
- Potential reductions much greater than the threshold for altering criteria. For example:
  - 10-fold reduction in iodine + particulate component implies *no* early fatalities
  - Releases will occur slower than predicted. Major implications for evacuation requirements
- Recognition of the above is a necessary component of policy formulation

POSSIBLE FISSION PRODUCT REACTIONS
Degraded Core Accident

Reaction Process — Iodine/Cesium	*Product*
Iodine with cesium in fuel	Cesium iodide
Cesium iodide with water	Dissolved cesium iodide
Dissolved cesium iodide with oxygen from air	Iodine
Iodine with water	Hypoiodous acid
Iodine with organic material (i.e. paints)	Organic iodides
Iodine with metals in reactor building	Nonvolatile iodides
Iodine with dust and dirt	Nonvolatile iodides
Gravitational settling of solid iodides	Nonvolatile iodides
Adsorption/plate out of airborne iodides on surfaces	Nonvolatile iodides
Filtration of airborne particulates	Immobilized iodides
Removal of nonvolatile iodides by water scrubbing	Iodide solutions

POSSIBLE FISSION PRODUCT REACTIONS
Degraded Core Accident

Reaction Process — Tellurium/Cesium	*Product*
Tellurium with cesium in fuel	Cesium telluride
Plate out of cesium telluride in fuel	Adsorbed cesium telluride
Cesium telluride with water	Cesium-tellurium solution
Precipitation of tellurium from solution	Solid tellurium
Oxidation of tellurium (solution) by air	Nonvolatile tellurium
Reaction Process — Particulate Fission Product	*Product*
Particulate becomes airborne after fuel clad rupture	Airborne particulate
Airborne particulate settles out due to gravity	Plated/adsorbed material
Airborne particulate scrubbed out by water	Water suspension or solution of fission products

WASH-1400

Approach/objectives

- Methodical examination of potential accidents
- Identification of key sequences
- Realistic estimates of plant response and public consequences for such sequences

Constraints in fission product release modeling

- Time and resource limits led to simplifying assumptions
- Uncertain predictions of accident conditions
- Presumed importance of large LOCA

Outcome

- Efficient but simplified analytical modeling
- Conservative assumptions in areas of complex or uncertain phenomena
- Tendency to overestimate consequences

WASH-1400
FISSION PRODUCT RELEASE TO ATMOSPHERE
Areas of No Attenuation

Primary system assumptions

- *No* water or surface sorption of volatilized species along transport path in any ECC injection failure sequence

Containment system assumptions

- *No* deposition along leakage path to the atmosphere for *any* species in *any* accident sequence
- *No* trapping of *any* species during flow through water pools *when* saturation conditions predicted
- *No* retention of *any* species by auxiliary buildings or structures outside containment

WASH-1400
FISSION PRODUCT RELEASE TO ATMOSPHERE
Areas of Conservatism

Release from the fuel

- Used 100% release for the volatiles (Xe, I, Cs, and Te)
- Assumed fuel oxidation very effective in releasing Ru group after steam explosions

Chemical forms

- Assumed iodine would exist in elemental form rather than as cesium iodide

Aerosol behavior

- Neglected modeling of particle agglomeration effects
- Only partially modeled steam condensation effects
- Particle deposition on walls not modeled

Release upon containment rupture

- Treated as instantaneous percentage loss of airborne contents

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WASH-1400 CONSERVATISMS IMPACTING CONSEQUENCES FOR DOMINANT ACCIDENT SEQUENCES

	Accident Sequence				
	PWR			*BWR*	
Area of Conservatism	*V*	*TMLB'*	S_2C	*TW*	*TC*
Lack of FP retention in primary system	●	●	●	●	
No FP deposition in containment leak passages		●	●	●	●
No FP trapping in saturated water pools	●	●		●	
No FP retention by auxiliary buildings	●	●	●	●	●
Total release of "volatile" FP's from the fuel	●	●	●	●	●
Uninhibited fuel oxidation and Ru release in steam explosions		●	●	●	●
Iodine assumed I_2 rather than CsI		●	●	●	●
Incomplete aerosol behavior modeling	●	●	●	●	●
Puff discharges upon containment overpressure failure		●	●		●

IMPACT OF SMALLER RELEASE MAGNITUDES RELATIVE TO WASH-1400

	Iodine and Particulates		
Consequence	*WASH-1400*	*1/5*	*1/10*
Early injuries	1	0.032	0.0020
Latent cancer fatalities	1	0.35	0.22
Area interdicted > 10 years	1	0.11	0.037

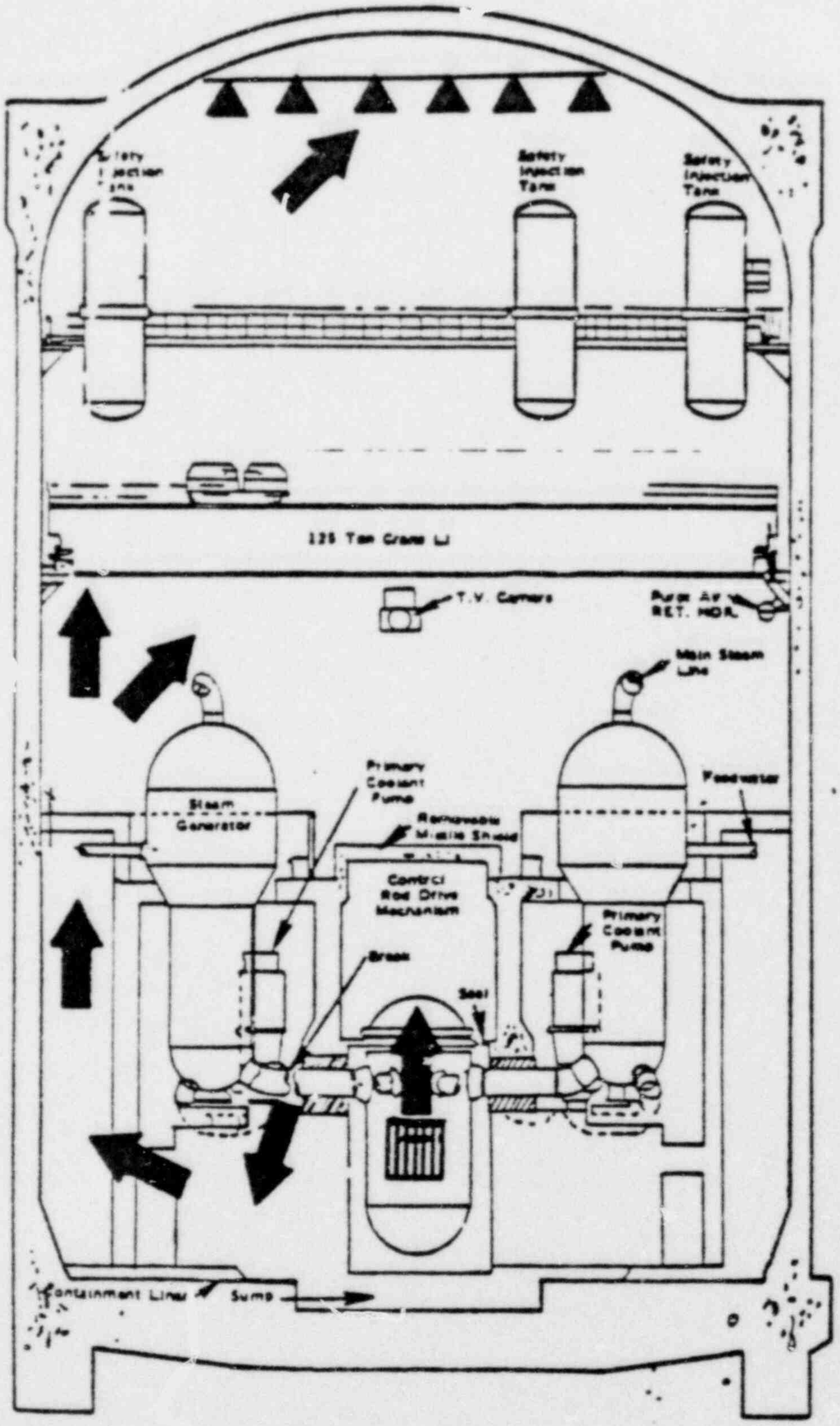
IMPORTANT TIMING CONSIDERATIONS

- MAJOR LOSS OF WATER FROM PRIMARY SYSTEM PRECEEDS FUEL FAILURE - WET AND STEAMY CONTAINMENT

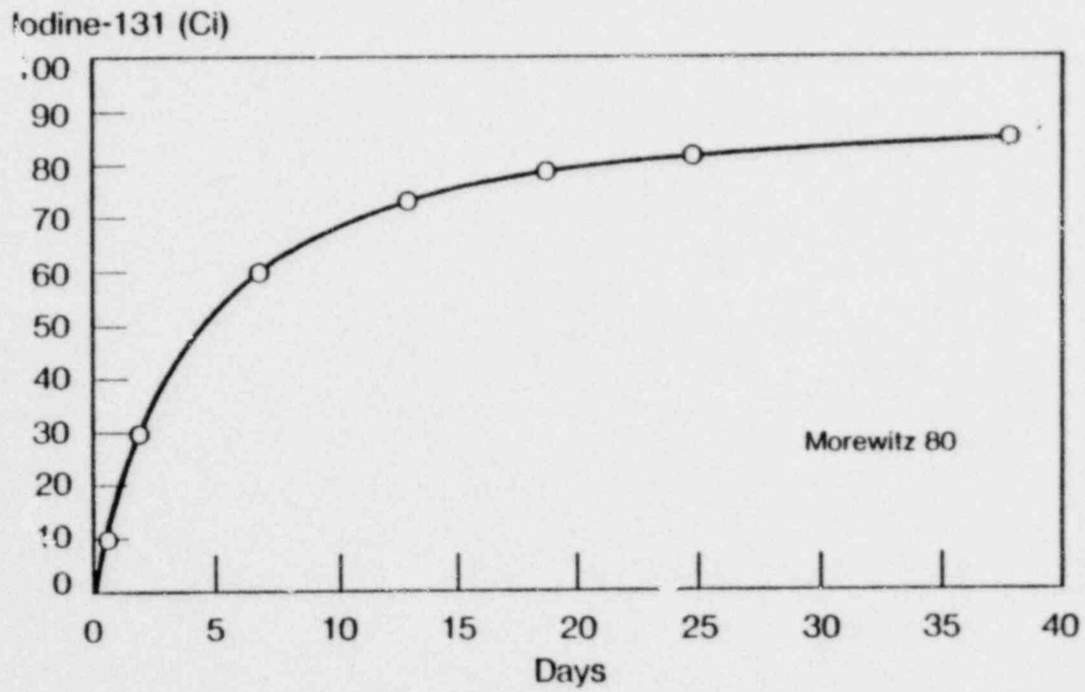
- FUEL MELTING
  - RELEASES BULK OF FISSION PRODUCTS
  - MUST PRECEED BY SOME TIME PENETRATION OF THE P.V.
  - AEROSOL AGGLOMERATION AND IODINE REACTIONS OCCUR INSIDE P.V.

- DENSITY OF FISSION PRODUCT AEROSOLS SHOULD BE BASED ON THE FREE VOLUME OF THE PRESSURE VESSEL - NOT THE CONTAINMENT BUILDING

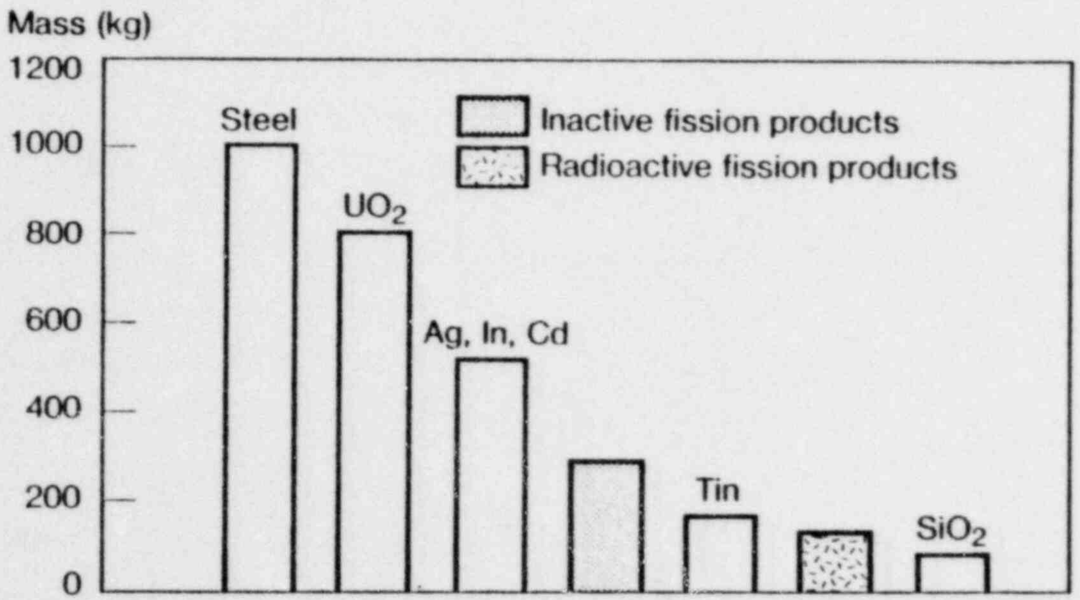
- FUEL MELTING WILL NOT START UNTIL FAST BLOWDOWN STAGE IS OVER
  - NOT APPROPRIATE TO USE THE SPEED OF ESCAPING STEAM/WATER TO CALCULATE FISSION PRODUCT TRANSPORT INTO CONTAINMENT

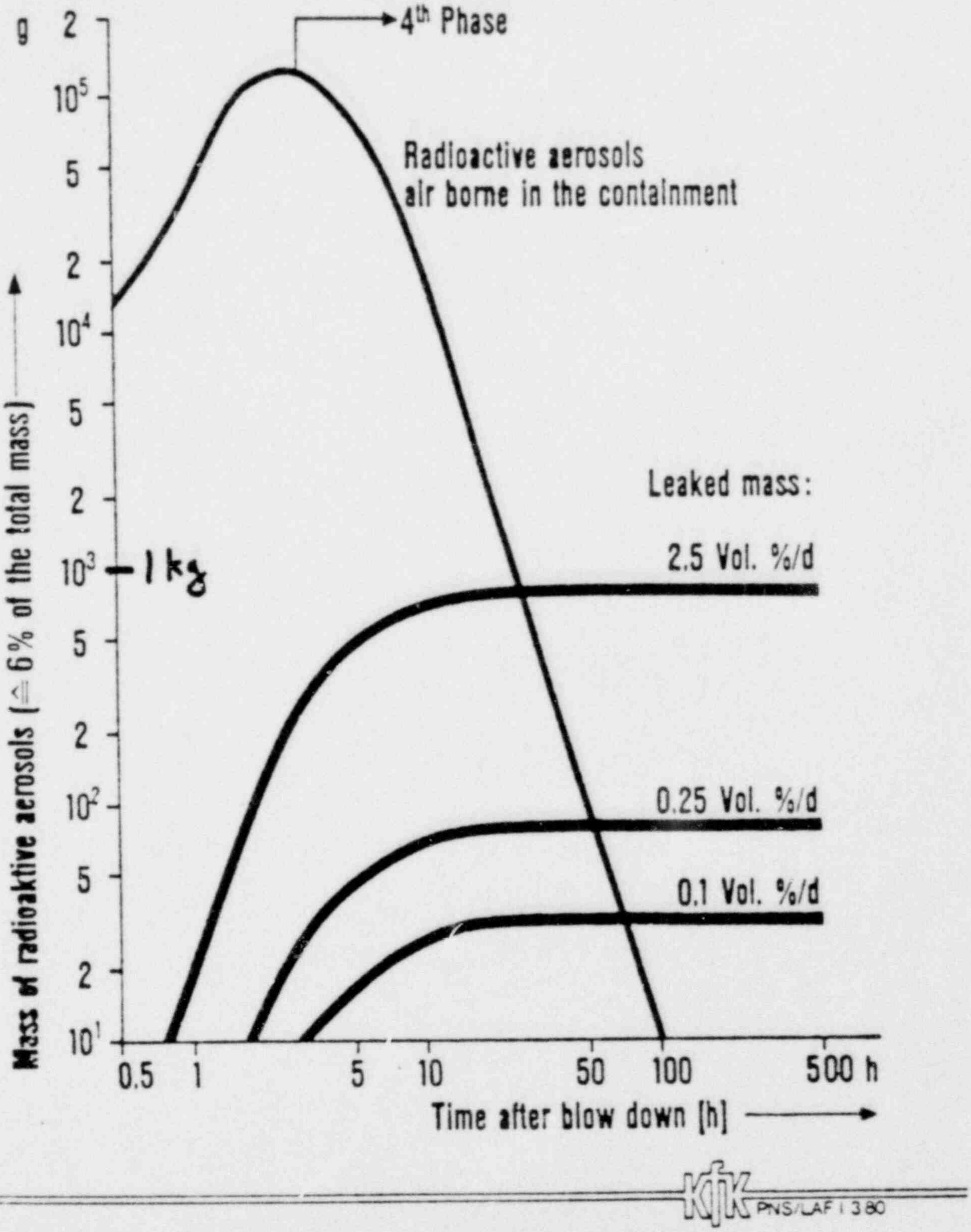

Safety Injection Tank
Safety Injection Tank
Main Steam Line
Primary Coolant Pump
Feedwater
Steam Generator
Control Rod Drive Mechanism
Primary Coolant Pump
Break
Seal
Containment Liner
Sump

CUMULATIVE IODINE RELEASE TO THE ENVIRONMENT FROM THE SL-1 ACCIDENT



AEROSOL MASS FROM HYPOTHETICAL ACCIDENT





Radioactive aerosols and leaked mass (NAUA calculation without H_2O-condensation)

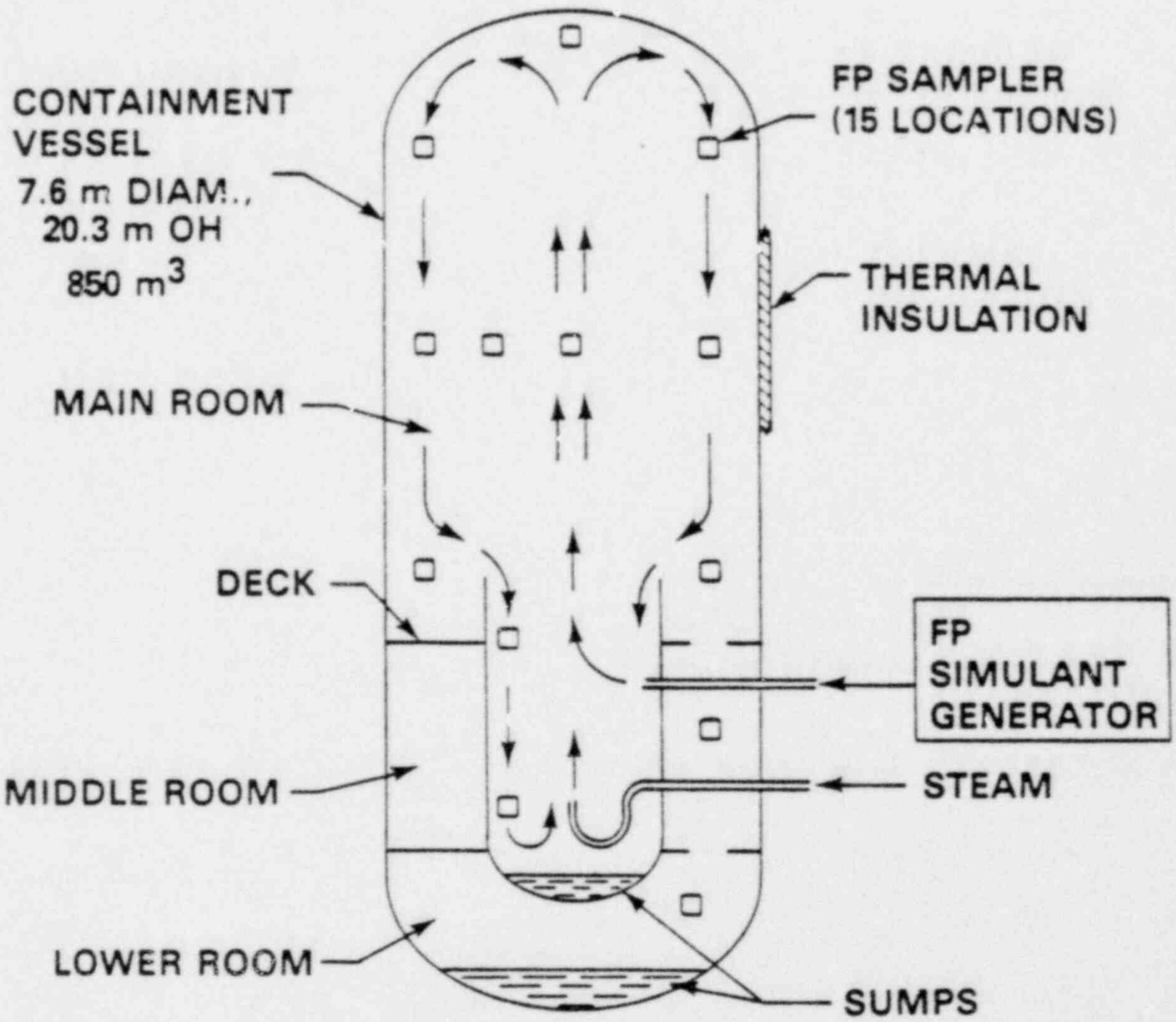


Figure 5. Schematic Arrangement for Fission Product Transport Tests.
Neg. 8012554-12

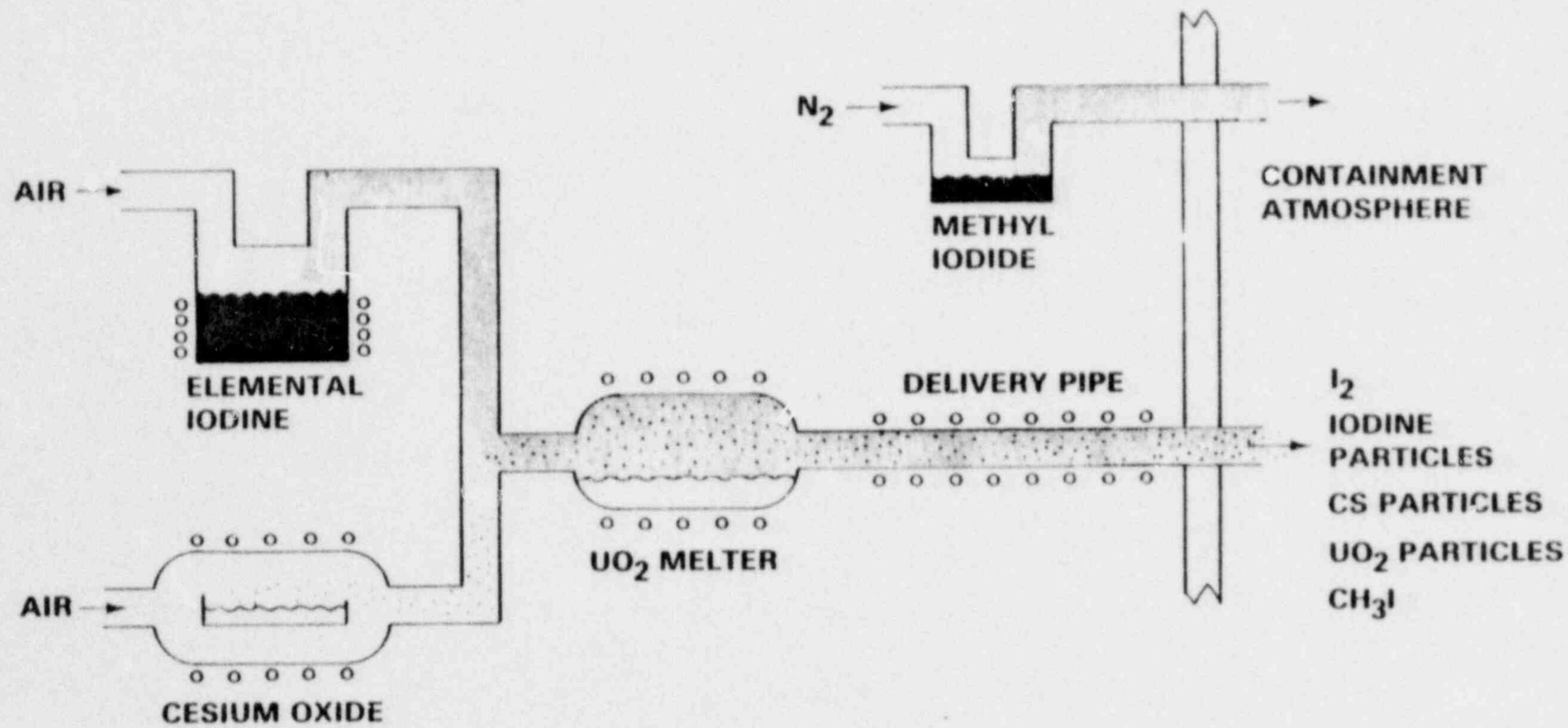


Figure 5. CSE Fission Product Simulant Generation. Neg. 8012554-4

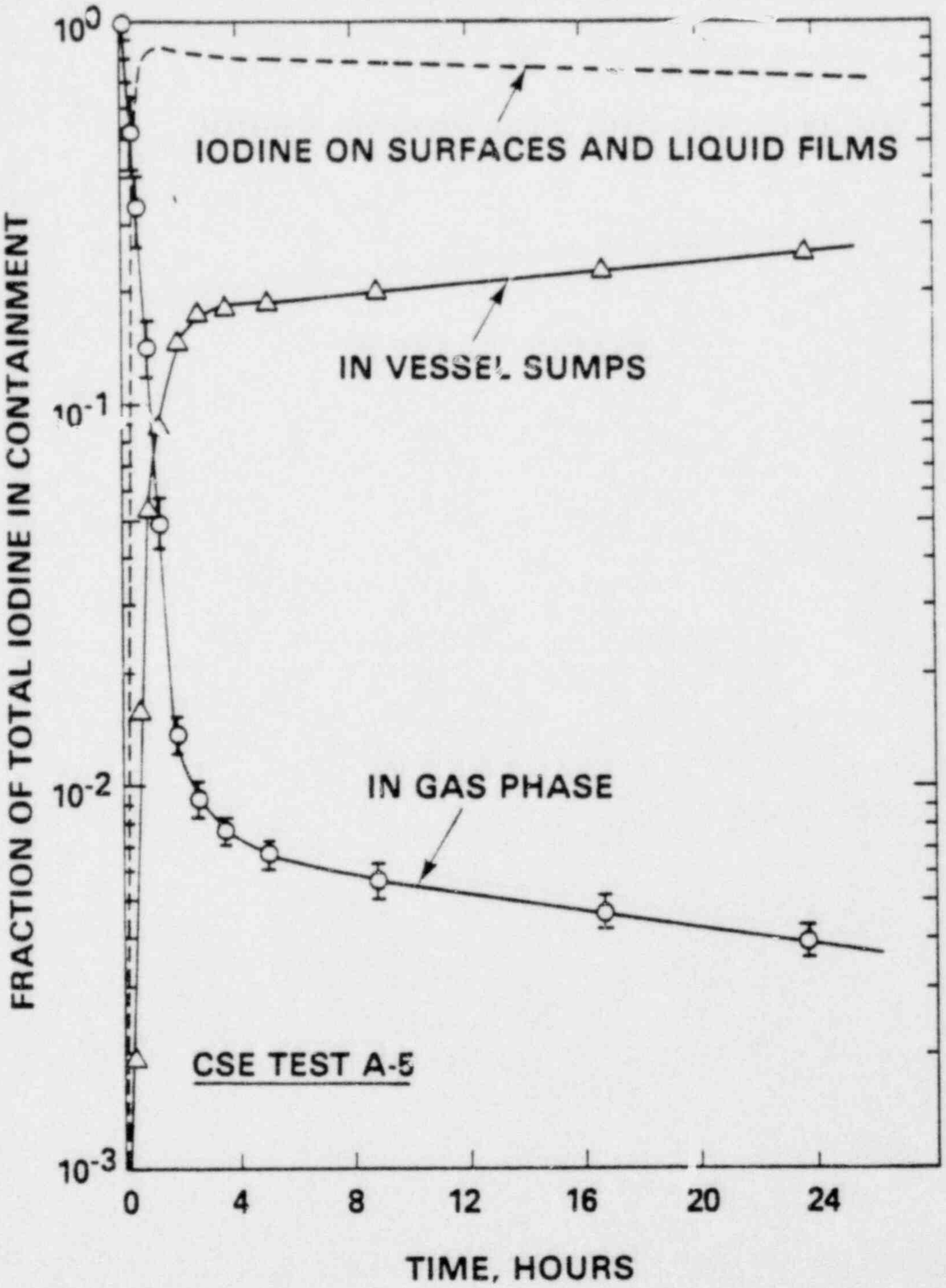


Figure 8. Typical Iodine Distribution Within Containment Vessel. Neg. 8012554-7

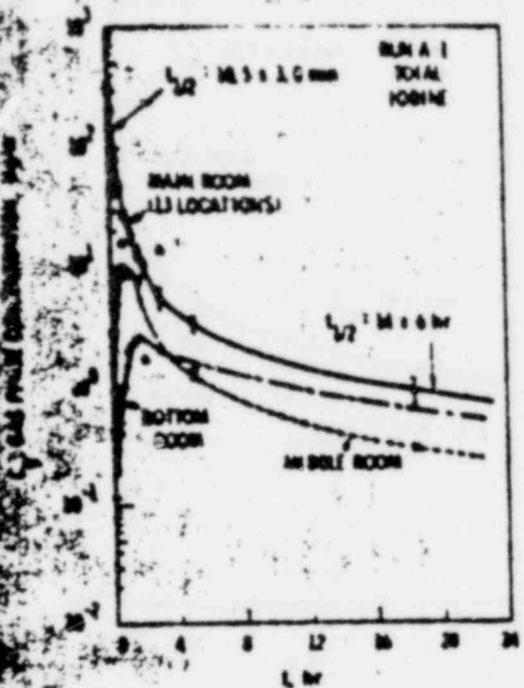


FIGURE B-33.
Concentration of Total Iodine in Gas Space, Run A-1

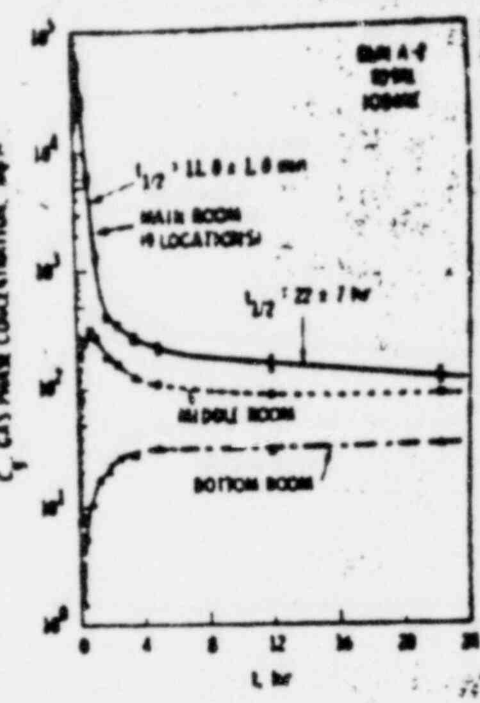


FIGURE B-34.
Concentration of Total Iodine in Gas Space, Run A-2

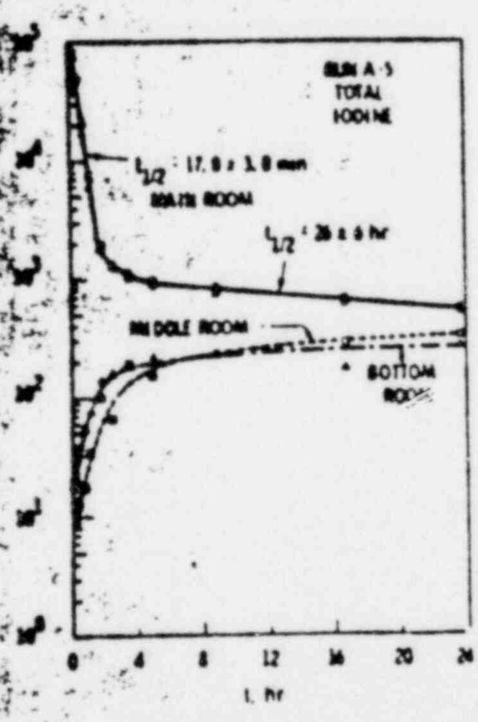


FIGURE B-35.
Concentration of Total Iodine in Gas Space, Run A-5

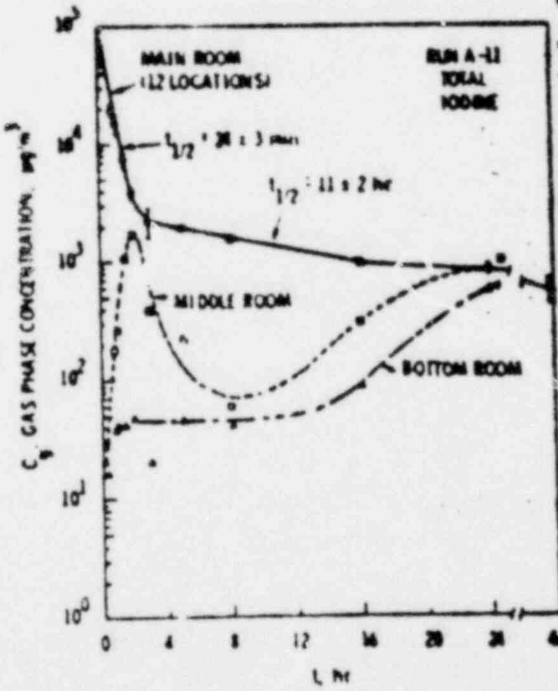


FIGURE B-36.
Concentration of Total Iodine in Gas Space, Run A-11

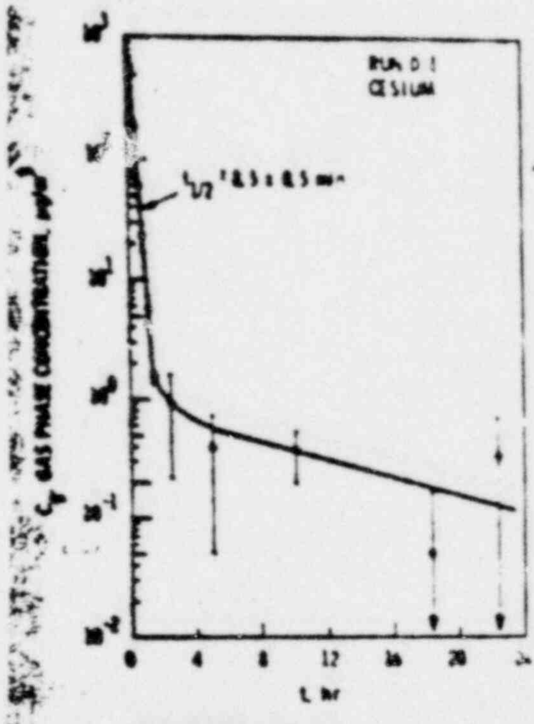


FIGURE B-37.
Concentration of Cesium in the Gas Space, Run D-1

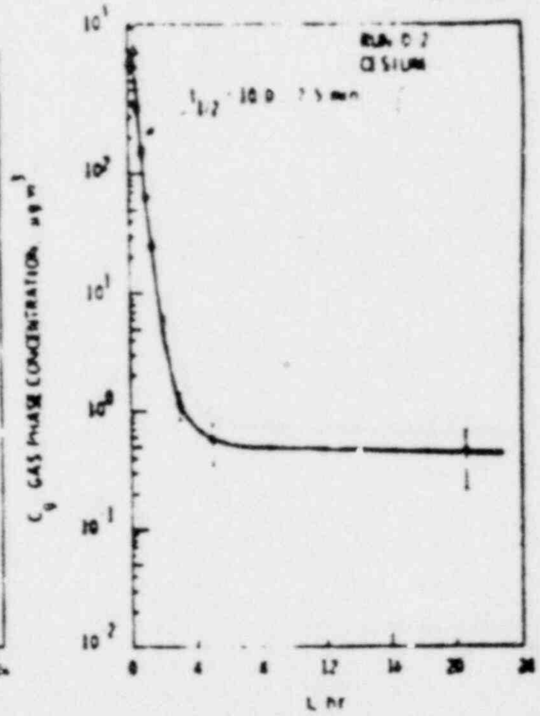


FIGURE B-38.
Concentration of Cesium in the Gas Space, Run D-2

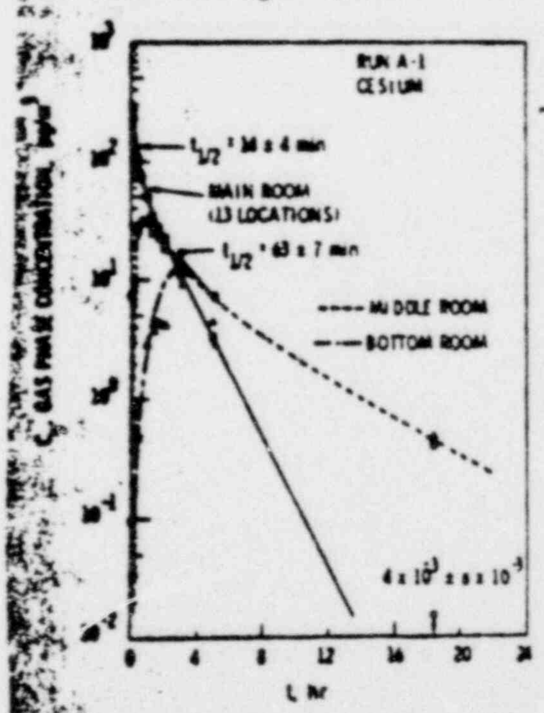


FIGURE B-39.
Concentration of Cesium in the Gas Space, Run A-1

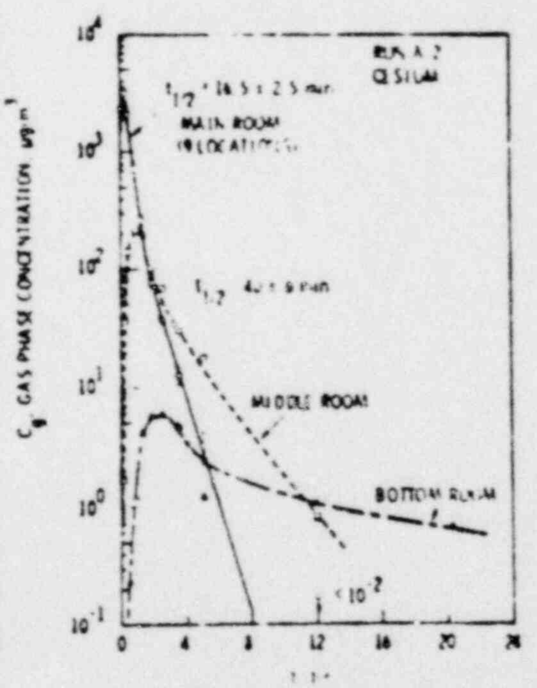


FIGURE B-40.
Concentration of Cesium in the Gas Space, Run A-2

SELECTED CONCLUSIONS OF CONTAINMENT SYSTEMS EXPERIMENT

- IN SPITE OF ATTEMPTING 100% RELEASE, AN AVERAGE OF 28% OF THE IODINE AND 67% OF THE CESIUM WERE RETAINED IN THE RELEASE APPARATUS AND INJECTION LINES
- LEAKAGE TESTS SHOWED THAT CONTAINMENT ATMOSPHERE LEAKS DIMINISH SIGNIFICANTLY IN STEAM-AIR ATMOSPHERES
- 15% OF CESIUM REMAINED ON THE PAINT; 85% WAS IN CONDENSATE
- VERY LARGE FRACTIONS OF THE FISSION PRODUCTS ENTERING LEAK POINTS WERE RETAINED IN THE CONDENSATE, (94% FOR IODINE, 99% FOR CESIUM)
- AN ATTEMPT TO EVAPORATE CONDENSATE BY BOILING TO DRYNESS ON A HOT PLATE LEFT 96% OF IODINE AND 99% OF CESIUM AS A NON-VOLATILE RESIDUE
- NATURAL ATTENUATION PROCESSES, IN ORDER OF IMPORTANCE, WERE RETENTION IN THE RELEASE APPARATUS, IN-CONTAINMENT REMOVAL SURFACES AND REMOVAL IN LEAK PATHS

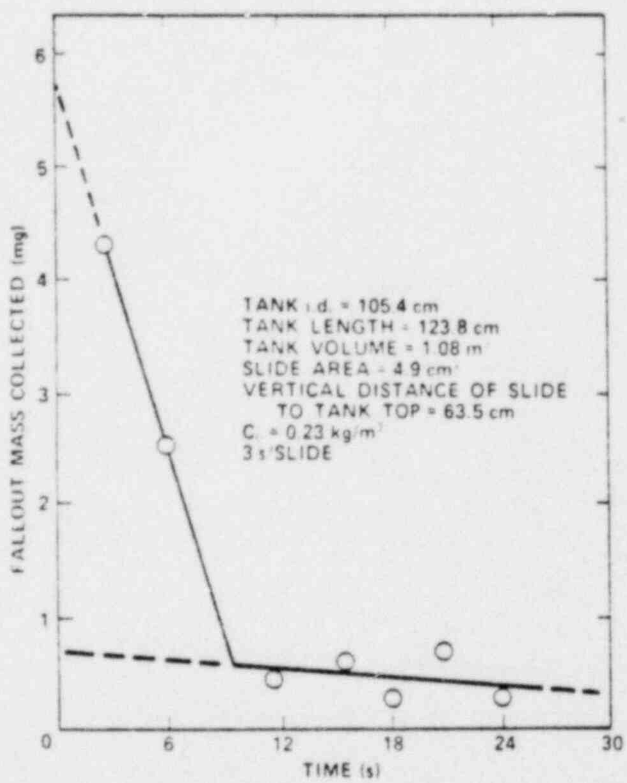


Fig. 3. UO_2 fallout versus time.

POOR ORIGINAL

Fig. 1. Aerosol collected at t_0 from HTCA test 13.

CRITERIA FOR GOOD EXPERIMENTS & MODELING

EXPERIMENTS

- INSTRUMENTATION MUST HANDLE PARTICLE SIZES GREATER THAN 10μ
- AEROSOL DENSITY SHOULD EXTEND INTO THE RANGE OF 0.1 TO 1.0 KG/M^3
- MEASUREMENT SHOULD BE MADE IMMEDIATELY AFTER START OF EXPERIMENT
- NO QUARTZ USED IN FISSION PRODUCT RELEASE EXPERIMENTS
- COMPARTMENT DATA REQUIRED

CODES

- TREAT HIGH CONCENTRATIONS CORRECTLY (UP TO 1 KG/M^3)
- REPRODUCE EXPERIMENTS CORRECTLY (INCLUDING MULTI-COMPARTMENT TESTS)
- CAN HANDLE BI-MODAL PARTICLE SIZE DISTRIBUTIONS
- RECOGNIZES THAT STOKES' SETTLING LAW NOT VALID AT HIGH CONCENTRATIONS