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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

DATE: December 7, 1990

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

368TH ACRS GENERAL MEETING

Nuclear Regulatory Commission

Room P-110

7920 Norfolk Avenue

Bethesda, Maryland

Friday, December 7, 1990

The above-entitled proceedings commenced at 8:30 o'clock a.m., pursuant to notice, Carlyle Michelson, Committee Chairman, presiding.

PRESENT FOR THE ACRS SUBCOMMITTEE:

Charles J. Wylie, Vice Chairman

James. C. Carroll, Member

Ivan Catton, Member

William Kerr, Member

Harold W. Lewis, Member

Paul G. Shewmon, Member

Chester P. Siess, Member

David A. Ward, Member

J. Ernest Wilkins, Jr., Member

P. Boehnert, Cognizant ACRS Staff Member

PARTICIPANTS:

R. Fraley	S. Duraiswamy
A. Chaffee	M. Caruso
D. Fischer	S. Mirsky
G. Belisle	R. Karsch
T. Marsh	J. Donahue
J. MacDonald	B. Levis
S. Long	M. Reinhart
C. Rossi	J. Calvo
R. Lobel	W. Hall
B. Sheron	N. Zuber
E. Beckjord	J. Murphy
F. Eltawila	B. Wright

P R O C E E D I N G S

[8:30 a.m.]

MR. MICHELSON: The meeting will now come to order. This is the second day of the 368th meeting of the Advisory Committee on Reactor Safeguards. During today's meeting the Committee will discuss and/or hear reports on the following: nuclear power plant operating experience and events; ACRS Subcommittee activities; new standardized technical specification; and, NRC Safety Research Program.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Paul Boehnert is the designated Federal Official for the initial portion of the meeting. We have received no written statements or requests for time to make oral statements from members of the public regarding today's session. A transcript of portions of the meeting is being kept, and it is requested that each speaker use one of the microphones, identify himself or herself, and speak with sufficient clarity and volume so that he or she can be readily heard.

I would like to remind the members at this time that if you have any comments on the draft letter which Charlie Wylie is preparing be sure to give them to him this morning because he's trying to put together a second draft now. If there are any, please do so.

At this time, I would like to call on J. Carroll to introduce the topic of nuclear power plant operating experience and events.

MR. CARROLL: This morning we are going to hear about four fairly recent reactor operating events. I guess Al Chaffee is going to lead the discussion for the staff.

MR. CHAFFEE: There are four events that we wanted to talk to you about today. The first one is the hydrogen gas build up of a charging system at Sequoyah. For that particular event, we have Mark Caruso from the Reactor Systems Branch who will give a little bit of an introduction on this one. Also, later on, we will talk about some of the follow up actions that the staff is taking.

Then we have Dave Fischer from the Events Assessment [illegible]nch, and he will go through and talk about the actual event itself at Sequoyah, exactly what occurred and what we learned from that. Later we may have -- there has been some analysis done on this particular type of a phenomena, and we plan on having somebody here present to be able to talk about some analysis that has been done there. As soon as he gets here, Steve Mirsky will talk to us about that.

The second event that we want to talk about is Brunswick Unit 2 where they had, due to some personnel errors, shutting of their main steam isolation valves. They also had some problems with some of their safety relief valves in that event. Al Belisle, who lead in AIT to look into this Brunswick event from Region II, he will be talking to us about that.

The third event that we wanted to talk about was the loss of offsite power event that occurred at Brunswick. For this one, Rudy Karsch from the Events Assessment Branch will take us through a discussion of that. We will see how, in this particular case, the licensee lost offsite power when they manually tripped the reactor after having a lock out of their transformer that caused them to lose their recirc pumps.

The fourth event we wanted to talk a little bit about was Pilgrim, where the licensee had some problems with their feedwater system and difficulties trying to use various other line up to feed the reactor vessel. For that particular one, Rudy Karsch from the Events Assessment Branch will take us through a discussion of that event.

Roughly speaking, we thought we would spend an hour on the first one, about 20 minutes on the two Brunswick events -- 20 each -- and about one-half hour to 40 minutes on the last event. That is flexible, based on the questions that you have to ask us. At this point, I would like to turn it over to Mark Caruso to lead off on an introduction on the Sequoyah event.

MR. CARUSO: The issue of hydrogen gas build up in the charging system in the Sequoyah event is not a new issue. We do want to tell you about the event and will have a description of the event at Sequoyah, but we also want to go somewhat beyond that; in that the event at Sequoyah and the issues raised there are not new. Similar events have occurred like this event at Sequoyah in the past. The staff has been studying the issue of this hydrogen gas build up in the ECCS system. There have been similar events in the past, and the staff has been concerned as to the number of generic communications.

MR. KERR: Excuse me. I think if you hold that microphone closer to where the sound is coming from it would be more effective.

[Slide.]

MR. CARUSO: The primary concern that the staff has with this problem of hydrogen building up in the charging system is the potential that it could damage ECCS pumps. Because of that concern, the staff has been looking at the potential for getting this gas in multiple portions of the ECCS, and also looking at the potential for gas to damage the pump.

The staff has done some analysis in this area --

MR. KERR: Excuse me. You said that there have been a number of other incidents of this kind before, so the staff must have started looking at it earlier.

MR. CARUSO: Yes. The staff has been looking at this since -- I think in some depth since 1988. There was an event that two other PWR's -- two other events very similar to Sequoyah.

MR. KERR: But you don't have any solution for it yet, apparently.

MR. ROSSI: Let me point out that we have put out an information notice on this issue back in 1988. We put out the first information notice, and I believe that information notice was prompted by an event at the Farley plant. We put that information notice out, and it clearly indicated what the problem was. I think even on the recent one at Sequoyah they had done something in response to the information notice, but it turned out that they hadn't done enough.

So, since we put out the original information notice we have put out three supplements. The most recent supplement -- it actually hasn't been mailed out yet. It has been signed and I think it's included in your package -- it will be mailed on December 10. The industry is clearly alerted to the problem.

MR. KERR: My question is has a solution to the problem not yet been found, or does a solution exist but the industry is just not aware of it?

MR. CARUSO: I believe that there are solutions out there that people have used effectively in response to this. I think the concern is that the information has been out there, the technology has been out there to find this problem and fix it, and Sequoyah raises the issue of is it getting done.

MR. KERR: Thank you.

MR. LEWIS: Could I ask, is the information notice that we are talking about the one that we have in front of us in which Supplement 3 is at issue? December 10, is that the one that we are talking about?

MR. ROSSI: Supplement 3, to be issued on December 10, yes.

MR. LEWIS: Supplement 3, I have been reading and trying to understand what it says. It says evaluate the problem to determine its extent, if any, and implement corrective actions if not already completed, which I find a little bit short in telling me what is going on. I assume the earlier part tells what it's really all about?

MR. CARUSO: I think that we agree with that, and that part of what we want to talk about today is the stronger action that we think needs to be taken.

MR. LEWIS: I will wait to learn what these words mean, I guess.

MR. ROSSI: I am not sure what you are reading from.

MR. LEWIS: That's why I was asking if that was it. I am reading from a thing which was passed out which says staff developing generic communication which requests --

MR. ROSSI: No, that is not the information. The information notice is about four or five pages long.

MR. LEWIS: That's what I should be looking at

MR. ROSSI: The information notice does not require the licensee to do anything. It conveys information to them, and then as part of their normal evaluation of operational experience they would address it.

MR. LEWIS: The communication referred to in this is based on that, and it simply tells people to look at that and find out what the problems are and fix them.

MR. ROSSI: Yes. It leaves the burden on the licensee to evaluate his own situation and come up with his own solution.

MR. LEWIS: Okay, I have no problem with that. I just wasn't getting any information from what I have in front of me.

MR. MICHELSON: You should have a copy of the information notice.

MR. LEWIS: I have no doubt that I do.

MR. CHAFFEE: Also, we will see in the discussion that Dave will take us through in terms of what Sequoyah had happened and what they did, some of the interesting aspects of what it takes to deal with this type of a problem. We will get into some of those details then.

MR. MICHELSON: Why don't you proceed.

MR. CARUSO: After we go through the Sequoyah event, we will talk some more about the pump performance issue and talk about our analysis. Then, I will come back and talk about the follow up. At this point, I guess Dave Fischer is going to come up and run through the event for us.

MR. FISCHER: Good morning. My name is Dave Fischer, and I am the PWR Section Chief with the Events Assessment Branch. I believe you have some viewgraphs in your package. I was not going to put the ones that have the discussion on the screen, but I will put the isometric drawing up and talk from it basically. I think I will cover everything that is written on the slides that you have in your package, but I will check at the end of my kind of informal presentation.

[Slide.]

Both Sequoyah units were operating toward the end of August, end of September at power. Sequoyah Unit 2 was the one that experienced a problem on August 22nd. They were using the A centrifugal charging pump for normal primary plant makeup. They were about to do a surveillance on the B centrifugal charging pump here, and they started the B pump in parallel with the A pump and didn't have any problem. When they secured the A pump, they noticed oscillations in pump amperage and in pump flow so they secured the B pump.

They vented the pump casing and the discharge pumping, and then tried to restart the B pump. Once again, they got oscillations in pump amperage and in flow. They secured the pump again. Again, they vented the pump casing and the discharge piping, but this time they also vented the suction piping at these locations and in this location right here. This is a crossover line that goes over the RHR system.

Based on change in the volume control tank level of about two percent they estimate that they got about ten cubic feet of gas during this venting operation. They also noticed that they had about 4.75 of unventable gas in this line right here, going over to the RHR.

MR. KERR: I must say that's a rather accurate measurement of the gas volume. It is sort of interesting.

MR. CARROLL: My question on that is, that is standard cubic feet?

MR. FISCHER: Yes, sir.

MR. CARROLL: The other question I have is, does everyone have motor amp meters in normal practice in pressurized water reactor pumps?

MR. FISCHER: I am not certain sir, but they had it at Sequoyah.

MR. MICHELSON: Yes, at Sequoyah they have it.

MR. CARROLL: It would be useful to find problems like this if you do have amp meters, but I am not sure that everybody does.

MR. FISCHER: The licensee believes that this gas stripping is coming from these mini flow orifices on the discharge of the centrifugal charging pumps. Where they have this pressure drop, they believe that the local pressure is reduced and the gas is coming out of solution. The volume control tank has a hydrogen cover pressure on it for chemistry control purposes, and this is saturated primary coolant in this piping that the gas can come out of solution.

MR. MICHELSON: That's a very low if not non-pressurized tank. I mean, it's not a pressurized tank.

MR. FISCHER: It is pressurized to about 15 pounds.

MR. MICHELSON: Insignificant amount of pressure. You are not forcing a lot of gas into solution by pressure at that point.

MR. FISCHER: It may be noteworthy that Unit 2 was doing an excessive amount of charging because it was late in life. It is probably also worth noting that --

MR. SHEWMON: What does that mean; what does late in life have to do with where it is charging what?

MR. FISCHER: They were doing a lot of dilution, I believe --

MR. SHEWMON: Oh, latent fuel cycle.

MR. FISCHER: Latent fuel, right.

MR. CHAFFEE: Apparently the licensee, in looking at this event, saw a couple of aspects that were contributors to the gas that was coming out of solution. One of them was the VCT and the other one was being late in life -- dilution they believe was bringing into play water that was not completely de-aerated and was providing another source of gas contribution to the problem.

MR. FISCHER: At Sequoyah -- another thing that might be noteworthy at Sequoyah, this mini flow orifice flow is routed at Sequoyah back to the discharge of the VCT through the seal water heat exchanger, right downstream in discharge to the VCT or basically to the suction of the charging pumps. If the gas is coming out of solution in that orifice, it would go to the suction of the pump.

It used to be that the mini flow was routed back to the VCT itself, but because of another concern with regard to overfill of the VCT they repiped this to the discharge of the VCT.

MR. CARROLL: Following up on what Al said, the gas that would be coming out from the dilution would be nitrogen from nitrogen blanket on the primary water storage tank?

MR. FISCHER: There is a hydrogen gas cover pressure in the volume control tank.

MR. CARROLL: I understand that.

MR. CHAFFEE: What I understood was that the licensee thought that there were possibly two effects. One was the hydrogen coming out of the VCT and the other one was by having a lot of dilution going on you were introducing some gases from this makeup water that was finding its way into the system as well. Exactly what type of gas it was, I don't know.

MR. CARROLL: Typically you have a nitrogen blanket on the primary water storage tank.

MR. FISCHER: They did analyze the gas at Sequoyah following the event, and it did turn out to be 97 percent hydrogen.

MR. CARROLL: Oh, okay.

MR. FISCHER: When they had the event on August 22nd at Sequoyah Unit 2, they got in touch with Westinghouse. Westinghouse provided the licensee with a letter where Westinghouse determined that six cubic feet was acceptable. This was based on engineering judgment from the results of some more detailed analyses that Westinghouse had done for Farley and for Beaver Valley. They felt that was bounding and they could use that six cubic feet criteria for Sequoyah.

MR. KERR: Six cubic feet of what?

MR. FISCHER: Of gas in the piping without affecting the operability of the centrifugal charging pumps.

MR. CARROLL: What is the basis for that analysis; how did they come up with six?

MR. FISCHER: I think that subsequent presentations may get into that with a little more detail than I am prepared to talk about.

MR. MICHELSON: Was that intended to mean uniformly distributed in the fluid or concentrated in the suction void points?

MR. FISCHER: Once again, I am not familiar enough with the study that was done by Westinghouse and with what our contractors have done.

MR. MICHELSON: That's where it will --

MR. FISCHER: It will be in the next presentation, is really what I am getting down to.

MR. MARSH: This is Ted Marsh from the staff. Let me just say at this point that we really don't know the technical bases for this six cubic feet. We have been in some discussions with Westinghouse, and at this point we don't know. We have some information of our own that you are going to hear about in the next presentation that will talk about volume and the impact of various volumes in other plant charging pumps but we don't, at this point, know the basis for six cubic feet.

MR. FISCHER: Unit 1 had a nearly identical event occur on September 6. They, as a result of the problems of Unit 1 went over, and they found the same unventable volume here on the crossover piping to the RHR system. It was a slightly less volume, I think it was 4.3 cubic feet. It was totally voided. Then they found a little bit more gas that accumulated on the upstream side of this valve. In fact, if you total the two volumes that they measured when they measured it with ultrasonic testing of the piping and if you added it, it was more than the six cubic feet. They went into a 303 Unit shutdown until they could vent some of that piping.

Initially, because the licensee thought the gas was coming from the mini flow orifices, they used the positive displacement pumps for normal plant makeup. They wrote procedures for what the operator should do if the positive displacement pumps were inoperable. In addition, they have instituted and are continuing to routinely vent the suction piping from the suction of both centrifugal charging pumps to positive displacement pump and in this crossover line.

MR. KERR: Has there been any evidence of pump damage in any of these operations?

MR. FISCHER: Not to my knowledge, sir. It seems like whenever they noticed that they experienced a problem they shut the pump off right away.

MR. MICHELSON: There have been several LER's in the past concerning this gas accumulation in the suction lines. The pumps quit. If you void the suction lines severely, and that has happened, then you raise the suction -- you drop the suction pressure so low that the pumps just quit. Then they will overheat if you don't shut them off.

MR. FISCHER: After they had the event they did do some flow testing of the system. They did surveillance of the system and the pumps were operating properly.

MR. MICHELSON: That was after the gas was purged.

MR. KERR: They didn't have any difficultly recognizing the situation.

MR. FISCHER: No, sir.

MR. KERR: In shutting --

MR. CARROLL: As long as you have amp meters you are going to recognize it. I am not sure that all plants have put amp meters in.

MR. KERR: The information notice talks about potential problems, and I am trying to find out what the problem is. Being as ignorant as I am about pumps --

MR. CHAFFEE: Again, later on, when we have one of the follow on discussions, we will go into some discussion in detail about the impact of the gas on these centrifugal charging pumps. Basically what they are going to say, as you said, it air binds the pump. They will talk a little bit about how rapidly that type of a scenario can degrade the pump.

MR. CARROLL: In a matter of minutes you are going to wreck the pumps, bottom line.

MR. CHAFFEE: The other thing that was interesting is, when the licensee did shift and started using the positive displacement pump they did see, as I understand it, a reduction the production rate of gas. Apparently that reinforced their belief that the gases that they were seeing were coming from these orifices that come off the discharge side of the centrifugal charging pumps. They used that as some evidence to corroborate what they believed to be one of the major producers of the gas.

MR. WILKINS: You indicated that one of the amp meters will detect this. I notice they also refer to fluctuations in the rate of flow. Are there flow meters or some kind of --

MR. FISCHER: Yes, sir. There are definitely flow meters.

MR. WILKINS: Is that on all such plants?

MR. CARROLL: I believe so.

MR. FISCHER: I am fairly confident that the do.

MR. WILKINS: I would think so. Would those by themselves have detected the -- given some warning of the event without the evidence from the amp meters.

MR. FISCHER: In my opinion, they should be sufficient to diagnose the problem, particularly if you are alert to the potential for problem.

The rate of gas accumulation is a function of the plant-specific piping configuration, the volume control tank pressure, the reactor coolant system dissolved hydrogen concentration, and to some extent the charging rate. Where you are going to get the bubbles is plant-specific as well.

MR. KERR: At some point you are going to tell us that either one can or cannot eliminate gas accumulation; is that the case?

MR. FISCHER: I don't think I am going to tell you --yes, I will tell you that you cannot eliminate gas accumulation. I think that's what the bottom line is. There will be some, and that you should institute measures --

MR. KERR: This is a problem that we have to live with. It is not something that we do to eliminate gas accumulation.

MR. FISCHER: It's a problem that you have to live with and establish procedures, and maybe have a plant design that does not have excessive gas accumulation.

MR. KERR: Can Sequoyah redesign their plant so that this is the case?

MR. FISCHER: Sequoyah has done -- in fact, in addition to doing this venting routinely, they have installed vents. On Unit 2 they have completed this modification. On Unit 1 they intend to complete this modification by the end of this month. They have installed vents on either side of this to eliminate this larger volume of --

MR. KERR: Vents don't prevent the accumulation of gas, they just get rid of it as accumulated. The problem is still there.

MR. FISCHER: Yes, sir.

MR. KERR: Gas accumulation. Is there nything that can be done about that?

MR. FISCHER: You could conceivably install continuous vents.

MR. CHAFFEE: As far as being able to prevent the gas from ever coming out of solution, I have not heard yet of any approach people are taking to prevent that. That doesn't mean that it doesn't exist, I am just not aware of it. Most of what Sequoyah seemed to do, at least from what

I have been told, is tried to address ways in which they can prevent the gas that is coming out from accumulating.

One exception to that, obviously, they did find that securing the charging pumps reduced the rate at which the gas was coming out. It reduced it somewhat. Mainly they focused on the frequency that they would vent and put in these vents in locations that didn't have them so that they could get rid of large volumes of gas.

MR. KERR: Thank you.

MR. MARSH: Mr. Kerr, again as we were saying, we don't know exactly why the gas is coming out of solution. It may be coming out for a variety of reasons. It may be coming out in the suction flow path, it may be coming out in the recirculation flow path, it may be coming out due to other reasons, and we don't know why. Because the system is operating with saturated hydrogen -- we have seen this accumulation at a number of plants.

What you are going to hear more about today is the actions we believe are necessary to make sure that if you get accumulation of gas that it doesn't come into the question of the pump operability. That is the next step that we believe we are going to have to take based on all this information.

MR. SHEWMON: Is this piping clad with stainless steel or is it bare?

MR. FISCHER: I don't know the answer to that.

MR. ꞏꞏꞏFFEE: I can only speculate. I suspect it is clad, but I don't know that for a fact.

MR. CARROLL: I'm pretty sure it's bore -- just stainless steel piping.

MR. MICHELSON: Yes, that's all.

MR. SHEWMON: The hydrogen overpressure is put in at the pressurizer?

MR. CARROLL: No, it's put in here.

MR. SHEWMON: The super saturation that you have is one atmosphere in the VCT.

MR. FISCHER: It's 15 pounds, approximately ten to 15 pounds.

MR. SHEWMON: That's damn close to one atmosphere, you have to admit.

MR. CARROLL: It is really two atmospheres absolute. You are at 15 pounds gage.

MR. FISCHER: As was previously mentioned, there were several information notices or several ways that the licensee should have been aware of this problem before August of this year. We had 88-23, the information notice after the Farley event that was almost identical to this scenario, we had two supplements to that information notice which identified several different mechanisms to get gas or hydrogen in the suction of your centrifugal --

MR. KERR: What would he have done differently had he been aware of the problem? It sounds as if he identified it fairly soon.

MR. ROSSI: He might have made the modifications to these and captured this event sooner had he known --

MR. FISCHER: He might have had other vents and would have had procedures in place to routinely vent the piping so that they didn't run into a problem.

MR. ROSSI: It's a little difficult for us to tell how much our information notices and supplements contributed to identifying his particular problem when it started to occur also.

MR. CARROLL: Did your information notices talk about the trick of using ultrasonic techniques to --

MR. ROSSI: I don't believe that it did, no.

MR. CARROLL: That's a good application.

MR. MICHELSON: When they are doing their current venting, are they trying to monitor the amount of gas they see in the vent stream?

MR. FISCHER: I don't know of them physically measuring the volume. Can I get some help here?

MR. DONAHUE: I am the project manager for Sequoyah. The implication is that Sequoyah was not aware of the problem, that somehow these information notices and information from Westinghouse came and they did nothing.

That's not true. They did something. They did an assessment, they just did it wrong. They reached a conclusion that was not correct but they did act on it.

MR. MICHELSON: That's not the question that I asked, of course.

MR. DONAHUE: I am talking back -- originally the implication was that they did nothing, and that's not true.

MR. MICHELSON: Did you have an answer to the question that I asked or somebody?

MR. FISCHER: Can you ask the question again, please?

MR. MICHELSON: Are they presently monitoring what they are seeing in the vent streams? Are they still seeing gas, or are they just routinely venting --

MR. FISCHER: I know that they are venting frequency as a function of which centrifugal charging pumps they are using, and the determination on what frequency to establish was based on ultrasonic testing of the gas accumulation. I would suspect that they would, on some frequency, check that.

MR. MICHELSON: Do you know if they are still seeing gas accumulation?

MR. CHAFFEE: I believe the answer is yes, but I don't think --

MR. FISCHER: Yes.

MR. MICHELSON: Whatever they have done so far hasn't stopped the gas accumulation, it is just keeping it purged out of the system.

MR. FISCHER: Yes. Depending on which pump the frequency is different, and they go and vent it until they get water.

MR. MICHELSON: The other precautionary steps that they are taking apparently are not doing a whole lot of good then?

MR. FISCHER: Now they are not exclusively using that positive displacement pump. They are using the centrifugal charging pumps and they are venting that piping more frequently. This piping -- say if they are running the A pump they are venting this one and this one.

MR. CHAFFEE: Also, I understand that after they had the problem and they shut down -- I guess they must have gone through refueling outage because when they came back up, apparently they didn't see the production rate of gases as high as they had previously. That is why apparently they were led to believe that the dilution somehow was a contributing factor. Apparently the production rate of gases is less now than it was before. Again, they don't completely understand it, but that seems to be an aspect of it.

MR. MICHELSON: Proceed.

MR. FISCHER: The only other things that I wanted to mention was that there was a Westinghouse letter that went to TVA that talked about the Farley information notice, and that information may not have gotten directly to the licensee but there was a letter from Westinghouse talking about this problem. There was also, I think, four INPO operating experience notices and one recurring significant event notification that could have alerted them to this problem.

MR. MICHELSON: Are you giving any thought as to whether other kinds of good information notices are escaping their system?

MR. ROSSI: Let me go back to what was said earlier. I don't think the notice escaped their system, I think they looked at the notice -- I guess I would characterize what they did as not enough to fully address the problem.

MR. MICHELSON: They were aware -- maybe I misunderstood. I thought the people that needed to know didn't get the information. Perhaps that is not the case.

MR. ROSSI: Do you want to say some more on that?

MR. FISCHER: I think this was, in part, the case. At least the Westinghouse letter went to TVA. Now, they have instituted procedures --

MR. MICHELSON: I am more interested in what happened, as to why it took quite a while apparently for them to get the word.

MR. DONAHUE: TVA did become aware of both the information notices and the Westinghouse report. They did an assessment. The violation that was issued in terms of the fact the assessment was not correct, all that was stated.

What they did is, they made just a wrong assessment.

MR. MICHELSON: Okay.

MR. DONAHUE: If you want to call it -- they were not smart.

MR. KERR: You say a violation was issued because they made the wrong assessment?

MR. DONAHUE: No. I am saying when the violation was issued on this, this was all discussed. It is all in the public record. They did get the information, they did evaluate it, they evaluated it in an appropriate manner. They just reached a wrong conclusion and concluded that they did not have a problem.

MR. FISCHER: The licensee, in this particular case, said that they did not fully understand the mechanism by which gas was coming out of solution. The licensee said that they had focused on piping configurations that were above the volume control tank, because they thought that was the emphasis in the information notices.

MR. KERR: They received a violation for this?

MR. FISCHER: I have no knowledge of that.

MR. ROSSI: I am not prepared to talk about the violation. I don't know whether we have anybody here --

MR. KERR: You are prepared to tell me that they did. I thought somebody said they received a violation.

MR. ROSSI: Can anybody tell them whether they did or didn't get a violation. Do you know briefly what the basis of the violation was?

MR. DONAHUE: No.

MR. KERR: I don't need to know the basis. I just was curious --

MR. ROSSI: Okay, fine. They did get a violation then.

MR. KEPR: Apparently they got a violation because they didn't understand what was going on. Apparently, nobody yet understands what is going on. I presume there will be continuing violations.

MR. ROSSI: There may very well be.

MR. MICHELSON: Was the violation because they didn't understand or because they just failed to take proper actions to assure themselves they understood?

MR. ROSSI: I don't know what the basis of the violation was.

MR. WILKINS: It might have been helpful if we had the text of the violation notice in front of us here this morning.

MR. ROSSI: We didn't really come --

MR. SIESS: I'm beginning to get a feeling that the people that know what happened and the people that assessed the violation are not the same people. Maybe the violation didn't have any relation to safety.

MR. CHAFFEE: Here's what the violation says, at least the cover page. It says the violation involves inadequate corrective action for a problem that TVA was alluded to by NRC, INPO and Westinghouse. Several concerns were relative to corrective action for experience review issues are stated in paragraph 7-A of the report. The violation will go into more detail relative to that.

MR. CARROLL: What level was it?

MR. CHAFFEE: It says here, it's a level four.

MR. CARROLL: Five is the lowest.

MR. MICHELSON: A slap on the wrist kind of violation. Why don't you proceed.

MR. FISCHER: The only thing that I might say is that the safety significance of this event probably relates to a small break loss of coolant accident where you need a high head safety injection pumps. It is probably more severe on plants that have ice condensers and have to go to recirc sooner following a small break loss of coolant accident, and it's probably more severe on plants that have their charging pumps in a dual role as their high pressure safety injection pumps.

MR. CHAFFEE: The reason for that is, where the saw the largest amount accumulation of gases in this crossover line -- in the picture there it shows from train A -- as I understand it, you end up using that particular portion of the system when you go to recirc. That is why plants that -- the recirc and how fast you go to recirc becomes --

MR. FISCHER: You use your RHR pumps to feed the suction of the --

MR. KERR: Is the implication that in a LOCA they would not be able to vent the gas, or that they might not recognize it was there, or none of --

MR. FISCHER: The implication is that if they had a loss of coolant accident and you did not assume operator action and they had unventable gas here, that could get ingested into the safety injection pumps -- the high head safety injection pumps and could fail the pump or it might cause degraded flow, or it could cause a pump to cavitate and then reprime itself. That is the discussion that the mechanical engineering branch is going to talk about.

MR. ROSSI: It also raises, obviously, this particular situation could be the source of a common mode failure which could cause loss of the safety pumps. That's the bottom line.

MR. MICHELSON: Those are manual vents yet?

MR. FISCHER: Yes, sir.

MR. MICHELSON: They have to go right up to the pipe and open the little valves.

MR. FISCHER: It is Tygon 2, striated over --

MR. CHAFFEE: What is interesting is, originally at Sequoyah the area where they had the highest accumul[illegible] of gas it wasn't ventable. This concern at least ini[illegible]ly at Sequoyah that they couldn't vent it, although subsequently they changed that at least in one unit. I guess they are in the process of -- at least have plans to do it in the other one.

MR. FISCHER: It appears to me clear that the licensee was allowing a solid slug of up to six cubic feet of gas accumulation, as opposed to having uniform mix as Mr. Michelson was asking about.

MR. MICHELSON: You are not sure that is where it is either, when you measure it. You don't know that that's the piece unless you measured just that piece somehow. I gather you measured it with a volume control tank, and you don't know where the void was?

MR. FISCHER: That's correct. They had this voided here, and they probably had little pockets of gas in this line here and maybe even right at the top of that horizontal pipe may have been filled with gas.

MR. MICHELSON: Suction of the pumps in all the vent lines.

MR. FISCHER: That's all I had. Are there any other questions before we get to the pump people? Mark, did you have anything to add at this juncture?

MR. CARUSO: I think I covered --

MR. FISCHER: You may want to use that microphone there if you want to talk.

MR. CARUSO: I really think you covered the issues which were the potential for a common cause failure of pumps. The problem at Sequoyah and others has been the gas in this pipe that connects the RHR pump with the high pressure pumps. There may not be vents there to vent all the gas, and there are no generic tech spec requirements to go over and vent that piece of piping.

I think we went through that. I think at this point we will go right to the analysis of pump performance.

MR. CARROLL: Okay, let's do that.

MR. MARSH: This is Tad Marsh again. Let me set the stage a little bit --

MR. WILKINS: May I ask one more question? Am I correct that you implied that we really don't know where this gas is coming from in the first place?

MR. FISCHER: I think that's a general consensus, they really don't know. It appears that it is happening where they are having local pressure reductions.

MR. WILKINS: Let me -- I am kind of naive about these matters too. Local pressure reduction would tend to pull the gas out of solution.

MR. FISCHER: Yes, sir.

MR. WILKINS: I understand that much. How did it get in the solution in the first place; where did it come from?

MR. CARROLL: In the volume control tank up there see, there's a level maintained and hydrogen is bubbled into that gas.

MR. WILKINS: Deliberately --

MR. FISCHER: Yes, deliberately.

MR. CARROLL: Yes.

MR. MICHELSON: It's not quite bubbled in, it's put as an overpressure on the tank.

MR. WILKINS: In point, it is deliberate.

MR. MICHELSON: You are trying to control the chemistry.

MR. FISCHER: It's even more than a free surface. The makeup is often times sprayed into that tank through this hydrogen --

MR. CARROLL: The reason for this is at primary coolant system pressure this provides hydrogen -- dissolved hydrogen in the primary coolant, not saturated anymore -- enough of it to combine with any free oxygen.

MR. WILKINS: To prevent corrosion.

MR. CARROLL: Yes.

MR. MARSH: You do not want any oxygen in the primary coolant system, so you input hydrogen to make sure that oxygen concentration is as low as it can possibly be. This is the place in the whole system where you put hydrogen into the system.

MR. CARROLL: The radiolytic decomposition reaction. MR. MARSH: That also. Let me just set the stage for Mr. Steve Mirsky from SAIC. As was earlier said, there have been other events at other plants where we have seen hydrogen accumulation. We saw some at Palo Verde, the suction of their positive displacement charging pump, we have heard about Beaver Valley and also at Farley.

What we did not know is the implications of this hydrogen accumulation in terms of pump performance. We hired SAIC who subcontracted to CREARE, to determine not where it came from but the implications of it; what is the impact of this hydrogen concentration on pump operability. So, Steve will talk to us about that analysis.

MR. MIRSKY: As Tad said, the purpose of our contract with Mechanical Engineering Branch was to perform a technical evaluation of the behavior of charging pump in a PWR with hydrogen in the crossover piping.

[Slide.]

For this specific analysis we looked at a three loop pressurized water reactor with three high head safety injection centrifugal charging pumps. Each of these pumps is a multi-stage, 11 stage pump with a free internal void volume of approximately eight-tenths of a cubic foot. There were also two residual heat removal low head safety injection pumps at this particular plant, and there is a high elevation crossover line from the A RHR pump to the charging pumps that has a long horizontal run greater than 150 feet. This elevation is above that of the pumps, the RHR and charging pumps, and the volume control tank.

For the purposes of this analysis, we assumed this crossover line was filled with 62 and one-half cubic feet of hydrogen, which is approximately the capacity of this line.

MR. WILKINS: What is the diameter of that line?

MR. MIRSKY: Eight inches.

MR. MICHELSON: That's not the ID necessarily.

MR. WILKINS: What's the ID?

MR. MIRSKY: It's a schedule 40 pipe.

[Slide.]

This is a simplified schematic showing the general piping, the elevations relative to the pumps, the volume control tank, the RWST and the containment sumps. In this case as previously mentioned for Sequoyah, there is a hydrogen gas overpressure of 17 psi gage which is also used for scavenging oxygen. I will refer back to this diagram as I go through the rest of my presentation.

Basically, one of the RHR pumps has a high elevation crossover line whereas the other one doesn't. There is also, of course, a source of water during a LOCA from the RWST. The specific sequence of events that we looked at for this analysis was a small break LOCA specifically in the size range between one and four inches. This size range was selected because for this size LOCA the refueling water storage tank water inventory is depleted during the injection phase and the need for switching over to recirculation occurs prior to the reactor coolant system depressurizing below the shutoff head of the RHR or low head safety injection pumps.

So that, there is a need for switch over to recirculation using the RHR pumps to boost the pressure from the containment sump to the charging pumps. What happens is, after the RWST inventory is depleted, switch over is initiated by having the RHR pump suction aligned to the containment sumps, the discharge is aligned to the charging pumps, and then the RHR pumps are started. For purposes of this analysis we designated the point in time when the RHR pump is started as zero.

[Slide.]

The analysis was done in two different phases. The first phase was just looking at the hydraulic response of the piping between the RHR pump discharge and the suction of the charging pump. The second phase was an evaluation of the behavior of the charging pump.

MR. CATTON: You calculated pressure in the piping system --

MR. MIRSKY: Yes. A detailed time sequence analysis was done in which the pump curves of the RHR pump were used in determining the pressure response of the piping and the behavior of the hydrogen gas in this crossover line. What happens is that when the RHR pump first starts it creates a pressure large enough in the downstream piping to shut the check valve connecting the RWST to the suction of the charging pumps, thereby aligning the charging pump suction solely to the discharge of the RHR pumps.

The flow through the crossover line is characterized by a high froude number greater than .7. A froude number is a ratio of inertia to gravity forces. This high froude number has been shown to cause column to flow through the pipe. That is, the water behind the hydrogen gas will push the gas through as a single homogeneous unmixed volume. Also, the pressure increase from the discharge of the RHR pump compresses this hydrogen volume from 62 and one-half cubic feet to approximately 23 cub'. feet.

At approximately six seconds into this event the calculation showed that an 85 percent hydrogen void fraction mixture enters the charging pump, specifically charging pump A.

MR. CATTON: Is it a mixture or hydrogen?

MR. MIRSKY: It is a mixture. There is only pure hydrogen in this volume here. There is some piping connecting down to this isolation valve that is filled with water, so the analysis actually followed what happened to the hydrogen from this point to the entrance of the charging pump. This charging pump has been shut off and isolated, and each RHR pump is just feeding one charging pump.

MR. CATTON: Why didn't the hydrogen --

MR. WARD: You are making some kind of assumption about mixing --

MR. MIRSKY: This is just a simple schematic. Actually, it's a more complex piping network with some elbows, bends and elevation cha s. There are horizontal and vertical runs that are filled with water. It was an actual analysis that looked at the relative velocity of the hydrogen as it entered those volumes with the known flow rate being sucked in by the charging pump.

MR. CATTON: A bit of speculation.

MR. MICHELSON: Where the pipe is totally voided and you are sending a water column from the RHR pump back to the charging pump --

MR. MIRSKY: The pipe is voided in this region.

MR. MICHELSON: Yes. You are blowing a gas column ahead of the water column that is coming out of the RHR pump.

MR. MIRSKY: Correct.

MR. MICHELSON: It's almost pure compressed gas entering the pump for a while.

MR. MIRSKY: You don't compress gas up to this point.

MR. MICHELSON: For a very short time thereafter, that's voided as soon as that compressed gas starts pushing, you void the pipe into the charging pump and then it's pure gas for a while. Then the water column hits it.

MR. MIRSKY: You are talking about the water column upstream. I am talking about the existing water that is in this piping segment.

MR. MICHELSON: That gets voided very quickly, of course.

MR. MIRSKY: Some of it does get mixed. This is a simplified drawing. This is not an exact drawing to show you all the piping connections. There is actually a dead leg here with some water in it, and as the flow goes through the pipe some of the water from the dead leg that is horizontally oriented will flow down into a vertical run of pipe and mix with the hydrogen. There was an actual analysis done to come up with --

MR. CATTON: Is it important how much mixing takes place?

MR. MIRSKY: The only thing that is important is the magnitude of the void fraction.

MR. WILKINS: Eighty-five percent number.

MR. MIRSKY: Being 85 percent is not as important as the fact that it is a high number. The results would be the same if it was 100 percent and the results would be the same if it was 50.

MR. CATTON: The answer to my question was, it really doesn't matter.

MR. MICHELSON: That's right.

MR. MIRSKY: It would matter if there was some configuration in which it was two, three or four percent void fraction.

MR. WILKINS: That would matter.

MR. CATTON: If it pushed the water ahead of it, it would matter.

MR. MIRSKY: If there was a large piping network here filled with water, if the volume of hydrogen was much much smaller so that by the time it reached the inlet to the charging pump the void fraction was very small, that would.

MR. MICHELSON: You somehow think the gas is being pushed on through and sort of mixing as it goes then, or is it a gas piston?

MR. MIRSKY: It's only mixing when it hits the slug of water that is downstream of it.

MR. MICHELSON: Doesn't it behave like a gas piston? It is highly pressurized from the head of the RHR pump.

MR. WARD: See, there's another branch --

MR. MICHELSON: That gets it voided in a matter of seconds.

MR. WILKINS: That is what he --

MR. MIRSKY: We are talking about six second time.

MR. MICHELSON: You are talking about just a few seconds for this whole business.

MR. CARROLL: I bet it will all be clear when you get to your next slide as to what happens in the pump.

[Slide.]

MR. MIRSKY: Just to put the timeframe reference for this particular configuration, we predict at six seconds this 85 percent hydrogen void fraction enters charging pump A's inlet.

The analysis then showed within one-half a second of this hydrogen void entering the charging pump, the pump will stall. What will happen is that the last two stages of this centrifugal charging pump will be filled with water and the first nine stages will be filled with pure gas.

MR. WILKINS: That's what you said, Carl.

MR. MIRSKY: The pump will continue running at its normal operating speed without providing any flow. What it will be doing is balancing the pressure difference between the inlet and the outlet. For this particular sequence the inlet pressure was assumed to be the shutoff head of the RHR pump 150 psi, and the discharge pressure was assumed to be the reactor coolant system pressure predicted for the LOCA of 600.

Those last two stages are all that is necessary to be filled with water to maintain the pressurize.

MR. MICHELSON: I thought the head of the RHR pump was more than 150 pounds.

MR. MIRSKY: For this particular plant it was 150 pounds.

MR. CARROLL: This particular being Farley, right?

MR. MICHELSON: No, Sequoyah, wasn't it?

MR. MIRSKY: I said it is a three loop PWR.

MR. MICHELSON: This is the three loop, okay. How did I miss that?

MR. MIRSKY: This is obviously a very unstable situation for the pump. At this point we made the following conclusions. The pump will fail within a matter of seconds. The only question is how it would fail. I have listed here a number of possible failure mechanisms.

[Slide.]

The pump can seize because of a number of various components within the pump that have a very small clearance and that rely on having water lubricant present. Also, the inboard mechanical seal can fail. Finally, we actually had an analysis to show that the shaft that runs through this pump -- and I believe this is typical of most centrifugal charging pumps -- the shaft is seven feet long supported at each end, and has design deflection at the center of about one-tenth of an inch. You can show very easily by having a small amount of water in one of these impellers in the gas filled area that the unbalance in the shaft will well exceed that allowable deflection. That would cause another means of failing the pump.

Finally, I wish to point out that these results are specific to these particular conditions that were assumed for this particular plant with its configuration in this sequence of events.

MR. MICHELSON: Even if you didn't deflect the shaft, wouldn't you have problem with bearing cooling and so forth since it depends upon flow anyway.

MR. MIRSKY: Yes. You are not going to maintain -- the pump is not designed to operate in an all gas environment basically.

MR. MARSH: Steve, will you comment please on what would happen to the pump if it happened to survive and more water got into the suction of the pump? In other words, if water were to arrive at the suction of the pump.

MR. MIRSKY: Most of these methods of failure would occur either with just operating in a nice, quiescent gas fill environment or when the first additional drop of water entered the pump. The pump impellers are not designed to be rotating at 1,700 RPM in a gas environment. Once the first additional amount of water entered and started rotating around in the impeller, it would cause such a hydraulic imbalance --

MR. CATTON: Eighty-five percent void, that's a lot of water.

MR. MIRSKY: It was 85 percent hydrogen void.

MR. CATTON: I see. Fifteen percent water.

MR. MICHELSON: Yes.

MR. MIRSKY: The pump is not designed to pump 85 percent void solution.

MR. MARSH: As part of this study, SAIC looked at pump data, pump test data, to find out what void fractions had been studied in terms of pump performance. Correct me, but there is very little data about --

MR. MIRSKY: Basically, none of the pump manufacturers test their pumps with any kind of a void fraction. If you ask them the reason why, it's because it's too expensive.

MR. CARROLL: Too expensive.

MR. MIRSKY: It will destroy the pump. Most pump experts will agree that up to somewhere in the range of about five percent void fraction they would expect the pump to survive without any damage. Most pump data that has been done with limited pumps -- not multi-stage centrifugal charging pumps -- shows that about 20 percent void fraction the performance of the pump degrades significantly.

MR. CARROLL: In normal operation of the pump, because of the pressure drop going into the suction, you probably have a small void fraction of hydrogen given the system is saturated with hydrogen.

MR. MIRSKY: The key word is small though.

MR. CARROLL: Yes. It normally runs with some free hydrogen.

MR. MIRSKY: I would also point out that eight-tenths of a cubic foot is the total internal free volume of the pump. We assume 62 cubic feet that was then compressed to 28. Eight-tenths or a little bit less than eight-tenths cubic feet was in this pump at the time it had this event occur.

MR. CARROLL: The rest of it is back up in the suction --

MR. MIRSKY: It hasn't gotten down, yes.

MR. MICHELSON: Is there much of a tendency for the hydrogen to come out of solution when the pump is in lay-by? These pumps, many of them, are routinely in lay-by.

MR. MIRSKY: I don't know the answer to that.

MR. MICHELSON: What keeps it in solution -- if you have enough overpressure I guess you can, but there isn't much overpressure on the suction. Usually there are vents provided on the pumps so once in a while you are supposed to go down and get your air out. I just wonder if they have had much experience with the gas accumulating; that was really going to be my question. Have they had much experience with gas accumulating in lay-by pump?

MR. MIRSKY: My only knowledge is that when a pump starts exhibiting any abnormal behavior that it is shut down immediately.

MR. MICHELSON: Yes, but it's too late if it's gas.

MR. CHAFFEE: I do not believe that any of us here know the answer to your question, Carl. I don't think we have information on that.

MR. MICHELSON: I don't think it's much of a problem and I haven't heard, but there are provisions usually to vent the pumps as well, the pump casings as well.

MR. CARROLL: How does the analysis that you performed comport with what we heard earlier, that Westinghouse thinks up to six CFM --

MR. MIRSKY: I don't think that we have access to all the information that is the basis for that number.

MR. MARSH: As I said earlier, we don't know the basis for six cubic feet. It very well may be for various plant configurations that six cubic feet is an acceptable number. It depends a lot on how that six cubic feet gets fixed and how it arrives at the pump, the pump volume, and all those performance numbers. We don't know.

We do know that for this plant configuration which was a real plant that it really did have this volume in it, and it was very deleterious to the pump performance.

MR. CARROLL: Yes, indeed.

MR. MARSH: That is with a high degree of certainty. It does depend -- you were saying it doesn't matter of the 85 percent. That's true, but it does matter in terms of smaller volumes and how that smaller volume arrives.

MR. CATTON: When I said it didn't matter I was referring to questioning the calculation. If 85 percent, 60 percent, 90 percent all does the same thing, then how good you do your calculations it doesn't really matter. That's the point.

MR. MIRSKY: The only importance of calculation is that if you had a much smaller volume the --

MR. CATTON: I understand. I was concerned about doing a lot of mixing calculations, and there's a lot of assumption and approximations to do it. Then you arrive at 85 percent, and the question is how important is the 85 percent. The answer was not too important.

MR. WILKINS: Because you are so high.

MR. CATTON: That's right.

MR. MARSH: We heard earlier today about another plant that had a pretty small volume, like 4.7 cubic feet. We don't know the importance of 4.7 cubic feet.

MR. CATTON: Whether or not that could lead to the same thing.

MR. MARSH: That's true.

MR. CATTON: That's right. Here, you have lots of gas.

MR. MARSH: The conclusions are relatively easy. This study had not been done before to our knowledge. No one had taken a volume of gas in a particular configuration for a particular pump and found the impact of that gas. We think it's important because it leads us to take the next step, which you are going to hear about in just a minute.

MR. CATTON: That, through a complex piping system and predictive void fraction downstream somewhere, is not an easy thing to do.

MR. WILKINS: That's true.

MR. WARD: It seems it's really not so important whether there is this 62 and one-half cubic feet or ten cubic feet, but it is really the mixing that you get before it enters the pump that is important. Even if there is only five cubic feet, if it doesn't mix adequately, it takes six seconds to blow the pump.

MR. MARSH: It does depend a lot on how the system is operating. It depends on the method in which the RHR pump is started, valves are operated, which pump is operated because of various elevation. It's a complex problem.

MR. WILKINS: This Westinghouse letter in TVA 88-825 was sent from Westinghouse to TVA, I assume. Does the NRC routinely get copies of such communications?

MR. MARSH: No, sir, we don't.

MR. WILKINS: We routinely do not get them. You have said that you don't know the basis of this, and I infer from that that you haven't even seen TVA 88-825. Am I jumping to conclusions?

MR. MARSH: We have not seen that letter. We routinely get Part 21 notifications from vendors to particular plants. I don't believe this was a Part 21.

MR. MIRSKY: We have seen the six cubic foot number previously, but not an explanation as to the basis.

MR. WILKINS: You haven't seen this 88-825 which presumably contains that engineering --

MR. MARSH: We may or may not have, we don't know.

MR. CARUSO. We haven't seen the analysis or the documentation, but we have been told that the six cubic feet is coming from the five percent mixing. How they get there, what they did to get there, we don't know. That is where that number comes from. It is consistent with the five percent where people feel if you are below five percent you are going to have a problem. If you start to get above five percent --

MR. WILKINS: I guess I am having a problem with a procedural matter. Do you have -- have you been told that Westinghouse will not send you a copy of that letter? Have you requested it?

MR. ROSSI: We can get anything that we want related to the safety of the nuclear power plant from Westinghouse by asking them for it, bringing them down for a meeting, or whatever we want. It depends on how deep and how quickly we choose to dig into a particular issue.

MR. WILKINS: I infer from that, that you haven't asked them for it yet.

MR. ROSSI: Apparently we haven't. We haven't gone back and probed as yet where we are going. Maybe you --

MR. CHAFFEE: I guess there's a little confusion on that. I guess we have -- we do have the document that TVA sent to -- that Westinghouse sent to TVA which simply says this is the number. What we don't have, I guess, is the engineering analysis that it is based on. I guess we are not even sure -- we don't even know if that exists.

MR. WILKINS: That wasn't made clear. You have the document but what you don't have is the engineer that wrote the document.

MR. CARROLL: The engineering analysis may be as simple as someone pulling a number up.

MR. ROSSI: Let me just address that procedural thing just a little bit more. Westinghouse is obligated, if they determine that there is a flaw in something they have sold to a nuclear power plant that would lead to a substantial safety hazard, they have to tell us about it under Part 21. Once they tell us about it under Part 21, we can probe as deeply as we choose into all the backup information and all that kind of stuff that there is.

Now, there is a level of information that is passed from Westinghouse to their customers and licensees and so forth, telling them about problems that we do not routinely get. I mean, they don't routinely put us on the distribution. In many cases we find out about it as soon as the licensee gets it because the licensee will decide it's a big enough problem that they have to tell us about it, either in a telephone call to our operations center or by submitting an LER. Once we know about it, we can obviously go back and probe again as deep as we wish to probe.

Now, there are a number of issues that are supposed to be handled by a licensee being responsible and responsive to any sort of information that he gets from a vendor of any equipment that he gets on his plant, and he is obligated to evaluate that information and do whatever is appropriate to keep the plant operating safely. What we generally do is monitor that process, and if we decide it isn't working in a particular case, we can jump in and issue a bulletin, a generic letter or order, or whatever it takes to make the licensee fix the problem.

What we do with information is, on the issues which we think are reasonably important and where we want to make sure that every licensee knows about the problem, then we issue an information notice. Again, once a licensee gets an information notice and he knows this information, he is obligated to do at least some kind of evaluation to determine whether it applies to his plant. If there is a safety problem he is obligated to fix it.

Does that help on the procedural matter?

MR. CARROLL: One other related issue. Has Westinghouse seen the SAIC analysis, or are they aware of it?

MR. MARSH: Yes, they have. We had a meeting with Westinghouse, with SAIC, CREARE, the staff, to make sure that the assumptions that were made by SAIC and CREARE were acceptable assumptions. We didn't deviate from the actual system configuration of the way the system would really perform.

MR. CARROLL: Tha[illegible] ssumptions that went into the analysis.

MR. MARSH: That's right. And, the analysis as well.

MR. CARROLL: Have they seen the analysis?

MR. MARSH: We had a two hour meeting with them, where we went through the same presentation in much more detail.

MR. CARROLL: What was their reaction to that?

MR. MARSH: No comment. We were asking them for, are we correct, are the conclusions correct, and what do you guys think about this. They said it looks like it's probably right. Some of the assumptions may be a little quibbable in terms of the froude number whether it's a little bit below or not. My remembrance if that it was a basic agreement.

MR. CARROLL: When did that meeting occur?

MR. MARSH: July.

MR. MIRSKY: July of this year. I would like to point out also that although Westinghouse may be responsible for their plants, the piping configuration is not a Westinghouse item. It is an architect/engineer. Every plant, maybe every two unit plant, may have entirely different piping.

MR. SIESS: If they were standard, they could all be wrong.

MR. CATTON: -- an arbitrary piping system, and arbitrary amount of gas and predict the void fraction as a function of time of the pump inlet.

MR. MIRSKY: Right. That's a difficult problem.

MR. CATTON: I would like to see your analysis, if that is possible.

MR. MIRSKY: Yes, sir.

MR. CATTON: I think there are some tricky things that you have to deal with.

MR. MARSH: There's much more that was done than what Steve is talking about. Time step analysis that he went through is a very detailed analysis. For each piping run as a function of time, calculated void number and how the fluid went through the piping, there is much more to it and we would be glad to share it with you.

MR. CATTON: I would like to see it.

MR. CARROLL: Okay, where do we go from here?

MR. MARSH: We would like to ask Mark Caruso to now discuss -- to summarize the event study that was done and where we go from here.

MR. CARUSO: There are a couple of important points that we heard this morning. One is the ability to get this hydrogen gas accumulating as a source of it is very well generic. We have a lot of plants out there that have the hydrogen cover gas in the VCT and the piping for charging also doubles for ECCS, and there is potential for having accumulation. From there it gets to be, as you said, tricky as to whether or not you have a big problem or a little problem or any problem depends on getting this gas out of solution. Where that can happen and where it can accumulate, that is dependent we think very much on the particular piping system and particular arrangements.

[Slide.]

In the case of Sequoyah and some of the other plants, there appears to be the propensity for getting absolution and having it accumulate at least in one case, a large volume. I think our feeling is that to study this problem somewhat more at the NRC level is really not going to identify where a problem exists and doesn't exist. A licensee have known about the potential for this problem -- we have assumed that they have been fixing it if they have the problem, evaluating their systems, taking action. The Sequoyah event raises a concern that it is not happening in an adequate way.

I think our feeling is that it is time for the licensees to do it if they haven't done it, evaluate and inspect if necessary with the ultrasonic devices, determine whether or not --

MR. CARROLL: Does this present information notice tell them about that technique?

MR. CARUSO: I don't believe it discusses that.

MR. ROSSI: The notice does not tell them about that. Maybe that is something that we need to look at, as to whether they all know about it. I gather that there has been other communications to the licensees --

MR. CARUSO: There has been a generic communication from Westinghouse to licensees.

MR. CARROLL: Talk about ultrasonics as a technique for finding these void spaces?

MR. CARUSO: I'm not sure. I would have to look.

MR. CARROLL: Maybe INPO has told them.

MR. ROSSI: That is something that I think we need to look at, whether they have been adequately informed of the technique.

MR. CARROLL: That's a pretty easy way to show what you got.

MR. MARSH: One thing we want to focus on though is yes, suppose they have a good way of determining where the volume is and what the volume is at that point. That still doesn't mean that the volume that they are trying to keep the system down to, the hydrogen volume, is an acceptable number. I think what we are concerned is that the number itself that some licensees may be trying to keep the number to might not be the right number, as well as the detection for it and actions to keep it at that number.

MR. CARROLL: If I know for example that I have a dead leg I can't vent, that is an important piece of information.

MR. MARSH: Right.

MR. CARUSO: We would basically in general propose that they evaluate and inspect and determine the propensity for accumulation in their piping, and the availability of vents at locations they need to have them at or continuous vents. We would think that in the short term if they have the problem that they take a short term action to reduce the potential for accumulation. Sequoyah did that to the extent of finding that just using their positive displacement pump because of the recirculation piping tended to reduce that potential.

Also, to vent with the vents that they do have until they can develop and implement more permanent fixes that take care of the problem. Taking care of the problem is not clear to us. I think we would like to have zero cubic feet of gas and that's what they would need to strive for.

This particular issue is somewhat similar to an issue that we had back in the mid-1980's, steam binding of aux feedwater pumps, where you could have steam leaking back through recirculation lines which are connected to a common header so you could have the problem of leaking into multiple pump suction. In that issue we asked licensees to inspect and determine if they had a problem and take actions to fix it, although I think in that particular case there may not have been hardware fixes other than preventing the leakage of the steam with the check valve fixes.

In this case, the leakage if they have it, I think what we found is if they are accumulating it is happening fairly rapidly;and that, to fix that there's needs to be some sort of continuous vent maybe.

MR. CHAFFEE: In the case of Sequoyah, they figured they were producing gas at the rate of one-half a cubic feet an hour. So, it's fairly rapid. Also, you talked about the fact that -- how much gas is enough and a problem or not. I guess in Sequoyah's case, they apparently did have an appreciable amount of gas in their charging pumps. It is not clear -- I guess from talking to the project manager they may have had such a large quantity that there may be some uncertainty -- it may add to some uncertainty in terms of how much gas it really takes to cause a problem.

I guess as you have seen from the analysis and stuff, there are a lot of subtleties to this thing.

MR. WARD: Mark, on the steam binding of the aux feed pumps that you referred to, wasn't one of the solutions or corrective actions taken in that was to ask the licensee to make use of any ability they had to monitor the temperature of those? That is kind of parallel with the --

MR. ROSSI: That one had an easy solution, in that you could go and feel the piping too and tell what the --

MR. WARD: Parallel with that is Jay's ultrasonic monitoring I guess here.

MR. CARUSO: My understanding of the technique is that it is very good at finding the boundary between the liquid and the gas. I think what they are doing is looking for the boundaries and saying I have the size bounded and how big the pipe is and how much --

MR. WARD: Yes.

MR. CARUSO: Another corrective action that I believe has been taken at least at one plant is to insert water seal between the RHR pipe that we talked about that feeds the charging pumps and the charging pump suction to basically be a barrier for migration. In that case, it is essentially probably reducing significantly the gas and the suction but it could still leave in the RHR pipe gas up there, which is very much of concern.

We don't think that the fixes are all that complicated, and we would imagine if we were to implement generic action that these things -- immediate actions could be taken as they were taken in Sequoyah and longer term actions could certainly be done we think, at the next outage if mods are necessary or that complicated.

MR. CARROLL: What you are saying is that you are just going to put out another letter with a bigger four by four in it to get people's attention.

MR. ROSSI: That's our next choice. If we decide that we have to do that, we can put out a bulletin or generic letter that requires a letter back from the licensee telling us what they have done and so forth. We can go to any level --

MR. CARROLL: Your present plan is just to put out an information notice?

MR. ROSSI: We have done that. We have put the information notice out now. Now, we are continuing to look at the problem.

MR. CARROLL: You are speaking of the one that is going to go out on December 10 or whatever?

MR. ROSSI: Yes. That one will go out, because it's on the way right now in the process. People are continuing to look at the appropriateness of sending the next two by four out, so to speak. The next two by four -- it means that we have to get more into the process of telling them how to fix the problem. That is what the next two by four means.

The information notice means here is the information, and it leaves it open to the licensee as to how he goes about fixing the problem.

MR. WARD: How much does this problem increase core melt risk in a three loop PWR.

MR. CARUSO: I don't think we know that answer.

MR. MARSH: I don't think it is insignificant. I do not. I think there have been studies that showed the circulation post-LOCA is, there are risks that are there, and that is a contributor.

MR. ROSSI: As a matter of fact, our notice says that the loss of high pressure recirculation capability of Sequoyah during a small break LOCA is a risk contributor for core damage frequency identified in 1150. You have to go on, what is the probability of this particular --

MR. KERR: The fact that it is already high may mean that this is not a significant contributor also. I think that's unlikely but it could mean that.

MR. CATTON: You mean, it's not going to make it that much higher.

MR. KERR: Yes.

MR. CARUSO: I don't think this particular failure mode of the pumps has been factored into risk analysis. There are other --

MR. KERR: That may well be, but it might be -- it could be that even if you factored it in it wouldn't have much effect, if the failure of the pump is already a significant contributor.

MR. LONG: This is Steve Long of the staff. I am in the Risk Applications Branch. I took a look at the NUREG 1150 PRA for Sequoyah, and it essentially asked that same question. If you fail one train of recirc which is what this will potentially do, because there's another train that it not affecting -- you just about double the core damage frequency from Sequoyah. It is a significant problem.

MR. MICHELSON: To what extent --

MR. WARD: Part of the risk, by the way --

MR. KERR: You don't know what the likelihood of failing the two simultaneously is. Until you know that, I don't think you know it is a significant problem, do you.

MR. LONG: I was really trying to give you a feeling for the exposure because you asked could it be a problem.

MR. CARROLL: There is a real common mode problem there though because --

MR. KERR: It's a problem only if it has a high probability, Jay.

MR. CARROLL: I understand.

MR. KERR: I don't mean it isn't. I am simply saying that the fact that it can potentially happen doesn't mean it is a big risk contributor.

MR. LONG: One of the things that adds to the potential risk is that there is currently no tech spec that requires you to flow test the crossover piping or to do anything other -- you don't have to vent the suction piping or cross piping. If a bubble occurs there it can persist for years. You test the stroke times of the valves in that piping, so you provide a mechanism for migrating the bubbles around. If they are produced in the charging header they can move up and continue to accumulate in the valves that normally -- there is a lot of exposure there. The problem is definitely worth looking into.

MR. WARD: Could I just get a repeat of that point? My impression was that if there is a large bubble in the piping that it is just sitting there forever. I mean, it's not --

MR. CARROLL: It ain't going to go away.

MR. MICHELSON: Yes, that's right.

MR. ROSSI: That assumes that the licensee does nothing to go and look and see if there is a bubble.

MR. WARD: I mean, if there isn't any action taken --

MR. RO??I: That means he would have to comply to a large extent the information that has been conveyed to him in information notices and by Westinghouse and so forth.

MR. WARD: Aside from the analysis that has been made recently, the mechanism for the bubble formation isn't something that just happens every now and then. It is an equilibrium situation with the plant.

MR. MARSH: It probably is. If there are high spots, there probably will be gas accumulation, and absent some kind of action it will stay there. We have heard theories that it is just recirculation during the recirc flow of the charging pumps, but we have seen other plants where that is not the case. In the Palo Verde case, operating the control tank in an incorrect manner caused them to accumulate gas in the charging pump volumes and to starve the charging pumps. It can occur in a number of different ways.

I think we are not sure about Farley and how it accumulated there. It may have been that just the suction flow path with no recirculation phenomena -- just the suction flow path where it is bends and elbows caused gas to come out of solution and to migrate to high spots. You are not sure of the mechanism, and it probably is a natural phenomena for that system.

MR. CATTON: Is there consideration for the ELWR's?

MR. CARROLL: I haven't heard any discussion of that.

MR. CATTON: We ought to raise this issue.

MR. CARROLL: We ought to raise this issue.

MR. MICHELSON: The gas binding of pumps, of course, is not unique to high pressure pumps, it is not unique to pressurized water reactors. Boiling water reactors also have an interesting set of gas binding potentials.

Are you looking at that full spectrum, or are you focusing just one PWR high pressure?

MR. MARSH: Up until -- that's part of the process that will have to be gone through for the generic communication to determine how widespread this communication of this sort needs to be.

MR. MICHELSON: While you are going through it, perhaps you should give some thought to a problem which is almost age old now -- early 1970's -- and it still exists possibly today, the resolution at that time was done at that time, and it may not stand the light of day today. The problem is simply that of boiling water reactors during post-accident to pump from a suppression chamber, keeping in mind you are pumping aerated water.

The gas from the dry well has been bubbled through the wet well, the steam is condensing, the gas is finally divided. The estimates at that time where there was a several percent average void fraction potentially in the suppression pool. The real problem is that if you can keep that divided and uniformly distributed, the low pressure centrifugal pumps can probably ingest it and get it through. If you allow it to start to strip in the appropriate piping points on the suction, you are going to build up gas bubbles, you are going to lose suction heads, you are going to hit the pump with gas bubbles and you got a real problem.

The resolution was that it will be finely divided. I don't know if that was a staff resolution or a General Electric resolution. In looking at the gas binding question again, I think you ought to go back and at least revisit the question of what are you trying to pump particularly during post-accident. You are also getting into almost the same problem after the relief valve problem on boilers were fixed because of the instability of relief, they put all these feet in and so forth. They also had to add vents inside the drywell to keep those pipes empty when the valves weren't operating. Those vents also aspirate the air then.

So, whenever you are venting during an isolation you are venting a steam air mixture, steam coming from the reactor and air coming from the drywell. Again, there is a question of aerating the suppression pool, and can you keep pumping that without stripping the gas and getting into problems.

While you are looking at gas binding, I think that one ought to be revisited because a long time ago people decided that was a non-problem.

MR. CARROLL: Is there any more on this particular issue?

[No response.]

MR. CARROLL: Let's hope the remaining three don't take as long. In fact, it's 10:00.

MR. MICHELSON: It's a good time for a ten minute break, until 10:10.

[Brief recess.]

MR. MICHELSON: Let's proceed.

MR. CHAFFEE: The next event that we are going to talk about is the MSIV closure at Brunswick. Al Belisle, who is a Section Chief in Region II and led the AIT, will talk to us about this event.

MR. BELISLE: As Al Chaffee explained, my name is

Al Belisle. I am the Section Chief of the test program section. I happened to be at Brunswick when this -- right after this event and when the determination was made to make a team I was chosen to lead the team.

Basically what happened was, it was a scram. The problem was the scram would degrade performance of some valves. The cause was a violation of plant procedure. That is unique, and I will discuss that in just a minute. The safety significance was the unnecessary challenge to the plant safety systems. Both units were operating at the time. A staff briefing was held for routine surveillance that had to be done that evening. The work was basically dispositioned among the technicians.

One of the tests that had to be done had to do with PCIS containment isolation. The way Brunswick administrative procedures are written, this requires two people to do it. The technician, about 9:00 o'clock that evening, the technician received permission from the control room operator to commence this test. The man that was assigned with him to help him perform this test was back in the INC shop helping some other technician repair a recorder.

The technician commenced to do the test. Basically it's a four sequence test. He goes into cabinet A-1, generates a trip signal, verifies some lights and breakers work and the appropriate lighting is received in the control room, clears that channel, goes to the second channel and does essentially the same thing, clear those signals and goes to the third channel. When he was in the third channel what he failed to do was clear the signals.

Consequently, when he went to the fourth channel with one channel partially tripped and put the test signal in, the plant scrammed on a two out of four coincidence signal. Just prior to the scram he came out to talk to the control room operator. As the control room operator was going back to talk to him, the control room operator says did you just give me this scram signal? The instrumentation technician says, I just put the test module in. I think it must have spiked.

The communication, what they were actually talking about was two different channels. The control room operator was talking about the insertion of the scram signal on channel A-2 and the INC technician was talking about the scram signal because he put the test module in channel B-2. The lack of communications between the two guys basically said -- and then the control room operator said oh, okay, thinking that they were talking about the same channel when in reality they were talking about two different channels.

Because they were talking about two different channels when the INC technician put the signal in on the B-

2 channel it caused the plant to trip. When the plant tripped--

MR. SHEWMON: Is there anything that the second technician does except to watch and double check what the first technician does?

MR. BELISLE: The second technician's function is for independent verification. When the plant tripped, the first technician got on the MC system and called the second technician and says come out here real quick. He says I have been doing the test and everything is okay. Here, sign my procedure form. We didn't have anything to do with the scram.

The second technician, recognizing honesty and integrity or whatever you want to call it, did it.

MR. MICHELSON: Did it, meaning sign it?

MR. BELISLE: He signed for steps that were not verified. Later into the event the site incident investigation team met about midnight, and by 4:00 o'clock they had talked to the technicians and says what you say on this piece of paper could not have happened and what did happen. Basically they extracted confessions from the technicians that said we lied.

During the course of the event, reactor pressure reached 1,133 pounds and some of the safety relief valves did not operate. Those safety relief valves that did not operate were put under quarantine and sent to Wylie for testing. During the subsequent testing at Wylie they were basically found to be set high. Previous to their installation during the last outage they were also set within specs at Wylie, and this is kind of an ongoing issue in safety relief valve drift.

MR. CARROLL: Wylie had performed the last actual setting of them but --

MR. BELISLE: Yes.

MR. CARROLL: What is the explanation, do they know?

MR. BELISLE: They expect some pilot seat bonding.

MR. MICHELSON: Some people think it's hydrogen, I guess.

MR. BELISLE: I am not a safety relief valve expert, so I can't address your issue one way or the other.

MR. MICHELSON: I think it's still premature to talk about them but they do have a sticking problem. Some people, including one of our former members -- this has been going on for years more or less -- thought that it was hydrogen welding.

MR. BELISLE: It gave one data point, in that the unit had only been operating for a couple of months since coming up from their outage. During discussions with the plant people and these safety relief valve problems, it was never known if this was something that occurred over the course of the outage or something that happened just as soon as you put the valves back in and heated them up. At least this gave one data point that since the plant had only been operating for a very short period of time it appears that the bonding may be reasonably rapid. That's hypothesis on my part.

MR. MICHELSON: They did test the valves again at Wylie, or do you know?

MR. BELISLE: Yes.

MR. MICHELSON: They were now tested within their set point or found high?

MR. BELISLE: They popped the valves four times at Wylie. The pressures on the initial pop was anywhere from about three to ten percent high.

MR. MICHELSON: And then, after that?

MR. BELISLE: After each test pressure started to come back down again. The basic conclusion of the AIT was the scram did result from an intentional departure from procedural compliance exacerbated by a lack of command control by the operations people. The transient was complicated by some equipment failures, poor procedure aids, and negative training on the simulator.

MR. CARROLL: What were the operations people supposed to do?

MR. BELISLE: The operations -- what were they supposed to do, I'm not sure I understand.

MR. CARROLL: Your statement is that the problem was exacerbated by their lack of command and control. What did you feel was lacking there?

MR. BELISLE: When the communications, prior to the surveillance maintenance being performed, what the INC technicians do -- there's a rip off sheet on the surveillance test. He gives that to control room operators. This basically tells the control room operators, these are the following alarms that you are going to receive. Obviously, these alarms were received during the course of the evolution.

From our perspective the control room operators, since they do so many surveillance -- this is a routine evolution -- they get what we felt was maybe ho hum, it's another routine evolution and no big thing. When the instrument and control technician gave him the signal from channel B-2 that showed that the channel was in trip, he already had an indicating light -- an annunciator light showing him a valid scram signal on channel A.

We felt that when we discussed this with the control room operators and asked them point blank, you had this channel in scram and you had this channel in test, didn't that alert you to the possibility that when that instrument and control technician cranked his signal you were going to drop the plant. He waffled on that point somewhat during our discussions. We felt that maybe perhaps this is such a routine evolution that it maybe got to be sort of dull and boring because it was a later Sunday night or whatever.

A more positive control by the control room operator -- he had the opportunity to ask the question. When him and the INC technician met and discussed he is talking about channel A and the INC technician is talking about Channel B, he could have been more positive. He should have -- we felt he should have been aware -- more cognizant of what the INC technician was doing.

MR. CARROLL: These two techs were on shift or were called in specially to do this?

MR. BELISLE: No, they were on shift, as part of the routine weekend duties.

MR. WILKINS: Should the control room operator have known that there was only one technician in the room doing the work?

MR. BELISLE: The channels, relative to where the control room operators are, probably are separated by 50 feet or so. Unless he had physically walked back there and talked to Joe or Harry he probably would not have known.

MR. WILKINS: Let me rephrase the question differently then. Should he have asked -- can they communicate without his walking back?

MR. BELISLE: I believe there is some communication back there, but I am not sure. Should he have asked?

MR. WILKINS: Yes.

MR. BELISLE: That's an interesting hypothetical question which gives a hypothetical answer. Their administrative controls require a test of this type to be done by two people. So when the technician came to the control room operator and said I am ready to start this test, there would have been nothing to trigger the control room operator that he was doing the test by himself. These were seasoned technicians, they had been there for the average of I think -- one was there for seven years and the other guy was there for five years. They are not brand new people.

This is a routine evolution and they do it every 31 days. Both of these INC technicians had done it before on multiple occasions.

As corrective action because of what happened, they basically fired the two technicians. They re-performed the surveillance test, they went through and evolved some new maintenance pre and post-job briefing requirements. The plant manager conducted personnel meetings with all plant work groups. They instituted a course of formalized communication between the control room operators and people performing work in the plant. Maintenance people adopted some standards of excellence and upgraded some procedures, and did some work on the simulator.

MR. WILKINS: Let me approach my point in a different direction. These two technicians have a supervisor.

MR. BELISLE: That is correct.

MR. WILKINS: Where was the supervisor?

MR. MICHELSON: Could you use your microphone Ernest?

MR. WILKINS: These two technicians have a supervisor; where was the supervisor?

MR. BELISLE: The supervisor was not observing this particular test, he was tied up on other duties.

MR. WILKINS: The AIT and management the plant determined that he didn't fail to do anything he should have done?

MR. BELISLE: The supervisor?

MR. WILKINS: Yes.

MR. BELISLE: It has been -- Bill, please correct me if I am wrong -- it has been a long running issue I believe at Carolina Power and Light. I am speaking -- please keep it in perspective -- beyond the grounds of the

AIT. More supervision and day-to-day involvemen: s required by their people.

MR. WILKINS: This is just one more instance of --

MR. CARROLL: On something with experienced people as experienced as this a supervisor wouldn't normally be looking over their shoulder.

MR. WILKINS: Understood. Would the technician have said to the supervisor, I am about to start this.

MR. CARROLL: Not necessarily. He probably has a list of surveillance tests to do and just goes off and does them.

MR. BELISLE: That's exactly correct.

MR. WILKINS: Okay.

MR. LEVIS: This is Bill Levis, NRC Staff resident inspector, Brunswick. I would like to add one little thing to this. The technician was flying through the test. These channels typically take about 15 minutes a piece to do, so you would expect an hour total duration for the test. However, this technician was averaging four to five minutes per channel.

The supervisor, I wouldn't expect him necessarily to have gone out and actually watched this test while he was performing his supervisory duties.

MR. CARROLL: Once in a while it isn't a bad idea for a supervisor --

MR. LEVIS: That's correct. The supervisor is required to go out and monitor activities that he is responsible for. Had the test taken an hour, that very well might have occurred. We have seen them at the site, other supervisors monitoring the activities of this particular crew.

MR. WARD: Perhaps I didn't hear and I apologize for that, but is there any indication of whether or not this was an isolated incident or whether there is a pattern of testing like this?

MR. BELISLE: This was thoroughly investigated by the licensee staff, by their QA staff, and this truly appears to be an isolated instance. This is basically a plant manager's nightmare. They guy was winging it, for lack of a better explanation. Are there any other questions or comments?

[No response.]

MR. BELISLE: Thank you very much.

MR. CARROLL: Al, in terms of the sequence of what comes up in our remaining time, if we can't get to both of them is one or the other a better one to pick in terms of people being from out of town or something like that, that couldn't conveniently come back next month?

MR. CHAFFEE: I would suspect that you would want to probably hear about the other Brunswick event.

MR. CARROLL: All right.

MR. SIEGEL: Why don't we have Rudy Karsch go ahead and take us through that. I think you will find that one of interest.

MR. KARSCH: Good morning, gentlemen. I am Rudy Karsch, in the Events Assessment Staff in NRR.

[Slide.]

There are a lot of interesting aspects to this event. What you might not be familiar with are some of the human factors aspects. If I could digress for just a moment, I would like to go through those. We have identified those as one of the key areas in the problem are of this event.

The safety significance that we identified as the loss of offsite power challenges the emergency power systems. Emergency diesels are not one of the highest reliability items in a nuclear plant. We tried to avoid challenges to that system or reliance on emergency diesels for a long period of time.

Unit 2 was initially operating at 100 percent power when a ground fault alarm was received in the control room. Typically plants operate with a neutral grounding system on their transformer so that they can detect ground faults either in the switchyard or in the distribution network. In a three phase system you can tolerate one ground, but a second ground will cause high circulating currents that could damage transformers. Typically at a certain point the transformer will lock out and be isolated from the switchyard and from the distribution grid to protect the transformer because they are high cost items.

The crew in the control room received the ground fault, they notified the Carolina Power and Light relay crew man who is not necessarily associated with the nuclear site. They travel from site to site within the utility's distribution system. This man was alerted to the ground fault, and was called in to trouble shoot. June 17th was a Saturday. This was toward the end of their shift, and he was probably contemplating going home when he was called in and put on overtime to do the trouble shooting.

At the time they called the relay crew man in, the plant manager was called at home and advised of the problem in the switchyard. The plant manager felt that in case there was a transformer lock out, he wanted the operators to reduce power in the reactor by driving rods in. The reason he wanted them to do that was, if rods are inserted into the -- for a GE plant they come in from the bottom -- this tends to minimize the possibility of core instability, core oscillations if you have a recirc pump trip. So, he was sensitive to the fact that if they had a transformer lock out, the way their line up of the recirc pumps was on their buses, they would get a recirc pump trip and it could throw them into core oscillation. He wanted to avoid that if possible.

Here is one of the first instances of the human factors error. The operators didn't understand where he was coming from in asking them to reduce power. Instead of reducing power by driving rods in, they reduced power by running back recirc pump flow which really doesn't do anything for you. They were still at 100 percent rod line.

The relay crew man was in a hurry to get through the trouble shooting of the ground fault indication, and he strongly suspected that it was a problem in the indicating system logic and not an actual ground fault. He warted to eliminate that possibility first off. He called into the operators and said I want to put a jumper across the neutral grounding transformer, thinking in his mind that they had a current transformer. All the non-nuclear sites on CP&L's grid use current transformers for neutral grounding whereas, the nuclear sites use potential transformers for neutral grounding. The operator gave him permission to do that, picturing this is a jumper. In their experience when people come in to trouble shoot INC. This is the kind of wire that they use. When in actual fact, picture a set of battery jumper cables, something with number six wire. That is what he was going to jumper this transformer with. He got up on a ladder with his hot stick, attached the jumper to the transformer bushing and the other side was connected to ground, the thinking being that if it's a current transformer and you short across the winding of the current transformer if the light stays on saying you have a ground fault it's a problem in the indicating system, a stuck relay or something like that and not an actual fault.

What he did when he installed that ground -- this gave a second ground to the system because they had a legitimate ground in their bus from the transformer to the switchyard, got the high circulating currents -- probably maybe an instantaneous current of 100,000 amps and immediately vaporized this large piece of wire, blew the guy off the ladder. Fortunately, it didn't kill him, although afterwards he might have wished he was dead.

It gave him the second short and immediately locked out the transformer to protect the transformer and the recirc pumps tripped. Let me catch up with this slide here.

[Slide.]

MR. CARROLL: The start up transformer is receiving power from offsite and running and energizing the bus that the recirc pumps are on?

MR. KARSCH: Right.

MR. CARROLL: They don't use an auxiliary transformer which --

MR. KARSCH: You mean like a reserve transformer or something like that?

MR. CARROLL: Yes.

MR. KARSCH: No, this site does not have that.

MR. CARROLL: You don't have a picture of the electrical arrangement with you?

MR. KARSCH: We brought one, if you wanted to get into that aspect of it.

MR. CHAFFEE: They do have an aux transformer, and they do have the capability to power the recirc pumps to the aux transformer, but this licensee has chosen to power theirs through the start up transformers, as I understand it.

MR. CARROLL: Do you know why?

MR. KARSCH: They call it the unit transformer. They have a unit transformer and a start up transformer. Yes, we do know why. Let me just describe the bus set up real quick, and then I will get into why they had it set up on June 17th the way that they did.

MR. CARROLL: Okay.

MR. KARSCH: The unit transformer is driven off of the turbine generator. They have a breaker and a bus and start up transformer. Then they have the step up transformer that goes out to the switchyard off that same isophase bus. The recirc pumps are powered off the start up transformer, the breaker from that unit transformer to close on that bus is open.

The reason they do this -- early in the life of the plant they had a lot of trips of their generator or of actually their reactor which caused a generator trip. When the recirc pumps were powered off the unit transformer which, at that time, was their preferred line up, every time they get a reactor trip they lose the recirc pump seals because of the design of the seals and the way the seals are wetted and lubricated.

Their feeling was we are not getting a lot of reliability and we are spending a lot of money on seal packages, let's administratively tie the recirc pumps to the start up transformer which is offsite power which should be more reliable. So they operated for many years that way, with the breaker from the unit transformer open and the breaker from the start up transformer closed, recirc pumps both powered off that same bus so they cannot split them in power one off the unit transformer and one off the start up transformer.

Through another series of breakers and busing and so forth, they also power their emergency buses that way as well.

MR. CHAFFEE: Let me point out one more thing.

Also, unfortunately, once they got into that configuration when they recognized they were going to have problems with this -- might have problems with the transformer, they couldn't change the configuration. The way their electrical system is designed they have a break before make arrangement for the bus in question and it did not allow them then to shift the recirc pumps to the unit transformer in anticipation of possibly have a problem. That is why they had to stay in that configuration they were in, into what happened in the event.

MR. CARROLL: That's an unusual design.

MR. KARSCH: They cannot make a fast transfer. It would have forced them to trip the recirc pumps, and they would have gotten into the bind of having to scram the reactor if they wanted to realign them to the unit transformer in anticipation of the start up transformer being tripped out.

Let me revisit the human error for just a minute. I have discussed all three of them, and let me go through the score card. The first one was the operator's not understanding the rationale for reducing power. They didn't drive the rods in. The second one was what is a jumper. If the control room operators had understood that it wasn't this kind of jumper but something that would carry a lot of current, I think they would have questioned the man more, what do you intend to do by installing this piece of number six cable across the transformer. That might have triggered in their mind that there was some kind of an unusual trouble shooting scheme going on here.

The third human error was the lack of understanding of the relay crew man that nuclear units are different than fossil units, in that they have potential transformer neutral grounding versus current transformer neutral grounding. Out front we had all these cognitive or communication human errors.

MR. WARD: Would this trouble shooting with the jumper cable have been appropriate for the other type of transformer?

MR. KARSCH: For a current transformer it would have been fine because a current transformer is a low resistance to ground. Potential transformer is a high resistance to ground. Jumpering across the primary of that transformer gave you in effect, a dead short to ground and you got very high circulating currents.

MR. WARD: I mean the procedure this trouble shooter was following would have been appropriate for the different type of transformer?

MR. KARSCH: That's correct.

MR. CARROLL: These relay guys are not part of the plant organization.

MR. KARSCH: Right. They are not part of the operations department of the plant. They are separate and --

MR. CARROLL: I know the situation. I guess in my experience usually something like this is going on, and the plant electrical group would work with these outsiders, if you will, and make sure they knew what this guy was doing. That wasn't the case here?

MR. KARSCH: Apparently that wasn't the case, and I don't know who is on site on a Saturday at 3:30 or 4:00 o'clock and who gets to go home. What I do know is that the plant --

MR. LEVIS: Excuse me for a second. There were people from the plant staff out there with the relay group. The tech support people were out there, and concurred in what the technician did.

MR. CARROLL: They did?

MR. LEVIS: Yes.

MR. WILKINS: I heard a slight difference between what Jay said and what you said. You referred to the electrical crew and you just said tech support. Were there, in fact, people from the plant with electrical knowledge.

MR. LEVIS: The people from the technical support organization were electrical people.

MR. KARSCH: This is an interesting turn of affairs then. It wasn't just the relay crew guy that made the human error, it was actually plant people as well. That is something that I didn't know. Thank you very much.

At this point they are sitting there with 100 percent rod line, two recirc pumps are tripped, we have issued guidance to licensees since the LaSalle event, a bulletin called 88-07 and a supplement to that, Supplement 1 that says if you get a recirc pump trip you have to punch the plant out. We do not want to get into core oscillations. We have looked at a lot of events that show that core oscillations can build very quickly, you can get very large power swings, and there are a lot of different mechanisms involved.

We don't fully understand all of them, but we do know that we don't see that because you can get very high heat generation rates in very small areas of the core. They were then --

MR. CARROLL: Just out of curiosity, I have never heard the term punch the plant out. I have heard red handle it, scram it, all kinds of things. Where did you pick that terminology up?

MR. KARSCH: I really don't know.

MR. WILKINS: I think it's pretty commonly used. It's meaning is crystal clear.

MR. CARROLL: Oh yes, absolutely.

[Laughter.]

MR. CARROLL: I am just used to red handle it.

MR. KARSCH: Anyway, they scrammed the plant and got a normal scram, all the rods fully inserted. They were operating at this time under the NRC bulletin 88-07 Supplement 1, which requires that. Their procedures reflected that bulletin. Just about the time they scrammed the plant the plant operations manager arrived in the parking lot.

MR. CARROLL: What did you guys do to me?

[Laughter.]

MR. KARSCH: Actually, his intention was that if the plant had a problem and they had inserted rods sufficiently to get below an 80 percent rod line, they were going to try to keep the plant operating under a 50.54 X exception that would be their discretion. The reason they wanted to do that is, they did not want to trip the plant and take what ensued in this case a nine hour loss of offsite power.

Their feeling was that if they got below an 80 percent rod line that they were in an operating area where the chances of core oscillations were extremely remote, and they felt technically justified in taking exception to their procedure and exception to bulletin 88-07 Supplement 1 and keeping the plant running rather than taking the loss of offsite power and relying on their diesels.

That whole course of operations was precluded by the fact that they got the scram and they weren't at a lower power rod line.

[Slide.]

At this point, recirc pumps tripped, you got a loss of offsite power -- at this point, their start up transformers locked out, their generator isn't running. So, the only way they have to power their emergency buses is their on site diesels. At this plant, when they have a loss of off site power, they have four diesels at two units. All four diesels start and loads are shared between all four diesels.

What they have to do at this point to recover offsite power is, they have to physically open up the isophase bus, unlink the generator from the isophase bus, and then they can power back from the switchyard through their unit transformer. Because of the tag outs --

MR. CARROLL: They don't have motor operated disconnects?

MR. KARSCH: They do not. It is manual disconnect that they physically have to unbolt. Several plants have these. Millstone I is another example where they take a long time to restore offsite power. In fact, I think probably as many plants do not have disconnects as do.

It took them seven hours to go through all the clearances and tagging and the mechanical procedure of unlinking the generat . from the isophase bus. It took them another two hours to figure out how to shut their emergency diesels off because they have a relay that doesn't allow the emergency diesels to be unlinked from the emergency bus until it sees power coming in. It took them a while to figure out that they had to reset the logic for that relay, so it took them seven hours to do the unlinking and another two hours to figure that out.

After nine hours, they finally restored ffsite power.

MR. WILKINS: During all that time the emergency generators worked fine.

MR. KARSCH: They worked fine, with no problem.

MR. MICHELSON: I think though, something I didn't fully appreciate is that there are a number of plants in which if you experience a loss of offsite power or a disturbance that might lead to that disconnect, that it takes maybe as much as eight or nine hours to reconnect even though the offsite power is into the yard.

MR. KARSCH: That's correct.

MR. MICHELSON: I wonder, did we think about that when we looked at the power blackout situations and so forth; did we realize that it takes that long?

MR. ROSSI: I think there are number of events where this has been the case, as I recall.

MR. MICHELSON: There are just a lot of things that escape me. This one escaped me, because I was thinking of plants where they do have the capability of coming back much quicker. I just thought everybody had that capability.

MR. CATTON: Is this built into the PRA's?

MR. KERR: What does the third bullet mean? The third bullet seems to indicate that you can get some offsite power if you go through Unit 1.

MR. KARSCH: Let me explain this. I asked them, do they have -- I didn't want to put up a diagram of their on site distribution because I think it would just be more confusing than what it would clarify.

MR. KERR: I certainly agree.

MR. KARSCH: They have breakers installed where they can link emergency buses together and they can link other buses together. Administratively, they do not use these breakers. They have a complete separation of the buses at the various units, but they are there, they are installed and they are racked out.

When they went through their station blackout analysis and the various Appendix R analyses they developed emergency procedures where, in extreme circumstances, they could crosstie some of the buses between Unit 1 and Unit 2.

That is what I refer to in this bullet. I asked them, could you power Unit 2 loads from the Unit 1 start up transformer if you got into some kind of an extreme situation where the only thing that stood between you and core damage was loading that transformer.

The Brunswick people don't like to think about that situation because they never really analyzed what the loading on that transformer would be. They said that if it ever got to that where they had maybe three emergency diesels fail and the only thing that stood between them and real serious problems was using that transformer, they said they would figure out really fast some way to strip loads and connect that transformer. They do not have a procedure for that.

MR. CARROLL: It's not big enough to support --

MR. KARSCH: It's not big enough to support both unit ECCS loads. As far as the emergency procedures that they do have in place, I asked them how long would it take you to go through that procedure if you had to. They said it would take one-half an hour to 45 minutes. Although nine hours sounds bad, they had some cards up their sleeve that they could have played if they had to.

MR. CARROLL: Nine hours doesn't sound bad to me. I don't know why they put so many God damn bolts in those disconnects, but they do.

MR. KARSCH: I think a lot of it is tagging out to make sure someone doesn't get electrocuted too.

MR. CARROLL: Although they must have had some clearance all written up for that. I guess the other thing this reflects to me is that the business the way the operators responded to the plant manager. It doesn't sound like they fully understand the augmented training they have recently received on the matter of forbidden areas on the power flow curve and all that good stuff.

MR. KARSCH: I think they have a lot more understanding now than they did on the 17th of June. In addition since this event occurred, Brunswick has installed a better seal package in their recirc pumps and have gone back to powering the recirc pumps off the unit transformer.

MR. CARROLL: That's a very good idea.

MR. KARSCH: Are there any further questions?

MR. WARD: Brunswick has, as I recall, these kind of elaborate flow chart emergency operating procedures. Are you familiar with those?

MR. KARSCH: I am afraid not. I really can't speak to that.

MR. CARROLL: Rev 4.

MR. KARSCH: Does anyone on the staff --

MR. CARROLL: Rev 4 EOP's.

MR. WARD: Did they come into play here?

MR. LEVIS: The only way the EOP's would have come into play is in initial scram. If they had looked for various injury conditions there wouldn't have been any in this case. Had they not been able to power up their 4KV buses with the diesel loss, they would have been into --

MR. CHAFFEE: We also have some other people here from Region II. I don't know if they have anything they would like to add or not.

[No response.]

MR. CHAFFEE: It doesn't sound like we have enough time to go on with the next event. Since we don't, let me point out one thing. Another thing that was of some interest on this particular event, as I understand it, was when they finally did get the disconnect links and were ready to bring power on back to the main transformer, I understood there was some interlock or something that they made an oversight on, and that's what resulted in the additional two hours before they were finally able to secure the diesels. The point being, it was interesting that even after doing all this one would have hoped that this had been very carefully rehearsed and understood. Apparently they did have some trouble even doing the activity.

MR. KERR: That just points out that it's a good idea to have an incident like this occasionally to --

MR. CATTON: Sharpen up the troops.

MR. CARROLL: If I remember right, you did put an information notice out on this one.

MR. ROSSI: I don't remember whether we did or did not.

MR. CARROLL: It sounds familiar to me, but I read so much --

MR. ROSSI: I would be a little surprised if we did. I just don't remember.

MR. CARROLL: How does the rest of the industry hear about something like this? I mean, there are some lessons here?

MR. ROSSI: I don't know. It depends on whether we thought the lessons were important enough and generic enough and all of that to go with a notice.

MR. CARROLL: Or whether INPO thought they were.

MR. ROSSI: INPO may have put something out.

MR. KERR: Did you ever read Jean Kerr's book called Please Don't Eat the Daisies?

MR. CARROLL: Yes, I did.

MR. KERR: I am not sure one should publicize this sort of thing. Somebody else will come along and put a jumper across a transformer sure as shoot.

MR. CARROLL: It is not the first time it has ever happened in a power plant, I know that.

MR. MICHELSON: I would like to get a

clarification here. There was a procedure, pre-determined procedure on how to get these disconnects made and so forth?

MR. KARSCH: Yes, that's correct.

MR. MICHELSON: Apparently --

MR. KARSCH: That is covered by procedure. Generally they have the tagging made up ahead of time, as you were pointing out.

MR. MICHELSON: Why was there a --

MR. KARSCH: There still is a lengthy --

MR. MICHELSON: -- problem then with overlooking a relay? Was it because the procedure had overlooked it?

MR. KARSCH: That was not covered by this particular procedure.

MR. CARROLL: The relay had to do with the fact that the diesels were running.

MR. MICHELSON: Isn't that a part of a procedure to understand what all is happening at the time you try to implement a procedure?

MR. CARROLL: I think that the procedure is for the very normal operation of opening up the disconnect or in outages so that you can --

MR. MICHELSON: It wasn't envisioned to ever be carried out during a time when diesels were running; is that what you are saying?

MR. CARROLL: Yes.

MR. LEVIS: That's correct. The procedure was made up for outage purposes.

MR. MICHELSON: Only, okay. It has been revised I suppose, to cover diesel operation as well?

MR. LEVIS: Yes, sir, it has.

MR. CARROLL: As resident inspector down there, do you feel they would handle this same event better next time around?

MR. LEVIS: As a resident inspector, I hope there is no next time around. I am confident that in this particular event, they would handle it better, yes.

MR. KARSCH: We feel at this point, with the recirc pumps powered at the unit transformer they probably wouldn't even get into this box.

MR. CARROLL: That's correct.

MR. KERR: One puzzling thing to me is that the operators apparently did not follow the instructions of the plant ager.

MR. KARSCH: I don't think they understood the instructions.

MR. KERR: Whether they understood them or not, if they didn't understand them it seems to me they would have gone back and said we don't want to do what you told us to do. You indicated that he told them to insert rods.

MR. KARSCH: He told them to reduce power, assuming that they would understand the reason why and take the appropriate action.

MR. KERR: Your transparency said that he told them to insert rods, and that puzzled me. I just thought that you said that --

MR. KARSCH: The bullet says advise the operator to reduce power in case there was a transformer lock out. His intent was to have them drive rods in.

MR. WARD: If you had been the operator you would have done the right thing.

MR. KERR: No, not if you told me to reduce power I would have --

MR. WARD: With all you know about PWR's stability, you wouldn't have done the right thing, Bill?

MR. WARD: He said he would.

MR. KERR: I would not trust me to operate a reactor.

MR. WILKINS: Miscommunication is one of your great human errors.

MR. KARSCH: That was the first of three.

MR. CARROLL: Are you a human error specialist; do you have that kind of training?

MR. KARSCH: No. My area of expertise is instrumentation and control systems. I had the benefit of an excellent briefing put on by Carolina Power and Light about a year and one-half ago for Dr. Murley where they got into the human factors aspects of this very heavily. Like most events, there is always a human factors aspect.

MR. CARROLL: Anything involving humans --

MR. KARSCH: It is very difficult for us to get our arms around that and see what we can do to reduce the human factors problems. We can handle a lot of the mechanical problems, but how do you improve a human being in their performance.

MR. KERR: One lesson here is that you just aren't going to eliminate human errors. If you don't make these systems fault tolerant you are going to have trouble.

MR. KARSCH: I think that's our main thrust.

MR. MICHELSON: As a instrumentation and control expert, do you feel you are well qualified on solid state electronic control, of the variety particularly that we are using on the next generation of reactors; or are you more the traditional instrumentation control of the past?

MR. KARSCH: I am pretty knowledgeable of that state-of-the-art.

MR. MICHELSON: You would be somebody I might chat with when I want to ask some questions about problems of solid state electronic control?

MR. KARSCH: Feel free.

MR. MICHELSON: Is your phone number on your handout, like we always ask?

MR. KARSCH: It's 492-1178. I might add though, I do not work in the instrumentation and control systems branch.

MR. MICHELSON: That wasn't what I asked either. I asked if you were knowledgeable.

[Laughter.]

MR. CARROLL: It is on the cover sheet.

MR. MICHELSON: It is?

MR. CARROLL: Yes.

MR. MICHELSON: That's right, there are several cover sheets here.

MR. CARROLL: These guys learn.

MR. WILKINS: I notice that they have a standard cover sheet.

MR. MICHELSON: Yes. I was looking at the top of the handout. That is my fault.

MR. KARSCH: I assume that we are going to reschedule the Pilgrim event discussion, because that's also an extremely interesting event.

MR. CARROLL: I guess we will have to, yes. We are out of time this morning.

MR. KERR: Mr. Carroll, in connection with that, there is a November 19th memo to you from Boehnert which includes some event in Quad Cities II. Have you seen that?

MR. ROSSI: Apparently we do have a number of people from out of town on the Pilgrim event. I hadn't realized that, and I know you asked us that question. I don't know whether you want to reschedule it or --

MR. CARROLL: How long do you think it would take?

MR. MICHELSON: How long do you need?

MR. ROSSI: I don't know, can you go through it rather quickly, Rudy?

MR. MICHELSON: Quickly has to be identified since we have only one hour --

MR. WILKINS: You have future activities. Couldn't that be pushed into --

MR. CARROLL: What was the event at Quad Cities?

MR. KERR: It had to do with an event in which the operators were running a test and they got in trouble during a test, and it sounds to me like a classic Chernobyl precursor. I think it is very significant. I am curious as to what had been done about it.

MR. ROSSI: Which event was it?

MR. KERR: It's an event that occurred on October 27, 1990, and it was during an attempt to perform a special turbine test, turbine test to determine --

MR. ROSSI: Yes, that's --

MR. KERR: -- the reactor automatically scrammed on high and it appears that the test had not been sufficiently analyzed so that people knew what to expect in an unusual test that was non-routine. This is precisely the sort of thing that happened at Chernobyl.

MR. ROSSI: We will be happy to come and brief you the next time on that.

MR. KERR: I am less interested in a briefing than in getting word to people that if they are going to do unusual tests and persuading them that they really need to go through this in great detail -- I hope you are doing it.

MR. ROSSI: We are in the process, I guess, of issuing and information notice on that one. I think that's the one where AEOD had some human factors people go to the site.

MR. CARROLL: That's right. That's what I remember about it.

MR. ROSSI: It is getting a lot of attention, and we will issue --

MR. CARROLL: They must have, like you, concluded it was like Chernobyl.

MR. KERR: It is the nearest thing to Chernobyl I have seen in our own experience.

MR. CARROLL: I remember.

MR. CHAFFEE: Also there are some generic communications on this.

MR. CARROLL: Pilgrim.

[Slide.]

MR. KARSCH: This event occurred September 2nd of this year. Feedwater control was lost, and the cost was failure in the feedwater control system caused the operators to lose control of both feedwater regulating valves. The reason was maintenance oversights, and a defective procedure. The defective procedure caused RCIC to be rendered inoperable. We characterize this is a reactor scram with complications.

I am going to try to run through this really fast so that there will be a little time for questions, because I think you will have some questions.

The reactor was 100 percent power. The operators got a high level alarm and it took them about 20 minutes to one-half hour of going through various manipulations of the feed system when they finally realized that they did not have any control of the feedwater. They had just basically lost feedwater regulation in both automatic and manual.

At that point they tripped the plant and started going through various recovery procedures. They did not reach level two, so they did not get an automatic start of RCIC, but in anticipation of level going down they manually started RCIC, and because of this procedural flaw they rendered RCIC inoperable.

They tried to start up this motor driven start up feed pump and run through the start up feed regulating valves and had a failure in the start up feed regulating valve that also caused over feed to the vessel. They went through more unusual line up of the feed system to try and feed through a valve that they could throttle. At some point during the event they started HPCI and they saw flow oscillations in the output of HPCI when it was in the automatic mode. They secured HPCI during the course of realigning HPCI to a manual control mode. They managed to get feed into the vessel through a heater string block valve, and they were able to throttle that valve. They were also able to cycle pumps and control vessel level that way.

At that point they restarted HPCI and ran in a full flow test mode, and driving an HPCI turbine gave them a way to relieve pressure from the vessel. Prior to that, they were relieving pressure through the safety relief valves. At some point in the event -- and I don't want to get into a big long time line on this event -- the MSIV closed and they reset the MSIV's and began to depressurize normally using the condenser as a heat sink.

[Slide.]

The MSIV closure was reset and they reopened the MSIV's, and at that point they were able to depressurize normally using the main condenser. The vessel pressure had decreased to the point where they could use condensate pumps and, later on when they didn't require as much feed flow, they were able to use rod drive pumps and RWCU pumps. When they tried to align the RHR system they had a pressure spike in the suction that caused them initially to isolate RHR. It took them about 40 minutes or so to vent the RHR system suction side so that they could reopen and realign RHR.

MR. CARROLL: What caused the pressure spike?

MR. KARSCH: Inadequate venting in the RHR suction line. They have had a history of this on their A-train because of the pipe configuration.

MR. CARROLL: So, when I am trying to open the RHR valves --

MR. KARSCH: Three times out of four in the last one-half or three-quarters of a year they have had a suction isolation because of a pressure spike.

MR. CARROLL: What is causing the pressure spike?

MR. KARSCH: The insurge of water into the gas space in that pipe.

MR. MICHELSON: Why is there a gas space in the pipe?

MR. KARSCH: I am not sure.

MR. MICHELSON: I thought that was a fully filled pipe at all times, unless air is accumulating in it somehow.

MR. MACDONALD: Excuse me, Rudy, I can help you. John MacDonald, senior resident inspector at Pilgrim. It is actually a voided area in a pipe, it's not a gas area. There is a belief that when the shutdown cooling subsection of RHR is in standby that, due to convectional heat transfer from the RCS system temperature across the valves, a certain amount of the shutdown cooling system inventory boils and actually steams free from the venting causing a voided section of pipe.

When the shutdown cooling system suction isolation valve opens, some of the RCS fills that voided area and causes the pressure spike. The pressure spike actually occurs in the recirc loops, not in the suction shutdown cooling system suction line.

MR. CATTON: That's water hammer.

MR. MACDONALD: Very minor water hammer.

MR. CATTON: That depends on how big the steam bubble is.

MR. MACDONALD: That's correct.

MR. KARSCH: We tended to call it a water hammer. The licensee preferred to call it a pressure transient.

MR. CATTON: A steam bubble, that's a water hammer.

MR. KARSCH: I think we might be playing games with semantics here. The bottom line is that there were people in the room that didn't hear anything. They didn't see any pipe movement, and when they walked down the system they didn't see any damage to pipe or anything like that.

MR. CARROLL: To simply spike a pressure sensor doesn't take --

MR. MICHELSON: It doesn't take much, no.

MR. KARSCH: Let me get to the last bullet here, because I think this is also very interesting. Subsequent to the event they determined that they had an overpressure -- a pressurization of the RCIC suction piping in excess of the design rating of that pipe. In other words, they opened the safety valve and calculating the peak pressure that was reached, it was somewhere between 600 and 800 psi.

This pressure came from the reactor water clean up system pressure. The reason why that happened is, they have a check valve on the discharge of the RCIC pump which did not --it allowed backflow through that check valve, through the idle pump and into the suction line. The duration of this pressurization was about 50 seconds.

MR. MICHELSON: But the RCIC feeds back to the feedwater line, doesn't it?

MR. KARSCH: Yes.

MR. MICHELSON: What does reactor water clean up have to do with that?

MR. KARSCH: That also feeds into the same section of the feedwater pipe.

MR. MICHELSON: At the same point?

MR. KARSCH: Virtually the same point. Maybe John can speak to that. I think there's a header that goes in and all of these lines come into that header.

MR. MICHELSON: I see.

MR. MACDONALD: That's correct.

MR. ROSSI: I think that since we have people from Region I here including the senior resident, if they have any additional perspectives or corrections or augmentations to the description you might --

MR. KARSCH: I did run through this very quickly because we are pressed for time. John, you might have something to add that I have skimmed over because of the speed that I went through this.

MR. MACDONALD: The description was basically accurate, but was brief. Essentially, the event was very well handled by the operators that were on shift. They were presented with several system malfunctions and component failures, and they handled the event quite well. If you have any questions on the bullets, I would be glad to address them.

MR. CARROLL: Overall what is your perspective on how Pilgrim is doing since they restarted?

MR. MACDONALD: This is my opinion.

MR. CARROLL: That's what I asked for.

MR. MACDONALD: That's correct. I believe Pilgrim continues to improve. Their past problems throughout the plant continue to cause perturbation in that improvement process. This is an example of it. However, their ability to recover from these events is greatly improved. Management is well focused on being capable of identifying the root cause of the problems, correcting them, and ensuring any programmatic implications are addressed which is good, in my mind.

MR. CARROLL: They have always had very good operators there, haven't they?

MR. MACDONALD: Previously they had a major problem with the staffing level of operators. Recently, in the past two years, they have had 100 percent pass rate on all NRC administered exams.

MR. KARSCH: Are there any more questions?

MR. CARROLL: I don't believe so. We would like to thank you again for a good series of presentations. I think there was a lot of food for thought here. I guess of these events we would like to, the next time you are in, get a follow up on what has gone on in the hydrogen gas issue. That one concerns me.

MR. ROSSI: Let me just thank real quickly the people from the Region that came to the meeting, because they do travel a long way and give a perspective I think from being closer to the problems that would be missing without them. So, I would like to thank them.

MR. MICHELSON: Perhaps one of the things that we are going to have to be careful of is fewer events. You never know how long they are going to take.

MR. CARROLL: We only went over 13 minutes Carl, that ain't bad.

MR. MICHELSON: No, but we really gave the last one a rater short shift.

MR. CARROLL: That was all attributable to the first one, yes.

MR. WARD: I think it's really Jay's fault for selecting events that are so interesting.

MR. MICHELSON: That's right.

MR. CATTON: The first two were really very interesting.

MR. MICHELSON: Yes, and they are significant. Are you finished then, Jay?

MR. CARROLL: Yes.

MR. MICHELSON: We need to get on to our next agenda item, which is the future activities. There are several things that we need to talk about during that time, so I will let Richard get started.

[Whereupon, at 1[illegible] a.m., the transcribed portion of the meeting was recessed, to reconvene at 1:00 p.m., this same day.]

AFTERNOON SESSION

[1:05 p.m.]

MR. MICHELSON: The next item on our agenda this afternoon is new standardized technical specifications. This is a briefing by the staff. I believe Jay Carroll will conduct it.

MR. CARROLL: We have been generally following different efforts with the staff in the general area of tech specs. We had a briefing a while back on risk-based tech spec work. Today we are going to be hearing about the new standard tech specs. Jose, do you want to lead off?

MR. CALVO: Yes. I am just going to introduce the speaker. My name is Jose Calvo, I am the chief of the Technical Specifications Branch. Here with me are the members of my staff and my boss, Ernie Rossi, Dr. Rossi, Director of the Division of Operational Events Assessment.

Without going further, I think I am going to give the floor to Mark Reinhart, who is going to give you the presentation.

MR. CARROLL: You didn't have to introduce him to me.

MR. CALVO: I know he was here this morning.

MR. CARROLL: I hired him right out of the Navy.

MR. CALVO: You did, all right. Be nice to him.

[Laughter.]

MR. REINHART: My name is Mark Reinhart, with the Technical Specifications Branch. The ACRS has shown interest in the technical specification improvement program and the new standard technical specifications, so as we approach issuing our final draft we wanted to come and brief the ACRS on our progress and where we are headed. When we issue the draft for comment to industry, the staff will also provide it to ACRS for information.

MR. CARROLL: While Mark is getting started, there is some additional background information in your Tab A to the black binder.

[Slide.]

MR. REINHART: This is about the third slide in on the package. It shows the background and our progress today. In February, 1987, the Commission issued an interim policy statement based on a lot of effort by industry and the staff to improve technical specifications. Based on that policy statement the industry proposed to the staff a division of requirements that were in current standard technical specifications, which requirements would stay in the specs and which requirements would be relocated to licensee control documents.

The staff discussed that with industry, and in May of 1988 issued the short term titles, the Split report which delineated which requirements went elsewhere and which stayed in the technical specifications. Based on that split report, from May of 1988 through the March and June timeframe of 1989, the industry developed and proposed new standard technical specifications, one for each Owners Group, Boiling Water Reactors had two -- a BWR-4 and BWR-6 version.

The staff reviewed and discussed those proposals with industry from April of 1989 through December of 1990, where we are today. The staff is to the point where we are getting ready to issue this final draft STS and their bases by January back to industry and the staff for a final review. Following that review we will start to work more with the lead plants to implement the spec, and we anticipate we will have some iteration to the specs during that time and eventually issue them in spring of 1991.

[Slide.]

To show the extent of participation in this program we put together a slide that tries to generally show who all was involved. We have had we say 30 persons from industry. Those would be the key ones, obviously backed up by their staff. They represented NUMARC, the NSSS Owners Group, lead plant licensees and another group of licensees who were involved. To point out the lead plants we have North Anna 1 and 2 for Westinghouse, Crystal River 3 for Babcock and Wilcox, San Onofre 2 and 3 for Combustion

Engineering, Hatch 1, the BWR-4 and Grand Gulf with BWR-6.

Of course, they were all of them. Just to mention a few, we had representations from plants such as Davis-Besse, Diablo Canyon, Palisades, Rancho Seco, Waterford and Watts Barr.

MR. CARROLL: On the BWR lead plants, would the BWR-4 tech specs take care of earlier BWR's?

MR. REINHART: The BWR Group had an approach where they would take those two and most likely the earlier ones would go with BWR-4. The 5 would probably go with the 6, if I have that right. As time developed and plants came in, they would continue to add to the specs until they got a comprehensive set that would cover all of their plants.

On the staff side, we had NRC people -- about 65 -- representing the technical specifications branch. Virtually every one of the NRR technical review branches including Risk and Human Factors, we had the projects divisions, the regions and the technical training center. The technical training center took a set of specs proposed by the Owners Groups and implemented it specifically in one of the simulators and ran a class through on that set. They gave us some really good comments on the value of the specs. They appreciated them, the format, the bases, and the improvements that they saw.

Supporting the NRC we had about 25 contractors from National Labs, Lawrence Livermore, Idaho National Engineering Lab, Pacific Northwest and had Science Applications International also supporting. We think that we can say that not since the inception of technical specifications have so many people with such broad and diverse backgrounds looked so deeply for such a period of time at this document.

[Slide.]

Slide number six shows an outline --

MR. KERR: Could you then paraphrase Mr. Churchill to say never have so few owed so much to so many?

[Laughter.]

MR. REINHART: Good parallel. Our general outline here looks probably very similar to what current tech specs are, but I want to point out that in the 1.0 section that up until now has been mostly definitions, has been expanded to clarify how the specs are used. We are addressing the logical connectors, completion time, surveillance frequencies and operability. Also, the 3.0 section, applicability, has been improved to try to provide for the operator a uniform guide in using the specifications.

The split was applied primarily to the 3.1 through the 3.10 sections. Human factors principles were applied throughout. One of the obvious ones right here, if you remember the old 3-4 section which the industry commented provided a lot of confusion not only for them but for ourselves as well. We took those LCO's and surveillances from the three and four and integrated them into one section because they were together anyway. We will show in a minute an example of what a new spec looks like compared to one of the previous specs.

MR. CARROLL: I am curious about 3.10; what is that all about?

MR. REINHART: Three point ten is a group of special exceptions that licensees have requested to perform various tests. If they are going to do some physics testing they might need an exception to a particular LCO. The staff approved those. The PWR's chose to integrate those specific exceptions in with the particular spec and BWR's left it separate.

[Slide.]

To highlight some of the changes, from the split report about 40 percent of the requirements were located to licensee control documents. The licensees will provide controls on those relocated documents, and those controls will be approved by the staff and audited prior to implementation. The range of control will be to something similar to 10 CFR 50.59 control all the way up to a prior staff review and approval prior to making the change.

We want to point out that a lot of people had a concern that the requirements are removed, and I want to emphasize they are relocated. They are still there, they are important, we will follow them, and we will enforce them.

MR. WILKINS: May I interrupt you at that point? Was it a part of the charge that you had in this project to examine in fact whether they were important?

MR. REINHART: I think we say they are important. We know they are important to begin with.

MR. WILKINS: Maybe they were important to begin with and maybe they are no longer important.

MR. REINHART: That's a good question. The ones that we relocated, the staff and industry to date hasn't really delved into those. Most of our effort has been on the document that is remaining. When we go to the lead plant in the follow on plants as they implement those, they will be showing us where they are located, where the controls are and, at that time, those type of questions will come to the surface.

MR. MICHELSON: I may have missed it and for that I apologize, but have you discussed what you might be losing out of the LER system now by taking and moving this over into other areas where it isn't any longer clearly under LER?

MR. REINHART: Licensee event report?

MR. MICHELSON: Yes.

MR. REINHART: We have discussed that, and there's a lot of mechanisms for reporting to the staff other than the LER system.

MR. MICHELSON: Yes, but the LER system is a very clearly, well established mechanism to get general information about the state of the industry and its operation. There are other mechanisms but they are not formal, there are not any requirements for them, and you lose it if you --

MR ROSSI: I think the only place that you will lose in the area of the LER rule that says you have to report violations of the tech specs. There will be some things that are not violations of the tech specs anymore. So now, we will be more dependent on the other sections of the LER rule that tell you what kind of things you have to submit LER's on, on the basis of their individual importance to safety and --

MR. MICHELSON: You have looked at this carefully and have concluded that you aren't going to lose anything important; is that right?

MR. ROSSI: You will hit the other sections. We also have some other efforts as part of our regulatory --

MR. MICHELSON: Excuse me.

MR. ROSSI: -- underway on the LER interpretation.

MR. MICHELSON: By sections you mean the other triggering mechanisms for the LER?

MR. ROSSI: Right, for getting LER's, right.

MR. MICHELSON: You say that anything that we really need to get we get that way?

MR. ROSSI: That would be my view, yes.

MR. MICHELSON: That may be right. I am asking it because I don't have time to go back and look to see what those triggers might be. You have looked at it and you have satisfied yourself we are not losing any important information?

MR. ROSSI: We have not looked at each item that has been relocated in terms of whether we would --

MR. MICHELSON: I was thinking for instance of fire protection. Now you have relocated, I think, most of it into other areas. If I have a problem with a fire protection system since the system is no longer in the tech spec, what is the trigger to find out about that problem? I didn't have a fire, of course, I just had a problem with the system. I might have even inadvertently actuated the system.

MR. ROSSI: If you inadvertently actuated it and it gave you any kind of significant problem, I think that would trigger one of the other LER things. I also assume that in the tech specs there is a general fire protection thing even though the details are --

MR. MICHELSON: You mean, still in there?

MR. CATTON: Isn't there a general --

MR. CALVO: If I may, the fire protection requirements was not -- they had already been removed before this program came into being.

MR. MICHELSON: Yes, but I thought --

MR. CALVO: If I remember correctly, the generic letter established some reportability requirements and some ground rules in there which may take care of some of those things.

MR. MICHELSON: Which generic letter are you referring to?

MR. CALVO: We can --

MR. REINHART: I have the number here, and I can look it up real quick.

MR. MICHELSON: This is a fire protection generic letter?

MR. REINHART: It's generic letter 88-12.

MR. CALVO: They call it the line item --

MR. MICHELSON: That's when the discussion came about. It was about 1988 timeframe. That's when the discussion first came up about are we losing most of the information that we might have otherwise gotten on fire protection devices. I guess you have looked at that and you are satisfied that --

MR. ROSSI: We have not gone through line by line of the things that we have removed to determine their effect on what LER's that we would lose. The other triggering mechanisms in the LER rule are things like unreviewed safety problems beyond the design basis and those kinds of things, and inadvertent actuations that would be an important effect on safety related equipment are still going to trigger one of those.

I feel very confident that we are going to get everything that we need to get --

MR. MICHELSON: I will take your word for it.

MR. ROSSI: -- without going through line by line.

MR. MICHELSON: It was though, a conscious decision to try to determine that you weren't losing important information; is that right?

MR. ROSSI: I would not say that we looked at that particular aspect.

MR. MICHELSON: Did you think that was not important to consider?

MR. ROSSI: A systematic look at it?

MR. MICHELSON: Whatever look it takes to determine that you aren't losing important information. We have such a little amount of this information coming in anyhow, at least in a form that is disseminated widely in the indust[illegible] so forth such as the LER's are.

MR. ROSSI: Let us give some more thought to it. We do have some other efforts on relooking at the LER rule and 50.72 rules and the guidance on that.

MR. MICHELSON: There are some things that you can certainly get rid of. I don't want to lose good things in the process.

MR. ROSSI: We understand. I have a vested interest in that myself because of the other part of my job.

MR. MICHELSON: Right.

MR. REINHART: In addition to applying the split report, we mention here for a while these line item improvements. Those are an item that, while approved, parallel to the new STS. We have incorporated into the new STS. We had an evaluation, and industry-wide evaluation of surveillance testing and made some recommendations and incorporated those into the new STS based on industry as well as staff operating experience, to try to get more realistic surveillance testing where possible.

MR. CARROLL: This isn't risk-based, it is someone's judgment about --

MR. REINHART: Most of it is deterministic. The risk -- most of this effort was deterministic. We had a flavor of risk in certain areas that I will talk about on this next bullet.

MR. ROSSI: Mark, this includes -- the new standard tech specs include all the reports of the topical reports that have been submitted by the industry that we have approved.

MR. REINHART: That's true.

MR. ROSSI: Those, I think, have a lot more risk and quantitative stuff than some of the other.

MR. CARROLL: Just to give me a feel, in a big PWR, how much have you reduced surveillance testing?

MR. REINHART: I don't have a good feel for that. Rich, do you have a feel for that?

MR. LOBEL: My name is Rich Lobel from the tech spec branch. I can't give you a number off the top of my head, but it was a significant amount. If you look at the amount of testing that gets done, a lot of it was in the order of monthly channel checks, channel tests, that required all RPS instrumentation once a month. By means of the topical reports at lot of that got changed to quarterly or we gave the industry the opportunity to change it to quarterly.

There were also these things that were taken out of the tech specs that required surveillances too. A lot of it was instrumentation and a lot of it was reduced by a factor of three. As a rough number for instrumentation you could say a factor of three.

MR. CARROLL: I guess in our background section somebody is talking here about Limerick requiring 40 surveillance tests a day or over 14,800 tests per year.

MR. LOBEL: That's total number of tests. That's the number that are done now, and that number includes every test that is done of a circuit that is required by tech specs, every check that is required by tech specs of a configuration of valves in a system to make sure they are in the right line up. A lot of these are monthly and a lot of them are more often. It adds up to quite a big number.

MR. CARROLL: I guess the othe- thing that I was curious about with respect to instrumentation calibration, several of us recently visited San Onofre as part of our adopted plant program and heard a presentation on their so-called RIM program which I understand a number of other people are playing with too. Is that getting a lot of encouragement from the staff?

MR. LOBEL: Yes, it is. They have used some of the data they are getting from that, I am s_re that you heard, for justification for extending their cycle from 18 to 24 months. They are showing with real data that it is not necessary to do these surveillances as often as required in their tech _pecs now.

MR. CARROLL: I guess we should tell the rest of the Committee that wasn't there was RIMS is about. Why don't you give it a try.

MR. SHEWMON: Also, tell us what real data is as opposed to whatever they had before.

MR. LOBEL: What I mean by real data is that most utilities don't have real data. Most utilities come in with or would like to come in with general justifications to show that they don't need to do surveillances as often. This program that Southern California Edison has is a problem where they actually monitor the output of sensors for safety-related instrumentation, feed this into a PC and I believe the interval is at least five times an hour.

They do this over a whole cycle, and they look for any outliers, any indications that the instrumentation is starting to drift, that it is going off scale or getting out of calibration or out of the range that it is supposed to be in. What they found in general is that the instrumentation has behaved very well, and --

MR. SHEWMON: But did they keep track of whether the technician when he did do the check found that it was in range or out of range?

MR. LOBEL: Yes. In fact, they even tracked not only that but they looked at what happened to their readings after the technician did he tech spec required calibrations, and they found in some cases that even though the instrumentation was well within its range and they couldn't see any differences in -- the operators couldn't see any differences in the control room, with this system they could actually see that and the technician actually made things a little worse.

MR. SHEWMON: That is interesting, but let me ask the same question I just asked again which I did not make clear. Before they had this fancy PC-based system, did they keep track when they did it once a month or once a year or once a quarter, whether or not the technician found the system was in or out of spec?

MR. LOBEL: Sure. They have to do that, and they are required to do that.

MR. SHEWMON: That's not real data?

MR. LOBEL: Let me --

MR. SHEWMON: Or, it's less real than what they are getting with the PC which is real data.

MR. LOBEL: What they are getting now with this RIM system isn't whether just something is in or out of calibration. They are tracking the trends of the instruments and are showing that even when the instrumentation is still within calibration they can track whether it is behaving well or drifting toward getting out of --

MR. SHEWMON: I understand all of that and I agree it's better. I am getting back what data did they have before, and I guess the fact that you didn't trust it or they didn't accumulate it and use it --

MR. LOBEL: I don't believe most of any utilities that don't have a system like this keep track of the things in kind of detail that they are doing with the RIM system.

MR. SHEWMON: It's absolutely impc e to do it in the line of detail, but that's still not the question.

MR. ROSSI: I think you are taking issue with the use of the term real data. Perhaps a better characterization --

MR. SHEWMON: It was my impression that there must have been a fair amount of data there before on their plant and their instruments if somebody cared to use it.

MR. LOBEL: If the problem with the words I used, let me clarify what I was trying to say. What San Onofre was trying to do -- what the utility was trying to do is, in a very responsible way, gather sufficient data so that there couldn't be any argument about drift, about whether their instrumentation was behaving well, whether if they got to the end of an 18 month cycle if they continued for another six months they were going to get out of calibration or not.

They gathered all this data in enough detail so that they could make arguments about the fr.quency that it was necessary to do surveillances.

MR. SHEWMON: I understand. The data they got before was not adequate in quantity or in quality to give you that piece of mind; is that --

MR. LOBEL: That's right. It was a different kind of data.

MR. CARROLL: Their ultimate goal Paul, is I think to get rid of calibration entirely. You don't just calibrate because 18 months are up or 24 months are up. You calibrate because one of nine channels that you are tracking isn't following the other ones, and it's an indication that something is wrong with that instrumentation.

MR. KERR: This implies that the NRC has adopted or formulated reliability standards by which they judge the performance of this equipment. That is interesting. Has your Subcommittee looked at these criteria?

MR. CARROLL: The NRC is watching this experiment with interest, I think is a fair statement.

MR. KERR: I thought they said that they had now permitted one plant to extend its --

MR. CARROLL: Calibration intervals?

MR. KERR: Yes, on the basis of these data. This seems to me to mean that there is a reliability criterion or a set of criteria which the plant has demonstrated that it can achieve, and which is satisfactory to the staff.

MR. CARROLL: Have you let them extend to 24 months?

MR. LOBEL: I believe they have gone to 24 months for their instrumentation. I wasn't involved in the review. I saw the system when I was at the plant talking about something else. I don't think I am the person to talk about what the criteria were for --

MR. KERR: I wasn't trying to find out what they are. I think this is commendable, and I was just curious.

MR. LOBEL: I don't believe there is reliability criteria that have been established.

MR. KERR: There must be some criteria that they are meeting.

MR. CALVO: We approve the 24 month extension, the safety evaluation report for that criteria. I don't recall what it was. It was done about two years ago. I believe that one we accepted. Whether that system had been in place long enough, whether that system was used as the basis for the staff approval, I don't know.

We had that staff criteria which was extended from 18 to 24 months. San Onofre had not been the only plant that we had done this. I think we had done this to Harbor Cliff and all this. Whether those people had the same systems or not, I do not know. If you are interested we can, in some kind of way, identify what we had written which documents the criteria that is used for this.

MR. KERR: I was trying to find out if any of our

Subcommittee's has reviewed this. Maybe, indeed, it should be the instrumentation subcommittee for all I know. I hadn't recognized that criteria for reliability had been established. I think that's commendable.

MR. ROSSI: Most of what we have done when we have extended surveillance intervals and that kind of thing has been on the basis of looking at the delta change in something and saying that it's a very small one, so there's a small difference between whether you do a one month surveillance or a three month surveillance, an 18 months surveillance to a 24 month.

MR. CARROLL: Delta change in what?

MR. ROSSI: Whatever is being looked at, availability of the instrument or going outside the drift or that sort of thing. We don't have a firm criteria, but we say there's a very small change in the benefit that you get from an 18 month surveillance as opposed to a 24 month and, therefore, we believe that a 24 month is --

MR. KERR: You haven't reached any conclusions as to what is appropriate. It is just that as long as people don't make any changes in what they are saying it's okay.

MR. LOBEL: Getting back to the slide, the RIM's -- that system wasn't involved in any of the work that we did with the technical specifications. It had no input into what we are talking about here. The criteria that we used for this work --for the topical reports wasn't changed in core melt frequency. Changes were proposed in surveillance and allowed outage times, and calculations were done to see what the change in core melt frequency would turn out to be.

For the work that Mark Reinhart was talking about that was more qualitative, what was done was a look at operating experience and an evaluation of the surveillance requirement. What we did was look at the benefits of doing the surveillance requirement in terms of how many problems did that surveillance requirement identify and was that surveillance actually identifying the important contributors to unavailability, and balancing that by problems caused by that surveillance requirement. We did have criteria for that.

We had four criterion. The criteria were, was the surveillance causing unnecessary wear to the equipment; was it causing a burden to the operators or to the plant; was it causing an increase in dose to people unnecessarily. Those kinds of criteria were used, and it was a qualitative balancing of looking whether the surveillance was accomplishing anything and what it was costing.

MR. KERR: Presumably the surveillance was designed to ensure a certain level of reliability; was it not?

MR. LOBEL: No.

MR. KERR: You don't care about reliability --

MR. LOBEL: That's a different question. I didn't say that we didn't care.

MR. KERR: I can't understand why else one would do surveillance if one was not interested in trying to achieve some level of reliability.

MR. LOBEL: The purpose of a tech spec surveillance requirement isn't to determine reliability. The purpose of a tech spec surveillance requirement is to determine operability. You want to determine whether that equipment is operable. Most tech spec surveillances aren't done often enough to determine reliability in the short term.

MR. KERR: I don't understand what you are telling me, but I guess --

MR. LOBEL: I am telling you that tech spec surveillances are done to determine operability. Nobody is requiring utilities to determine reliability.

MR. KERR: How can something be operable if it isn't reliable?

MR. LOBEL: I think that's fairly easy. It can be operable one time and not operable the next 12 times.

MR. KERR: You only care if it's operable when you start it up. You don't care what happens after that? The periodic verification gives you some reliability inevitably.

MR. REINHART: Sure. It gives us a sense of reliability in a macroscopic sense. We were talking about the risk insights. Again, the work on existing as well as new STS has been largely deterministic, but there are a few areas where we used what risk insight was available. One was in the split report itself. In addition to the three criteria that would capture requirements to remain in the spec, we used existing operating experience coupled with risk significance to capture a few other systems.

We mentioned the topical reports that various vendors submitted for their Owners Groups were largely based on PRA type information for extension of surveillance frequencies and completion times for reactor protection systems. To give us a scoping evaluation of where we were on the tech specs, we had SAIC use three 1150 PRA type plants and run dominant risk sequences with the changes we made to surveillance frequencies and completion times to see if we were in the ballpark.

In a broad spectrum we found out that we were will within a comfortable range. We did find a few outliers that caused some problems and went back in and adjusted those frequencies until we brought those numbers back into --

MR. KERR: Excuse me. How did you determine the comfortable range?

MR. REINHART: Well, the number we used was a change of around ten percent core melt frequency. We felt that was within -- I mean, one-tenth of a percent of core melt frequency. Rich, do you want to --

MR. LOBEL: What SAI did was to compare the change that we made to the base 1150 number and look for a change in core melt frequency in these cut sets. If they found a change that looked significant, we looked at that in a little more detail and evaluated it qualitatively. In the cases where it was significant like a change of core melt frequency, I believe some were very large because the conservative assumptions we made -- without going into a lot of detail -- these were all done pretty conservatively.

If we saw a large change of core melt frequency we went back to the original tech spec number which was the number that was in place when the 1150 analysis was done.

MR. KERR: I assume then that what SAI used was a difference in the reliability of individual components or systems in order to detect a change in core melt frequency; wasn't it?

MR. LOBEL: They used the difference in the surveillance test interval or the allowed outage time.

MR. KERR: In effect then, that's a measure of availability?

MR. LOBEL: It is measure of availability, that's true.

MR. REINHART: What that gave us was a ballpark feeling. We wanted to see if our effort was in the ballpaik, and we felt that it is. The third thing that I would like to hit here --

MR. KERR: This means that what you were trying to do was determine that the changes you were making did not make any change in core melt frequency, any significant change?

MR. REINHART: That's correct. A third highlight is the human factors effort. The staff human factors people as well as industry human factors people looked at the specs, made some recommendations. We documented that in a writers guide that was agreed to on both sides and have tried to follow that as closely as possible throughout this program to again, make the document user friendly, if you will.

MR. CARROLL: How many human factors people had apoplexy after being first exposed to the original standard tech specs?

MR. REINHART: I don't know how many we had to revive. We will get to an example here that I think will probably demonstrate what you are saying there.

MR. WILKINS: Before you take that off, what is an instrumentation completion time?

MR. REINHART: If an instrument becomes inoperable for some reason or the limiting condition for operation isn't met, the completion time is the time allowed to restore that to the normal situation.

MR. WILKINS: Either by repair or by replacement.

MR. REINHART: Right. Or, by going out of the applicability. It might be changing mode, it might be replacement, it might be repair or whatever.

[Slide.]

I would like to address a summary of our improvements. A goal was to focus on operational safety and make our specification more operator oriented.

MR. KERR: Operational safety means what? Does it have anything to do with core melt frequency?

MR. REINHART: We weren't using that risk criteria in what we are calling operational safety. We are trying to focus what the operator is going to do for the plant.

MR. KERR: What does operational safety mean then?

MR. REINHART: Let me see -- I think I have a slide that really hit on that. I don't have it with me. What we are looking for is a number of things that are listed here. We are trying to make the specs more operator oriented, we are trying to reduce the action statement induced transients of the plant, we are trying to make them less complex and more easily understood to the operator, we are trying to focus on a requirement that an operator in a day-to-day operation of a plant would run across as opposed to something that maybe maintenance would run across. Those types of things.

MR. KERR: That is what you mean by operational safety?

MR. REINHART: That's a good chunk of it. There's a whole list, and I don't have it with me. Does anybody remember anymore of those?

MR. KERR: That's okay. What our split report did was really focus on requirements that the operator would use. We tried to make the specs designed so that an operator could quickly determine the correct course of action in a given situation. We tried to adjust the completion times and surveillance frequencies where we could justify it so that we would minimize a plant transient that would be generated just because of one of those times.

Another thing that we tried to do was eliminate redundant surveillances. If we went through the specs we would find a number of specs that required the same surveillance on the same equipment, so we tried to isolate that into one place. We still did the same thing, but the plant's attention now was more on operating the plant rather than keeping the paperwork and trying to track those surveillances.

[Slide.]

Maybe if we compared the specs, this is an example of what an operator faced on one of today's current specs. It is generally a prose-oriented approach. The operator had to read paragraphs to find out if he was in a condition that wasn't one that he wanted to be in, what he had to do, how long he had to get out of it and any kind of contingencies that he might have to take.

Our approach was to take these requirements and put them more in a tabular format where in one place the operator has his limiting condition for operation and any amplifying note, where it was applicable and what mode, and give him in a concise statement what the condition was, what he was required to do and how long he had to complete that action. That fact alone, we feel generates operational safety providing that ease of use to the operator.

[Slide.]

Surveillance frequencies for surveillances were approached in a very similar way. Again, rather than trying to read a lot of prose, the surveillances were broken down into discreet requirements the operator had to do, amplified by notes where necessary, and a given frequency when that requirement came due again. We tried to be consistent in the tech specs not just in a given Owners Group but across the line of Owners Groups so that the industry, the staff, the management, the operators would all have the same type of wording, the same type of approach to understanding the requirements.

MR. CARROLL: I am a little puzzled on that one, Mark. Why is the note above the requirement?

MR. REINHART: That's a good question. Some individuals tend to like it below the requirement and some tend to like it above the requirement. Those of us that liked it below the requirement lost.

MR. CARROLL: I would have voted with you.

MR. KERR: You mean standard tech specs have to have it above, and if it were below it wouldn't be standard?

MR. REINHART: I guess that's true, if that's a level of standardization. The convention proposed by the industry was to have those notes above and after much discussion, that's where they are.

MR. CARROLL: That wasn't Sam Bryant's idea, was it?

[Laughter.]

[Slide.]

MR. REINHART: Another improvement that we felt we have made in the specs is in the bases. We have tried to expand those from just some curse statements to really describing what the bases do for us. I will go back to my previous slide here.

[Slide.]

We tried to provide in the bases the reasons for each requirement, be it an LCO, a surveillance, a completion time, and to try to tie that requirement back into the safety analysis where that was possible. We also tried to tie it into the margin of safety. It wasn't always easy to specify where that connection was, and we came up with an acceptance limit that would tie that requirement to that spec to the margin of safety where possible. If it was determined that it was not possible, the spec will clearly say that so there's no ambiguity.

Again, we mentioned that we tried to promote better understanding of technical specifications and that was the wording. We mentioned the improvements of 1.0 and 3.0, the applicability and use and application section. We hope that will minimize interpretations coming from licensees for the specs.

That really summarizes where our improvement program is going. After the staff and the industry complete our final review of the specs, we will provide that to NRR management, to CRGR for approval, and certainly will provide copies to the ACRS for information at that time.

MR. CARROLL: Tell me more about what the lead plants are going to do here in the near future. They are going to convert their existing tech specs and use them for a while?

MR. REINHART: During the final approval period of the new STS, the lead plants will start to implement. We are going to iterate back and forth. Before we actually issue a license amendment to the lead plant we want to have an approved STS, but we want to learn through the initial first months of that process to get the feedback.

MR. CARROLL: They will be operating under their existing tech specs during that period of time but making the transition, training their operators and people on the new ones coincidentally?

MR. REINHART: What most of the lead plants have proposed is to operate under their current specs while they develop new ones. Once the staff approves the specs but before we issue the license amendment, they want to take about a year to go through and update their procedures and start training their personnel. Then for most of them -- I think this is the approach that we prefer -- during a refueling outage make the switch, do the final training, and start up with a new core on the new specs.

MR. KERR: In discussing the surveillance frequencies, apparently your criterion was that one did not change the core melt frequency appreciably. Is it your view that the new tech specs make risk greater or less or, again, did you use the criterion that the risk shouldn't be changed?

MR. REINHART: Again, we really -- the approach was deterministic in the development of the specs. Maybe I could show you --

MR. KERR: I am just asking you for a judgment of whether that was a conscious condition.

MR. REINHART: I think consciously we are saying it's not going to increase risk. We don't want it to increase appreciably, obviously. We didn't really use a risk-based criteria to be able to point to some solid numbers.

MR. KERR: Did you want it to decrease risk?

MR. REINHART: That would be ideal. Again, we don't have numbers to prove that.

MR. KERR: I am trying to understand the motivation for doing this. These are referred to as improved tech specs.

MR. ROSSI: Let me try. Qualitatively it's our belief that these will reduce the risk by being easier to understand and focusing the operator's attention more on the most important things. It will also allow the licensees on the less important things to more promptly revise them under a 50.59 process without coming to the staff to get prior approval. So, in that sense, we think it will make the plant safer.

From a quantitative standpoint, we have not looked at what the surveillance changes and that kind of things do. I guess qualitatively, there we would feel that it would reduce the risk too because we -- our feeling is that by increasing things like surveillance intervals and allowing more time to repair equipment that is out of service, that in a qualitative sense that will reduce a risk even though perhaps we haven't quantitatively tried to calculate it.

Would you have any comment on my characterization of it?

MR. REINHART: I think that's a good characterization. The operator is the one operating the plant, and the more his attention is focused on the plant rather than something else, the safer he is going to operate that plant. We feel that we have made some progress in that direction.

MR. CALVO: Dr. Kerr, when this program first started we were a little concerned that maybe we are relaxing things a little too much. We felt some good reasons behind it. Maybe the data that we had based on operating experience, we felt kind of the way we wanted to couple with a little of risk -- so this one we hire the service of the SAIC to look at it and see if we are doing anything wrong up there because of an outlier that will get us into trouble.

We did that, but we do it in kind of general way.

We did find out that for all practical purpose where we could relax it to allow for all the convenience in operation and maintenance it was not so bad. We found in a few cases where we have some problems, and those we corrected. We did that. We were concerned about that problem.

Again, you know, every plant has different characteristics and peculiarities in it. That may be different in the one that we had generalized but we are hoping to pick those up as we go along through this process.

MR. KERR: How thick are the new tech specs compared to the old ones?

MR. REINHART: They are probably thicker. If you look at them --

MR. KERR: I thought we had simplified things.

MR. CARROLL: We improved them.

MR. REINHART: We put white space in where there is a lot of words. I think if you look at the bases, the new bases compared to the old bases, they are going to be significantly larger. If you look at the LCO surveillance portion they are going to be a little bit larger, but there's going to be a lot more white space on the paper. If you remember from the example that we showed rather than having all that stuff jammed together they are kind of split out so the operator can, at a glance, tell --

MR. CARROLL: Forgetting the bases, Mark, the guts of the tech specs in terms of words, how may words do you think there are compared to the existing ones?

MR. REINHART: I don't know. The contractor who is producing these, I have asked to give me a page count. They are not done printing yet. I can get a number for you.

MR. CALVO: To be honest it is much bigger than the others because we are trying to explain things better.

MR. CARROLL: The bases aren't something that the operator looks at every day necessarily.

MR. ROSSI: Even the ICO's, you know, they can be easier to understand and simpler for the operator to use but still take a lot more thickness of pages than the old ones.

MR. CARROLL: Simply because you don't have as many words on a page.

MR. ROSSI: Also, the words are better and easier to understand. That's the other thing.

MR. REINHART: I think your answer in word count, my gut feeling is that there are going to be fewer words.

MR. CARROLL: Yes, that's what I would think.

MR. REINHART: A lot fewer words.

MR. ROSSI: There was one viewgraphs that gave a comparison to the number of LCO's that we believe have been removed from the tech specs, and I think the number is something like 40 percent reduction in the number of LCO's that are controlled by the tech specs in the new tech specs as compared to the old ones. That, I think is a better measure for the degree to which we specified the tech specs in taking things out and trying to stack the pages up.

MR. KERR: How thick is one of these things? I must say that when you add them with the tech specs, is this a ten volume thing?

MR. CARROLL: No, it fits in a binder like this.

MR. REINHART: The LCO's, I hope will fit in a binder like that, I'm not sure.

MR. CARROLL: About that thick.

MR. REINHART: Maybe thicker. The LCO's might fit in a volume and the bases will fit in maybe a large volume to two volumes.

MR. WILKINS: You don't really expect any particular operator to know everything that is in that whole volume?

MR. CARROLL: Yes. He doesn't get a license if he doesn't.

MR. WILKINS: The operator doesn't get a license if he doesn't pass the test on the whole thing.

MR. CARROLL: It's an open book test, but he has --

MR. WILKINS: That means that he's got to thumb through it and find what he's looking for.

MR. CARROLL: He has to know what it says and what it means, particularly the senior operator.

MR. CALVO: We tried the Pacific Northwest Laboratory in the last two months. We have requested to be provided to us on licensing examiners. We want to say tell us what you think of it and see what is your feeling of it. They all love it. I couldn't believe it, because there was a lot of words in there but they like the idea that it explains the reasons for the limited conditions for operations.

They say at least now I know for right or wrong what is operable before training -- the bases will tell me these things. They like it. There was some self-purpose because they figured out they can use that to give test to the operators.

MR. KERR: Who is this that liked it?

MR. CALVO: The Pacific Northwest Laboratory who are helping us out with the operator license.

MR. CARROLL: Contractor licensing.

MR. KERR: I would wonder how licensed operators would like it rather than how Pacific Northwest Laboratory people liked it.

MR. ROSSI: You might speak again to what you did at Chattanooga, because that may address that question better.

MR. REINHART: I mentioned we took a set of these specs and gave them to a training center. They implemented on one of their simulators, they put in specific numbers for that simulator and had a class of people who at least at one time held SRO licenses to operate the plants. From the people that took the class as well as the training center itself we got very good comments that they liked those specs greatly more than the current specs.

MR. KERR: From that I assume that industry generally is enthusiastic about what you are doing?

MR. REINHART: I definitely think so. Industry proposed the format and has been very enthusiastic about it from the beginning. I mention both they and us agreed on that format at the start.

MR. CALVO: Keep in mind that it was the industry idea. All we are doing is tuning it up and we are confirming that safety has not been degraded. That's all we do. The idea and the concept, the format and presentation was the industry. You have to give them credit for that.

MR. MICHELSON: Are we finished?

MR. REINHART: I have finished the presentation.

MR. CARROLL: One of the things with the existing tech specs was that there was never a requirement to update the bases, not that that made a lot of difference because the bases were so bad. Is that going to be required as you make changes to the plant?

MR. REINHART: There is a portion in the administrative controls that provides for the control of the bases and how changes would be made to the bases. If a licensee proposes a change to an LCO they would reflect it on the bases. They may even come in and propose a change to the bases based on what they learned.

MR. MICHELSON: In the tech specs there are various places where there is certain requirements concerning motor operated valves that will be met. Are those requirements still in the standard tech spec, or have they been moved to some other location?

MR. CALVO: The requirements --

MR. MICHELSON: Surveillance, for instance, periodic surveil'ance.

MR. CALVO: Some of them are there --

MR. MICHELSON: They were there and now are they still there?

MR. CALVO: If those particular motor operated valves had to do with the system that is important that say satisfy the criteria that are required to stay in the tech specs yes, that particular motor operator will have all the surveillance that you had before.

MR. MICHELSON: Maybe I missed those criteria then that decided what stayed in the tech spec.

MR. ROSSI: Somebody must have the viewgraph with the -- why don't you put it up.

MR. REINHART: I have it here.

MR. LOBEL: In some cases we are allowing for deletion of lists of specific valves; is that what you are referring to?

MR. MICHELSON: That's part of what I am referring to. When you delete them what happens to them, just delete them and forget them?

MR. REINHART: They are relocated to licensee control documents.

MR. MICHELSON: You mean -- how do I know what document or whether it's even picked again? These surveillance still have to go on.

MR. REINHART: That's true.

MR. MICHELSON: Clearly --

MR. REINHART: When the licensee proposes his new tech specs he is required to tell us where the relocated requirements go, how they are implemented and the staff is required to go out and inspect to make sure that is --

MR. MICHELSON: Each licensee may do it differently according to his particular arrangement, is that right? You have to pre-prescribe where it has to be moved to, so I guess it depends on the licensee.

MR. CALVO: If it is a system that puts in -- we had reference on the bases to tell where that information is located. Keep in mind -- only the tech specs establish the framework where the procedures on that plant that they got to be implemented to assure that the criteria set forth on that surveillance have been met. If you want to list all that equipment and the bases you are not talking about --

MR. MICHELSON: You have to list it somewhere or people don't know what they are supposed to do.

MR. CALVO: That's right. That's the procedure.

MR. MICHELSON: This is found in another document now. That document, they prescribe how frequently the surveillance has to be performed.

MR. REINHART: That's correct.

MR. ROSSI: Specific isolation valves -- the actual list of the containment isolation valves -- augment or correct if I say something wrong -- the actual list of the specific valves by valve number will not be in the standard tech specs. They will be somewhere else. There will be statements covering LCO's and surveillance times and action statements in the tech specs for the containment isolation valves as a whole but the specific list will be somewhere else.

MR. MICHELSON: In other words this tech spec will say you need to do the testing but it won't indicate the acceptance standard --

MR. ROSSI: The time responses on them will be somewhere else.

MR. MICHELSON: It would have to be, or you are back to a list. Let me -- we used to have that information in a tech spec and now it has been moved. The requirements are still the same in a new location; is that correct?

MR. ROSSI: The requirements, I would say, are in the tech spec --

MR. MICHELSON: No, the requirement that it must close in 15 seconds, that kind of requirement.

MR. ROSSI: Yeah, that is somewhere else.

MR. MICHELSON: That will be in a new location. Now, what control is there over that new location in terms of my changing it to 20 seconds instead of 15 --

MR. ROSSI: It will be through the 50.59 process basically, or a process similar.

MR. MICHELSON: Was that the way --

MR. REINHART: A staff approved process in 50.59 as upgraded is one of the methods that is proposed.

MR. CALVO: The requirement how often you got to do the test, that is in the tech specs. What is outside the tech specs is the procedure or mechanism how to accomplish that test. That procedure has to satisfy that criteria that is set forth in the tech specs. For instance in containment isolation valve, I think the requirement for the containment isolation valve is in accordance with the in service testing inspection program who establish possibly once every quarter. That is a requirement governed by the tech specs and nobody can change it without staff approval or without issuing an amendment.

The mechanism to implement that is outside the tech specs in a procedure. That time cannot be changed. You go back and change the tech specs.

MR. MICHELSON: The frequency --

MR. CALVO: The frequency is controlled by the tech specs.

MR. MICHELSON: The acceptance standards are what I was really trying to deal with.

MR. CALVO: If you have some peculiarity in there that you want the leak rate for that particular valve has to be so much and you feel that it is -- you put that as part of the surveillance and then you are controlled by the tech specs.

MR. MICHELSON: The key question that I asked is that was what was in the old tech spec and now in the new tech specs, has now been moved and has anything been changed when they moved it.

MR. CALVO: No, not in all the cases. On some very few cases. It was established in the tech specs and sometimes not.

MR. MICHELSON: If it was established that it had to be a certain time to closure for instance, that I will find now in this new document.

MR. CALVO: Right. When we went through the process of reviewing all these surveillance of what stays in the tech specs, we also challenged some of that acceptance criteria that we used in the tech specs. It was a staff decision which it wants to still keep them in and which it we felt was not important enough to keep them out and let that be controlled by the document.

MR. MICHELSON: Let me ask the question a little differently. In the process of creating this new document, this new location for that particular listing, did you drop things off the list when you did that or is it the same list that would appear in the old tech specs.

MR. REINHART: That is to be audited by the staff--

MR. MICHELSON: What was the intention --

MR. ROSSI: I think the answer is, recognize that we have some plants out there today where the list in the tech specs isn't up to date, and to get that up to date takes a license amendment. By moving these out into someplace else it will be much easier --

MR. MICHELSON: The adders I am not too concerned about. It's where you have subtracted --

MR. CARROLL: Well, the subtractors they have to do 50.59.

MR. MICHELSON: That's right, and that's the answer that I got. It is the same list unless they have done a 50.59 on a particular item that got dropped off. I am not challenging that you have done it right or wrong.

MR. CARROLL: Any more questions of the staff?

[No response.]

MR. CARROLL: Did NUMARC want to make any comments on this program?

MR. HALL: My name is Warren Hall. I am the Operations Manager of Support Service, Division of NUMARC. I would like to thank the Committee for giving me an opportunity to speak here, and I appreciate it. Basically my thoughts here are, we have listened to the presentation and would just like to clarify a few things as least as far as the industry and NUMARC are concerned.

First of all, the staff review and discussions with the Owners Groups, we have not been in discussion with the staff on the tech specs, the LCO surveillances or the bases since about late July or early August timeframe. We have not had any meetings, nor have we had any reviews of the things that they have been writing to date.

We have had several discussions with Mr. William Russell of the NRR staff, and we are under the impression that the tech specs that will be issued by the staff in

April are not the final draft. That was our impression, and that is what we were told by Mr. Russell. What we will get is a set of tech specs that the industry will review and comment on along with the staff. We will return comments to the staff on these tech specs. We will, at that time, proceed to meet with the staff on these issues and try to resolve these things, at which time when and if we get all the comments resolved or whatever the final resolution of the issues are, the tech specs will then be issued in final form to ACRS, CRGR and the rest of the world to look at and comment on or go through the process.

There is also included in there an appeal process for issues that the staff and the industry do not agree on. We do have some, they are aware of some, and we are aware of some. I just wanted to kind of let you all know that that is our understanding of how this process goes prior to coming back to you all for another session. It was also our understanding that it would be coming back to you folks for another session prior to being issued for use by the industry and for implementation by the industry.

Also, our understanding was -- and I may be wrong and if I am correct me please -- that the lead plants would not be implementing these programs until after we have been through the review process and the discussion process with the staff. That was our understanding of the issues several weeks ago when we spoke with Mr. Russell.

Outside of that, I don't have any other comments. I just wanted to get that on the record to get that straight.

MR. CARROLL: What is the appeals process as you understand it?

MR. HALL: Excuse me?

MR. CARROLL: What is the appeals mechanism?

MR. HALL: The appeals mechanism, as we understand it, if after we have marked up our comments and submitted them back to the staff and after our meetings if we have an impasse, we then have the first process would be Dr. Rossi. Then we would go to Bill Russell and then to Dr. Murley. I don't assume we would go much past that at that point.

MR. CARROLL: Generally the industry is happy with what is happening here?

MR. HALL: I don't know. We have not seen anything since July or August, and I would not want to comment one way or another about it until we see the final product.

MR. WILKINS: Let me ask the question a little differently. Are you happy that something is going on?

MR. HALL: Again, I would have to see what was there before I would say I was happy or unhappy.

MR. ROSSI: I wonder if you could comment on the format and the user friendliness and that kind of thing of the tech specs. I don't think there's any changes going on. I think most of your comments apply to individual line item disagreements that you may have with the staff.

MR. HALL: Format and so forth is as -- we agreed on that, and I think everybody is quite happy with the way the format has been laid out and feel that is probably going to be very beneficial. The operators from the various Owners Groups that have looked at the format also in concert with the staff think that the format is very good.

MR. CARROLL: Are you a party to the idea that you give people cautions before you tell then what you are cautioning them about? Question withdrawn.

MR. WILKINS: I notice in the EDO's letter to the Commission -- SECY something or another -- 93.66 dated October 29, the staff expects to resolve any public comment, complete ACRS and CRGR review and publish the final version of the new STS in the spring of 1991. That doesn't somehow seem compatible with what this gentleman has just said nor, in fact, does it seem compatible with what I heard behind me.

MR. ROSSI: We are in the final stages now of completing the editorial work on all these sets of standard tech specs. We hope to send those out by letter very soon, hopefully by the end of the year or very soon thereafter to

NUMARC and the Owners Groups and within the staff and obviously they will be made public at that point in time asking for the comments from the Owners Group and NUMARC, and I guess anybody else that wants to comment on them.

We are anticipating I think it's 30 working days now to get the comments back, and then there will be some period of discussion and resolution of the comments. Then we would hope that we can issue these things in final. We believe that we are talking spring of 1991.

MR. WILKINS: That means you will do it before you have the experience from the lead plants.

MR. ROSSI: We are not intending to have the lead plants try to use the tech specs on a plant before we issue them. The lead plants have been involved in this. Recognize issuing the new standard tech specs is not the same as issuing the tech spec for a particular plant. If you issue the tech specs for a particular plant it's a very legal document and only can be changed by license amendment.

The new standard tech specs really serve as guidance for people to use in developing plant-specific tech specs. Obviously, anything that we learn through the process of a lead plant adoptions of these new standard tech specs, we will factor them back into the new standard tech specs as part of a reasonable process. It is also the lead plants have been involved all along in the new standard tech specs, so it's our hope that there is not going to be a big gap here anywhere.

Obviously, with something like tech specs there's always disagreements between the staff and the industry over the need for individual requirements and whether something ought to be seven days or 14 days; whether a particular piece of equipment really needs to be controlled by tech specs or not. For that, there will probably be some disagreements, and they will be resolved through some kind of an appeal process.

MR. MICHELSON: Will you have to review them on every plant? How many people are going to use the standard tech specs?

MR. CALVO: About 70, 75 or 76.

MR. MICHELSON: You have to review every conversion since licensing action --

MR. CALVO: Yes.

MR. MICHELSON: Voluntary.

MR. WILKINS: If what I heard this gentleman say, he doesn't know either, and that will depend on what they look like.

MR. HALL: That's correct. I think that's a fair statement.

MR. MICHELSON: It is going to be a rather large effort on the part of any given licensee to convert since this is a quite a bit different kind of tech spec. He has to now make it a plant-specific tech spec. He just doesn't take it and fill in a few blanks.

MR. CALVO: Somebody tells me -- some of the industry and some of the licensees -- you require three years from the time you make your mind to do it to the time that you implement it. I guess the hardest part is to collect the information to establish the basis for the standard because -- the other hardest part is to prepare those significant considerations to go from what you go to what the new one is. You got to explain that it cannot be --

MR. MICHELSON: Haven't you been allowing them to remove certain items from the tech spec already and replacing them over in other documents?

MR. ROSSI: Yes.

MR. CALVO: That will require also significant hazards too --

MR. ROSSI: We have issued a number of generic letters, and there are some more generic letters that are going through the CRGR process now that allows them to do things like remove component lists and put them somewhere else without adopting the whole new standard tech spec.

MR. MICHELSON: Without adopting the standard tech spec.

MR. ROSSI: Surveillance interval changes we have done through topical reports, and people can do that today in a lot of cases.

MR. CALVO: It will be a very expensive endeavor.

MR. MICHELSON: Let me ask one other question. There is the NSAC document 125 dealing with 50.59 interpretations which I guess must get into this process since that is the mechanism you are using. Have you people reviewed NSAC 125 and adopted its principles, or how --

MR. ROSSI: We have reviewed the document and we have commented on it a couple of times, and our comments I guess are included in it. It is out now. I think some utilities are using it today; are they not?

MR. HALL: Yes. All of the comments that Dr. Rossi's group and the staff had are incorporated into the at document before it was issued. We issued it about a year ago, and we have just -- we went out and asked for comments from the industry. We have gotten back approximately -- we have gotten back comments from 25 utilities regarding their use of the document over a year.

MR. MICHELSON: Is it reasonable though in my reading of it that I can say that the staff has blessed that document?

MR. ROSSI: Where we are right now is that we have commented on it, our comments are in it, and at some point in time we are going to solicit our own round of comments from people within the NRC and then we will discuss the industry comments in it. Then, there will be another round of blessing of the document.

MR. MICHELSON: ACRS has never, to my knowledge, reviewed that document. It is becoming more and more significant because of its use in lieu of whatever is already said in the regulations. Presumably it complies with the regulations. At some point I think we ought to -- at some appropriate Subcommittee time it would be well to look at it Jay.

MR. CARROLL: I think that's right.

MR. MICHELSON: I find it -- I have some questions. I am not sure that I have any problems, but I do have a lot of questions about it.

MR. HALL: We would be happy to accommodate you as far as anything that we can do.

MR. CARROLL: When do you feel it would be a good time? When is the dust going to settle?

MR. ROSSI: After we get our new standard tech specs out. That's where all of our effort right now is going, and then we will return to some of these other efforts like further blessing of NSAC 125. That also, at some point in time, is probably going to have to go to CRGR before we put something out that more formally adopts it.

MR. MICHELSON: It is getting somewhat widespread use without appearances of being -- it's not a reference document --

MR. ROSSI: It doesn't have Reg Guide status, no.

MR. HALL: It was issued as a guideline. That was the purpose.

MR. MICHELSON: Only as an industry guideline, not as an NRC guideline.

MR. HALL: I might pass on a bit of information. In the process we have been trying to gather information from our members on the 50.59 as I said. There was the staff mostly NRR people, did an inspection as Palisades on their steam generator change out program. They went in and inspected there, and spent quite some time I guess, about a week, going over their 50.59 program that they were doing for their steam generator.

The inspection report has been out several months. It gave them a very clean bill of health with regard to that. Our discussions with Palisades indicates that their entire 50.59 program is based on the guidance that was put out in NSAC 125. At least from that point of view it looks like it has been fairly positive.

MR. CARROLL: I think what you are suggesting Carl is appropriate. Paul, do you want to sort of keep in touch and find out what a good time for us would be to sit down and look at NSAC 125. Are there any other issues on tech specs?

MR. WILKINS: I just observed that the then Commissioner Hazeltine had some rather caustic remarks to make. I thought that at least a couple of them are things that staff ought to pay a little attention to. I assume they did.

MR. CARROLL: Page 21.

MR. WILKINS: In my book it is handwritten page 21. He wants to be sure that the NRC continues to have its ability to fine a licensee or to seek escalated enforcement action against a licensee who fails to comply with a relocated technical specification.

MR. CARROLL: No problem.

MR. WILKINS: You have no problem with that at all.

MR. CARROLL: That is what Appendix B does for them.

MR. HALL: Thank you, I appreciate it.

MR. CARROLL: I thank the staff for a very informative presentation. Paul, I guess we have to decide what we are going to do on future interaction on these new standard tech specs. I guess from reading the SECY 93.66 which we just heard some discussion of, it sounds like the staff expects to resolve any public comment, complete ACRS and CRGR review and publish the final version in the spring of 1991, which sounds like we are supposed to be in that loop.

I guess that would take place after NUMARC and the staff had interacted. Again, I guess I will charge you with keeping in touch and finding out when a good time to have a NUMARC and staff discussion on that prior to publication of the final version. Back to you, Mr. Chairman.

MR. MICHELSON: Thank you. Time for our 2:30 break. We will be back at 2:45.

[Brief recess.]

MR. MICHELSON: We are ready for our next agenda item, which is relating to the NRC's safety research program. Ivan Catton is going to conduct the discussion.

MR. CATTON: The DCH issue seems to come and go, just as my personal view of it does. About a year and one-half ago Novak Zuber was asked to address a scaling issue as associated with severe accidents. I am not sure how it came to pass, but the DCH question was chosen for the demonstration. The project is almost completed, and a report is due in draft form by the end of this month.

The reason for asking Novak to give a presentation at this time is that he is retiring at the end of this month. I thought that in that he has had an illustrious 40 year career in the business of boiling and two-phase flow, we should hear what he has to say about the scaling in this arena.

MR. ZUBER: I would like to thank the Committee for giving me this opportunity to present the results of the --

MR. MICHELSON: I think you are going to need to put the microphone closer to you because we can't hear you.

[Slide.]

MR. ZUBER: I appreciate the opportunity to be able to present the results of the work that we have been conducting for about two years, and the work was done by technical program group. You will see the names of the participants. The reason I am to be here is that if you have any criticism please address them to me, because I would like to be able to answer and accept it.

What I would like to present today is given in more detail in the handout. I will not go over the entire material. The reason I prepared extensive handout is so that you can read it if you are interested and follow it in a more -- in a better way than if I skip something in my presentation. All this material is presented in the report, and I will discuss the outline of the report, the content and the date it is planned to be issued.

[Slide.]

What I will present today is an integral structure and scaling methodology for severe accident technical issue resolution. A technical program group was formed in January of 1989 to address this problem and develop a methodology. The members of the group are listed on this slide. You can see that you recognized authorities or experts or knowledgeable people from industry, from laboratories, from universities. It's a balance of talents and inputs of different point of views. What we present is output from nine meetings we had with the TPG.

[Slide.]

The outline of the topics which are covered in the --you have five handouts, five parts to the handout. You have the topics which are covered. There is an overview of the structure for technical issue esolution. There is a brief description of the components and overview of the scaling methodology SASM, a brief description of the components, and overview of two-tier scaling analysis, an application to DCH transient and the content of the report.

What I shall do is just mention this in about two minutes. You can read it, and I will emphasize and spend most of my time on the scaling analysis application to DCH and what conclusions we derived.

[Slide.]

ISTIR, the methodology has five components. These are shown on this slide here. The purpose of this structure is to provide an efficient method for technical issue resolutions. In component one you specify the issue, you specify the requirements, and the phenomena in the particular transient. This is the requirement for experimentation and code development. The reason that you have this one here, you want to provide the same requirement to two activities; experiments and code analysis.

Box number two is SASM and severe accident scaling methodology and experimentation. Its function is to ensure that the data obtained from experiments are prototypical and can be used either in codes to develop models or a special models done for a particular problem in activity three. The technical issue resolution is achieved either through codes and uncertainty analysis or through some special models and experimental data and uncertainty analysis.

I will not discuss item four, five and three. I will just give you an outline of one and spend my time on item two. You have the description of the activities in the handout.

[Slide.]

Component number one specifies the requirement. You have to specify what the issue is and provide the success criteria. To specify the scenario, you have to specify the particular plant because plant configuration is important aspect on this problem. You have to specify the accident part, because different parts lead to different results. You have to provide a rank and table of phenomena. You identify the phenomena and rank them, and this provides the requirements for experimentation and for code. This is the first activity.

[Slide.]

I will discuss now the second activity, SASM, and give you an outline and go into details. This is scaling and experimentation. SASM is divided in three elements. In the first element from component one, you transpose the requirements into experimental objectives. In element two you perform scaling analysis, identify similarity criteria from integral test or separate effect tests, obtain the data. Element three is provide documentation and there is requirement for documentation. Those are the three elements. I will not describe the steps. They are in the report, and some of them are in the outline. This is the procedure to follow.

I will now stress from now on the scaling and the similarity criteria and its application to the DCH problem.

[Slide.]

What I will discuss now is an overview of a two-tier scaling methodology, and I will give you the rationale why we need the two-tier methodology for severe accidents and how we did apply this methods to DCH. The topics which are covered in the handouts are listed here. I will just briefly outline the highlights, and more information is provided in the handout. The rationale is discussed in the handout and in more detail in the report.

Let me first tell you something about severe accidents. Let me first tell you the objective. The objective of this activity is to ensure prototypicality of the experimental data, one. Two, to provide the methodology that is systematic, practical, auditable and traceable. This is what is needed by a regulatory agency. We have to provide the scaling rationale and similarity criteria. Somebody asked how did you scale the facility, what was the rationale that methodology should provide this. Four, we must have a procedure how to review design and test. You have to provide this procedure.

Finally, the final objective also is to -- if you have biases, if you have scale distortions or non-prototypical conditions, you would like to have a method to determine the biases. The objective of the scaling methodology is to meet these four objectives. What I should present is that this is methodology that meets all of them.

MR. LEWIS: Are you confident that there is a word prototypicality, because if so I have just learned something.

MR. ZUBER: Let me say that I think we can provide the phenomena that we observe in a small facility --

MR. CATTON: Novak, I believe he is questioning the english word, prototypicality.

MR. LEWIS: I agree that there should be such a word.

MR. ZUBER: I didn't coin it or wish I had. I just copied it.

MR. LEWIS: You were just being inventive.

MR. ZUBER: No, I was not inventive on that one.

[Slide.]

Let me tell you something about the characteristic of severe accident, because this sets up the tone of the development. The characteristic of severe accidents is the interactions and reactions of media, of many constituents, several phases which exchange mass momentum and energy simultaneously.

How we can characterize this problem is one, each constituent occupies only a fraction of the volume because they are acting in a given closed space. Each system component is characterized by a scale and by a time constant. Each physical process, whether it is physical or chemical, it is again characterized by a dimension and time constant.

What this means is that when you look at a problem in the entirety it is a problem which has multiple scales for spatial and temporal. What this means is, because of this complex iteration and reaction between various fields and phases and solids you have to take synergetic effects. You have to take global view of the problem. You cannot take one aspect of it and analyze it to death, because it may be relevant in the globality of the processes.

So, what this interaction, this synergetic effects forces you to take a global look. Because of the complexity this forces you also to look at the hierarchy. You cannot look at everything at the same time, you cannot scale everything satisfactorily. You have to have a rationale how you applied and then be able to sell this rationale to other people. This is what I am trying to do now. We have to do it outside.

The next viewgraph really summarizes the entire methodology, and let me spend some time discussing it.

[Slide.]

There are really five concepts which provide the basis and it is divided in four activities. One is that we need a hierarchy. What this means is that you have to decouple the system, provide a system hierarchy to identify the geometries and then identify the physical processes. You have to identify the geometries because you have different scales, different areas. You then have to identify the scale. There are really three scales that you have to deal with.

One is that each process has its own time scale. Each process occurs across the characteristic area. That area has a scale. For example, let me say that in a water and debris, you have to characterize the geometry. The third important factor is the concentration. You have to characterize the amount of material of any material in that volume. You cannot give a number of pounds or kilograms or tons in looking how does it affect the entire process.

There are three things that you have to really scale and provide this hierarchy. This is the activity here.

[Slide.]

The two-tier scaling analysis is being carried by a top-down system approach and a bottom-up process approach. The system approach is predicated because you have to look at the globality of the phenomena and formulate a rationale how to address them. What this means is you have to have the conservation equations, the scaling groups, establish criteria hierarchy, and identify important processes which have to be looked at in great detail.

I said there are many fields which are interacting. How can you scale all of them in the same way. Usually when you go into textbooks people scale or example the momentum equation ratio forces. You go to the energy of the ratio of energies. What we are using here is something which some other people did also before us. We used the time scale. We transferred everything in terms of a system scale which is how the system responds and how each process responds and we make a comparison.

This provides us with - mechanism to use the same meter, the same measure on all p.ocesses. This enables us to obtain the scaling hierarchy and identify which are the important process and then really scale them correctly. We don't care about scaling something -- you have to address the important phenomena and this methodology provides it.

Once we have identified important phenomena and scaling ratio, we perform a detailed analysis, a detailed scaling analysis to provide -- to ensure that the important processes are properly scaled. This is the reason for a two-tier approach. You cannot do this without looking at globality. Doing this together with the globality gives you assurance that you have addressed the important processes.

This activity ensures that the methodology is comprehensive, systematic and traceable. At every point of the analysis you can check this thing here. This activity provides for properly focused analysis. You identify what is important and you analyze it. Together, this provides the efficiency, this activity provides the sufficiency, and together they provide the method which is practical and then you can use it. I will then use this to the DCH, these steps to show what the results we obtained and what conclusions we reached.

[Slide.]

Let me illustrate how we establish system decomposition. We can decompose a system in subsystem in modules. I call them module control volumes. Each control volumes can have several constituents, water, hydrogen or whatever. Each constituent can have several -- two phases, either fluid and gas or fluid and solid. Each phase is characterized by particular geometry. That is important.

The reason the geometry is important is because transfer occurs at those areas. This is what you have to scale. You have to look at the particular geometry. For each geometry you can have then described in terms of three fields mass energy momentum, and for each of these fields you have different processes. This is the hierarchy, the marching order of the thinking and of the analysis.

[Slide.]

At each stage of this analysis you identify at time scale and length scale, and as you get into geometric configuration you have to identify also the concentration. This concentration really tells you how much of this amount is present in this volume and that volume. This provides the scaling of the amount. There are, as I said, three things to consider. There's time, length and amount. This has to be scaled. You cannot address this problem without thinking of these three elements.

[Slide.]

Now, what are the characteristic length. The characteristic length is the transfer area, because this is which this process occur. You have several processes For example, take the cavity. You have solid walls, you have structures, you have melt down, you have droplets, you have water, droplets. You have to provide a rationale how you can address all of them together and then scale it.

The thing to do is the transfer area concentration is the area for transfer divided by the control volume. These scales, each surface across which the transfer mass, momentum, energy or whatever. You define a void fraction of the given constituent, volume constituent divided by the control volume and this is the volume fraction of constituent V. The area concentration of this particular constituent is which energy and mass is transferred is given this ratio. It is a characteristic length multiplied by ..is volume.

This volume specifies the initial amount and this specifies the geometry. For example, for sphere this is six over D for films is one over thickness of the film. If you have solid structure we have another quantity. If you have pipes it's one over D and so on.

[Slide.]

Now let me see how you form hierarchy for the geometry. Suppose now I am considering water. Control volume V consists of V. The constituent is water, the fraction of the water in that volume is alpha sub-C. Water can be in gas form and in liquid form, each one has its own fraction of the volume. The water can be idle in terms of droplets or in terms of films. Each one has its own characteristic geometry.

This you analyze the system, you want to synthesize these results and you bring it up and this is the characteristic transfer area for water, which takes into account the initial amounts, particular geometry and particular lengths. This is how -- the thing to notice is this. You see how this affect is being attenuated because all of the fractions are less than one. This may be a quantity here, but this is factor of ten or more by the time you reach here.

This is the reason that you have to consider the total system in -- you have to look at all present phases to obtain these fractions correctly. I will not discuss the scaling of time. It is in your handout. Let me say something about the time processes.

[Slide.]

There are two time processes of interest. One is the system response. This is how the control volume, if I have a control volume and Q is the volumetric flow rate of a fluid, this is the residence time in the control volume. This specifies how the system, how fast it responds. Each transfer process has its own time scale. Let me take J as a general flux. Let me say this is a heat flux. Multiply by the transfer area gives me BTU per hour.

If size is general quantity, then it is a quantity per unit volume. If this is energy, this would be the enthalpy per unit volume multiplied by the volume of the control volume. This gives me the initial amount of energy in the control volume. This ratio gives me characteristic frequency. This tells me how important is a particular process. This is almost like interest rates. You put so much money in the bank and this tells you how many times this changes per second. This is identical if you want to develop number. It gives you the frequency. The ratio of these two numbers, of these two times, scales the relevance of a particular process. This is shown on the next slide.

[Slide.]

This tells you how long a particle remains in the control volume, this tells you how fast the transfer process occurs. It gives you the total change of a particular process during a residence time. This is the characteristic ratio. The important thing is that all processes are measured by the same residence time, so this gives you the common meter to compare all the processes whether it's mass transfer energy, transfer momentum, transfer -- this provides you the scale.

[Slide.]

For each process this ratio incorporates temporal and spatial scale. We use the same yardstick to evaluate all processes. The similarities provide that the processes have to occur at the similar time scales. If a process -- if this ratio is ten to the minus one and another process is ten to the fifth, of course, the ten to the minus one doesn't mean anything. We only focus on the important one. This ratio provides two things; the process point and system. It really puts everything together for each particular process. You will see how this works on the DCH.

[Slide.]

Let me summarize something important on this slide here. What I have discussed was, I gave you some physical explanation about the characteristic times are. You can derive the same criteria from the general balance equations. What this means is that all processes can be measured by a single measure in terms of time ratio. At each point this provides you with capability to establish a scaling hierarchy.

At each point in the hierarchy you can evaluate any process and you can examine it in detail. This then provides you for a methodology that is systematic, auditable and traceable. You provide the hierarchy, you can examine every point and any element in the hierarchy and then evaluate the importance. The hierarchy can be used for two functions. One is to provide you justifiable rationale why you perform these experiments in this way. This process is more important compared to the other ones, and you will see an example.

It also identifies which processes are important so that you have to pay more attention to them and perform a bottom-up analysis. The bottom-up analysis assures that what is important is properly addressed. This gives you the sufficiency. In a nutshell, this is the outline of the methodology. What I will now show you is the application to the DCH.

[Slide.]

This is discussed in Section 3. What I will just briefly mention is application of component 1. We identify the scenario which was DCH station blackout. We took Zion as the plant. We identified the accident and you will see what it is, and we identified the process. This is in your handout. Let me just show you the part and I won't discuss this because there is a big discussion of this in the report. What I shall discuss is the application of scaling, show you the flow diagram, how we approach the problem, how we scale the reactor pressure vessel discharge phenomena, and how we scale the phenomena in the reactor cavity.

[Slide.]

I will show you now the accident part we analyzed. This helps us analyze what are the processes at different stages, and from this we transfer in another activity to identify the important phenomena. It is in the handout, and you can see how we rated them.

[Slide.]

Let me show the application of SASM to the DCH. We have to set up the initial conditions. We looked at the pressure vessel failure conditions. We even looked at the reactor pressure vessel discharge phenomena and reactor cavity phenomena. The items which specified initial and boundary conditions were looked at by Sol Levy. There is a quality report in the appendix our report. He addressed the following items; reactor system pressure behavior, progression of the core damage, the relocation of debris at the bottom head, heat transfer to and failure of bottom head in order to be able to obtain the amount and composition of the material coming out. This sets up the conditions.

Then you looked at discharge phenomena, corium solid melt discharge, multi-phase discharge steam blow through hole ablation, solid debris retention in vessel, and single phase. What is interesting thing, this was something that we found is that if you have debris which is partially solid and partial y melted, the solid will remain in the vessel. There is an angle of 45 degrees from the hole. Everything beyond that angle will remain in the vessel. He performed some experiments and obtained that.

What it means is that if you have some debris, a large portion of the solid material will remain in the vessel and only the liquid may come out and a fraction of the solid. They he proceeded to look at the reactor cavity phenomena. We did the two-tier approach of scaling. We did the pressure rate equation and I shall discuss it. From this we obtained the similarity criteria and obtained these hierarchy. Then we performed a bottom-up analysis to analyze corium discharge and dispersion.

[Slide.]

Let me just give you an example of the results that Sol Levy obtained in his analysis. He specified initial amount, so it is station blackout at high pressure and low pressures. The point of interest is that you can see the difference in the composition and a difference in the amount of material. This is the reason why it is important to specify the scenario. Different scenario and condition will give you different initial conditions, different initial conditions give you different scaling groups, different volumes for the scaling groups and different conditions to perform your experiments.

This table that is also in your handout, a table of contents of his report, so you can see all the items which are addressed in his report and which will be reproduced in our final report.

MR. CATTON: He concluded it was about one-half the core.

MR. ZUBER: Forty tons.

MR. CATTON: Less than half. The temperature is 2,500 degrees?

MR. ZUBER: Twenty-five, but the composition changes. I think that is important for several reasons, and you will see why.

[Slide.]

This is information we had. We had to analyze what is available in order to set up the conditions. Let me show you an example of applying the top-down approach to obtain top-down analysis. We formulated the problem, Wulfgang and I did this. We formulated the problem in terms of conservation of steam, hydrogen, water liquid, and debris conservation of mass. Conservation of energy for steam, hydrogen mixture, water and liquid and energy balance of the water liquid interface and gas-liquid interface.

Then we work with these equations and derived the pressure rate equations. I shall discuss it in a moment. We used this pressure equation to obtain the scaling groups which were expressed in terms of time ratio, and from this we obtained the scaling. This is what is important phenomena, where we have to put our attention and where we have to put our money. So, this is the result.

[Slide.]

I will show you just the equation to show you that what I am saying exists. It is in the report. This shows you just how we addressed the problem of water in the cavity. We have here debris, we have hot gas, we have a liquid which may be subcooled. The debris can radiate to the interface, the gas can transfer energy by radiational and convection to interface. You have a transport due to the vapor which is vaporized. You have an transport to the interface with the fluid, and you have heating of the fluid because it's subcooled. The mass and energy balance is here. This is something that we used to formulate the problems.

[Slide.]

The pressure equation is shown on this slide. Let me tell you and identify the terms so that you can see what it addresses. I won't discuss each term. Pdt is the rate of pressure change WG is the volume of gas. The first term here accounts for the enthalpy of the steam and the hydrogen. This is the enthalpy output of the cavity of the steam and hydrogen. Item three is the gas structure heat transfer, this is the area of the structures, temperature of gas and temperature of the structure.

This is debris to gas heat transfer, debris of temperature of the debris in gas, and this is the area for transfer of the debris to gas. Item number five is the zircalloy oxidation. It has two terms. The steam gas is moving through the pellets and transports in enthalpy. This is a loss to the mixture of the gases. Hydrogen is coming out of the pellets due to the reaction with the given flow. This is the balance of energy at interface and reduction occurs in the pellet.

Zero is the area of the zirconium available for the oxidation in the pellet. This term here is due to water, this is the enthalpy flow of the saturated operation. This is the heat transfer from the gas to the interface, and this is the interfacial area between the gas and liquid. Each process has a different area. This is the reason you really have to look totally to address the problem.

This is the PtV term due to moving the liquid. This is the PtV term due to moving the debris, and this is the most interesting quantity that came as a final result. Because the hydrogen doesn't have the same density of the steam, as you generate hydrogen there is a PtV due to hydrogen generation. This term accounts for the difference in density between the hydrogen and steam.

[Slide.]

Let me just show you a type of equations we get -- we put these equations in non-dimensional form. We obtain the pie groups for different assumptions. Let me just illustrate what we get. For example, the effect of oxidation zircalloy is given in this group here. These are the parabolic rate equations. This is the diameter of the particle. This is the initial temperature of the debris, and this is heat of reaction. This quantity here accounts for the amount of the debris which is melted which may be in droplet forms and the amount of zircalloy. This is the reason I am saying you cannot just take one problem and look at it, you have to formulate it globally and look in detail at each step. This is all pie ratios are of this form here.

[Slide.]

I will not discuss them. The rest of them are reproduced in the report. What I will show you what we did on the bottom-up scaling because we found out, of course, this was particle size was important and then we analyzed detail. This was done by Ishii and Sal Levy. We looked at the corium discharge modes, corium impingement and spreading in the cavity, cavity flow conditions, and corium entrainment and droplet size.

Once we have established what is important, then we focus in more detail on the important phenomena. In discharge modes we looked at the single jet breakup, two phase jet breakup, jet breakup length and droplet diameters. In the corium impingement we looked at the corium jet and droplets impinging on the flow, and the spread out in thickness.

Here we looked at the conditions in the cavity, the conditions. The final thing we obtained inception of entrainment, transient entrainment rate, and droplet size.

[Slide.]

I will not go into details, but you have in the handout. You have table which summarizes the results. Let me just show you one thing, for example, that Sal obtained. This is correlation and this is scaling factor, this is represents entrainment parameter, and this is correlation of the data. There is additional data in your handout. This is something that we obtained.

You can ask me now what did we do with it. Well, we formed the pie groups. This is not in your report for one reason, that this was not reviewed by the group. What I will tell you is my opinion and this is opinion of BNL who did these calculations. Having these pressure calculations we obtained the pie groups and we obtained the scaling.

This shows the results. This shows the effect of heat transfer of liquid, water and zirc oxidation.

Here we have six particle sizes; one millimeter, six and 20. The reasons we worked with six and 20 is that analysis of Ishii and correlations available indicate that the particles in the reactor will be in this range here. Pie PG means heat transfer from debris to gas. It has for one particle has a volume of 14. That is the largest one that it can have, otherwise it will be smaller for this particle size.

Gas to structure is -- this you can completely neglect with respect to this thing here. If you change the size, these are the volume that you have. This is important to discuss, there are two terms with the water. We first looked at the effect of heat transfer from gas to the liquid by convection and radiation. We are now looking also at the effect of radiation from the debris to the gas or to the interface.

There is a mechanical term which is much smaller than this, but let me say something about this term here. This is the minimal value that we can have if you want conservative. In fact, it can be much larger than this. This calculation was performed only for this calculation you have 40 tons of melt. The amount of water was only five percent in the cavity and you obtain a quantity of two.

Sandia has performed some experiments where the cavity was half full which means ten times larger than this. This number then becomes much larger.

What I am trying to say is that you cannot perform an experiment and take any arbitrary amount, either of solids or liquid. You have to do it on a consistent basis and address it and perform experiments in a consistent basis. That is number one. Number two is also the effect of droplets as they evaporate the droplet size decreases and operation gets faster and faster. Therefore, this contribution of water will be even larger than this thing here.

What I am really caution about this is while conservative, it may be much larger depending how much water you have and the operation. The effect of zirc oxidation there are two terms. One is the thermal and the other is mechanical. This one comes from the PtV term and this comes from the heat of reactions on order of one and one and one-half.

What can we do with this? We can say fine, I can perform experiments and verify this or I can use different assumptions and do sensitive analysis on any one of these numbers. You don't need a code, you need a slide or hand calculator, and you can perform sensitivity for different assumption of heat transfer coefficient or of sizes, and you can establish a rationale how to approach something. Then what you want to verify in experiments.

This gives you the scaling criteria, and gives you the roadmap, the hierarchy to approach something. Of course we can neglect heat transfer, here we can neglect the PtV term for water and so on. Let me show you one more thing and then I will have to quit.

MR. CATTON: About ten more minutes.

MR. ZUBER: Okay, good. We were interested to compare the amount of how important this chemical reaction versus heat transfer to debris, because debris has to effect one to transfer and one to zircalloy reaction. We formed this ratio here. You can see that as the droplet size decreases the importance of the chemical reactions gets more and more important compared to the debris heat transfer. The point is, what we found out from Ishii analysis is that in the reactor the particle size probably will be in this range here.

Essentially, this would indicate that chemical reactions using parabolic the way we used it, is unimportant and much less important than debris in addressing the debris would be probably more important. We can perform another sensitivity analysis and use different reaction rates to see what happens to these numbers here. It provides a way to do sensitivity analysis in a very efficient way.

MR. CATTON: If I have a lot of water in that cavity then the sizes are going to be measured in microns.

MR. ZUBER: Put it this way, if you have lots of water it is completely different ballgame. I think that is what is important. Let me say one more thing. Equations which we used we didn't use the fragmentation. I think these numbers for water may even be larger than that. Even in this conservative way they approach -- if I have a cavity half full of water it will be more important than heat transfer.

[Slide.]

Let me tell you what is in the report and what will be available. This is your handout number four. The report is divided in two volumes. The first volume presents the general analysis and application to DCH, and volume two has all the appendices. Everything what we have here is the integrated structure, general application, hierarchy approach. This is all typed and finish and 3.4 is in typing. This part three of volume two will be ready probably by Monday or so.

In part two is the application to DCH. This is what I am working on now. I have input from other people and have to put it in the kind of integrated form. This will be finished by the end of the month. The plan that I am shooting for is to finish the volume one by the end of the month, to have it reviewed by the Committee. I will retire at the end of the month, that's what I said, but I would like to get together on my own free time and not charge the government to review with the Committee whether any change be made in the final draft. Then we are planning to have this in mid-January. If the Committee has no problem, volume one can be published.

Volume two, the appendices provide more information. This, I have to put together to get from these other people in a readable form. This will be available in January, toward the end of January. As far as the final results of the program, everything, this is in volume one and should be available at the end of the month. If the Committee reviews it in the middle of January the draft should be out by the middle of January.

MR. CATTON: You are going to do that for nothing?

MR. ZUBER: To me that was always a technical challenge. I would like to have the opportunity to do it at no cost.

[Slide.]

Let me say what we did accomplish. I think we presented a methodology that is auditable, that is traceable, that is systematic and comprehensive. We presented methodology which can be applied to severe accidents. The reason it works is because we use this time ratio and provide the hierarchy. It is sufficient because we address it in a two-tier, the top-down and the bottom-up.

Every point in the analysis can be tested, discussed, argued. There is no arm waving. I mean, everything is there on a piece of paper and people can evaluate it, agree or disagree but there is something to be discussed and assessed. I think this is the presentation. If you have any question I will be very happy to try to answer them, or any criticism, put it this way.

MR. CATTON: The first paper I heard Novak Zuber give was in 1961 at the International Heat Transfer Conference, and it was interesting. There was a person named Ralph Stein who challenged him, and there were a couple of students who were from the University of Colorado. Novak got so excited in answering, one student was holding the microphone trying to keep it in front of him and another one was in the back running the volume up and down trying to keep it right. I decided then that boiling was not for me.

MR. ZUBER: You have a better memory than I do. I have other recollections.

MR. CATTON: If there are no questions, --

MR. WILKINS: Can I make a comment? I have known this gentleman for a few years, maybe not as long as you have, and I have always been impressed by his understanding the depth of his understanding of the various concepts. I never understood a pie group as well as I do now, after he explained it today. I have heard about dimension groups and all that, and I have always thought as a mathematician I didn't need all that nonsense because I could write down the differential equations and invent my own dimension groups.

I must say this discussion today has been masterful.

MR. CATTON: But as a mathematician you certainly have dealt with problems that have multiple scales.

MR. WILKINS: Absolutely.

MR. CATTON: Now you know where they come from.

MR. WILKINS: And now I have a whole lot better appreciation for what mathematicians call ascentotic. Ascentotic, they want to let all the other scales go to zero or infinity depending on how you look at it.

MR. ZUBER: Thank you. Let me say that I would like to leave a message to this group or whoever is going to do the work. Ivan is in this field anyway. You need a two-tier approach. There is no way you can address all this. You have to address in a globality to evaluate what is important. You have to make it tractable. This is a top-down approach.

In order to have a good feeling in your belly that you addressed the right things, you have to have this scaling hierarchy and identify the important thing and hit them very hard. Using this method we can go in front of any group, physical society, we can always present a rationale which is defensible. I think this method provides it.

MR. CATTON: I also noticed you have shifted in your position. My recollection is that in the beginning you were an advocate of top down and weren't too sure about the need from the bottom up.

MR. ZUBER: No. The top down gives you the roadmap. I could not even start from -- if I know the problem I can solve it from something. If you start something which is really kind of -- look, people said you cannot first devise a methodology and I could read you letters. I didn't bring them here but I could read letters that this is the most stupid thing to propose, to do a scaling methodology for severe accidents. Well, it can be done.

You have to do it two-tier. You have to address top down to tell you what is important to provide you this scaling rationale, hierarchy, and they you use bottom. We did the same thing on the LOCA on uncertainty. The concept is not new. We use it before, except we applied it to the scaling.

MR. SIESS: I tried to understand the :cope of applicability. The document I have is headed integral structure and scaling methodology for severe accident technical issue resolution which is certainly a long title. There must be some other limits on it. It is limited only to thermal hydraulic issues? I can't quite picture how to apply this to questions of containment integrity for example, which to me is a severe accident technical issue resolution.

MR. ZUBER: Let me say, I show you how the pressure changes due to all these factors. You can now quantify experiments --

MR. SIESS: I'm sorry --

MR. ZUBER: How the pressure changes. I give you the rate of pressure --

MR. SIESS: I am interested in the integrity of the containment, the structural engineering issue.

MR. ZUBER: This will be a different conservation equation. You can do the same methodology you can apply it. The same thinking. I applied it here was to metallurgy because we have different composites, to heat transfer, mass transfer and chemical reactions. This is what governs the rate of pressure change.

If you want I will address another. Structural aspects, these can be also done by pie groups but this was not the --

MR. SIESS: I have been doing things wrong all my life them.

MR. ZUBER: No, look. There are different ways to skin a cat. One can approach it in this way also. Actually, people use dimension groups in structures.

MR. WILKINS: You have still to conserve energy.

MR. ZUBER: That's right. You have to --

MR. CATTON: I think that you will find scale sets that some of these things you can trash.

MR. WILKINS: Of course, and that's exactly what his top down method tells you how to identify.

MR. ZUBER: But you have the -- the thing is that you have to express it in terms of time ratio. Then you have the same meter to measure everything. I think this is the -- then you establish the hierarchy and you can argue why should I preserve this, why are my experiments in this way. It tells you that you cannot put half of the water without really thinking what are the consequences. It gives you a rationale how to justify every step in your experimentation and analysis. MR. CATTON: Thank you, Novak. I look forward to getting the report.

MR. ZUBER: I am sure you will.

MR. SHERON: Thank you. I am Brian Sheron, from Office of Research. What I would like to talk about very briefly is the use of the SASM approach that Novak has developed in our severe accident research program and the role in severe accident issue resolution. I think there is a little bit of a difference of terminology here when we talk about what a severe accident issue is.

[Slide.]

There is issues and there are issues, okay? If one is talking about the question of how can I accurately calculate the pressurization of containment due to direct containment heating using a validated computer code, that is an issue. That is a technical issue. We have used the word severe accident issue in the sense of should this agency do something about direct containment heating and, if so, what is it that should be done. That is a more global issue which involves a much broader set of questions than what SASM would address.

MR. CATTON: Isn't there an equivalent issue in how does the Sandia experiment direct this in both codes or the experiments?

MR. SHERON: I am going to touch on this, so let me go --

MR. CATTON: There are both of them -- I don't think you should separate them.

MR. SHERON: They are not separable.

[Slide.]

I think Ivan said you weren't really sure about how all this came about. Back when I took over the severe accident area which was in June of 1988, we were concerned -

- not just myself but Mr. Beckjord, Dr. Speis and a number of other people -- about the scaling rationale for in particular the SURTSEY test that were being run. We weren't sure that, for example, the proper mass was being used in the experiments with the initial energy of the thermite melt was properly scaled in a sense that when and if one takes your computer code and validates it against the experiment, what confidence did we have that we could extrapolate up and apply that code confidently to a large plant.

Quite honestly, I didn't feel I got a very good answer from the contractors or the like with regard to the scaling rationale. That is not to say that a scaling rationale was not done, but I think it was not done at the proper depth or understanding. I think there was a much more classical approach taken in terms of perhaps the usual dimension was types of groups and numbers and so forth.

Based on that I asked Novak, who had just finished up the CSAU method to -- again, that was basically a scaling exercise I think which was how can we quantify the uncertainty in our computer codes which involves computer codes which are validated against scaled experiments. We were trying to scale them up to a large plant and estimate the uncertainty in the answer.

My question to Novak was to look at the problem and first to determine if a general scaling methodology for severe accident experiments could be developed, and second, if he concluded that one could develop such a methodology to indeed go ahead and do it. The objective was obviously to make this methodology available to all of the people around the country involved in severe accident experiments, in particular our contractors, so that they could use it as guidance for when they were developing their experiments.

As you know, Novak formed a technical program group. He pulled together I think it was 17 experts from various fields relating to scaling and severe accidents, so there was a pretty broad spectrum of expertise on the group. As I said before, the experiments that prompted my real concern in this area were the SURTSEY experiments on the direct containment heating. Because I had sort of looked into that, I thought that since that was pretty much my primary concern at the time was should I continue doing experiments in that facility or not, I told Novak that I thought that DCH would serve as a very good example on demonstrating the applicability of the general methodology that he was to develop.

The charter of his group, the TPG, was to develop a general methodology with an example use of that methodology, keeping in mind that we still had many experiments going on around the country and we would certainly expect each of those experimenters running those experiments to be responsible for developing the particular scaling analysis for their experiment. I still -- the accident evaluation branch which manages the severe accident research program would still be primarily responsible for the review and approval of contractor tests and the basis for those tests.

[Slide.]

Sandia, for the SURTSEY facility, they are still in fact responsible and I hold them responsible for all facets of the testing which includes the basis for the tests, the scaling rationale that would form the basis for the tests, conducting the tests and associated environmental safety and health which basically means that when they run these tests they are responsible for making sure that they don't blow something up or the like.

Although Novak's group as you just saw developed an example scaling group for DCH, Sandia is currently developing their own scaling groups to support the proposed SURTSEY tests. This is not to mean that there is something that greatly different here. Sandia participated very extensively in the TPG and we told them they were to be utilizing the methodology developed by the TPG as it evolved in developing the scaling factors for SURTSEY.

The plan is to review the SNL scaling report when we receive it. We are supposed to have a draft in on Monday experiments to be responsible for developing the particular scaling analysis for their experiment. I still -- the accident evaluation branch which manages the severe accident research program would still be primarily responsible for the review and approval of contractor tests and the basis for those tests.

[Slide.]

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I was told now. We will ask the staff -- I want Novak to take a look at it as well as people in Farouk's branch to look at it, as well as asking some selected outside experts which would most likely come from the TPG group to take a look at this report and give us their comments. Based on the comments that we receive, we will get back to Sandia and try to resolve any difficulties or differences and hopefully, we will be able to provide them with an approval to start the DCH testing again in SURTSEY.

If everything goes according to plan, SNL said they would be ready to start testing in March of 1991 with the actual scale DCH test. Novak told you the schedule for the SASM methodology report. The TPG is basically going to hopefully stay together until that is finished, and that group would be dissolved. We expect completion hopefully by the end of the year. Novak told you what the schedules is.

MR. CATTON: You are going to hold it together until January --

MR. SHERON: I will hold it together until they have done their final whatever is necessary to complete the report. MR. CATTON: Good.

MR. SHERON: When Sandia runs the first tests in SURTSEY hopefully in March, obviously, we are going to have to take a look at them very close to determine whether the scaling analysis is indeed adequate and whether we have to make any adjustments to the tests inn terms of the future tests.

We will also be running separate effects tests which we are trying to get done hopefully in the first half of 1991. These have to be factored into the overall scaling analysis. What these separate effects tests are that in the SURTSEY facility when you run the discharge into the simulated cavity, you cannot measure the entrainment, de-entrainment and fragmentation during the process, during the blowdown process. In fact, the way you try and come up with a correlation for the entrainment and the fragmentation and the like is to, after the test is over you go in and measure the oxidation, the hydrogen, you look at the particle sizes of the material and try and infer what those parameters were and see if there is an entrainment model in the literature that gives you reasonable agreement with the test results.

The question is, you may be able to do that but there is a big question regarding scale up. So, what we would like to do is run some separate effects tests to try and get a better handle on entrainment, de-entrainment and fragmentation process. We do have RFP's out right now and are soliciting proposals to do those tests.

MR. KERR: Brian, in what sense can one determine the adequacy of scaling after the test; what is it about the test that will permit you to determine the adequacy of scaling?

MR. SHERON: I think you can look at the processes that took place. As Novak pointed out, you can neglect certain processes. If you believe the equations that are written down you can neglect certain processes. If that's the case, then you should be able to look at the results and somehow infer that you indeed picked the right pie groups for example.

MR. KERR: Okay, I see what you mean.

MR. SHERON: Novak, I think you wanted to add something to that?

MR. ZUBER: What one can do is this, for example, you run in a given geometry let's say SURTSEY, you run a test and change in the systematic way the amount of water or amount of temperature in the energy of the debris and see whether the results predict -- forcing that. Then you can perform for example, one test without any water and you put effect of water in the step way to see how this contributes.

This really forcing the general point of view. The second thing what would be really good then is to perform similar tests with initial scale conditions in two geometries; one in SURTSEY and one somewhere else or maybe we can get the foreign -- the NRC may get a foreign facility and do this.

Then you have a different initial conditions and initial scale. In my judgment -- I mentioned this at this last meeting of the Subcommittee last spring was -- in that approach if you coordinate th[illegible]ort on three scales or two scales and really specify th[illegible]nditions around this testing parallel, my judgment was that this problem could be put to rest in one year. I accept bets in terms of bottles of rum. I would really bet a bottle of rum that this could be done in this way.

Thank you.

MR. SHERON: In fact, we are running different scale tests at Argonne National Laboratory. Sandia tests are one-tenth linear scale. The tests are Argonne are one-thirtieth scale using thermite. The objective is to run tests at two different scales using the same scaling parameters and rationale, and to see if indeed we get the right results so that we can at least confidently extrapolate up from the one-thirtieth to the one-tenth scale.

MR. KERR: Thank you.

MR. SHERON: Let me talk a little bit about how we use SASM in the resolution of DCH as a severe accident issue. Number one, DCH is a complex and multi-faceted issue. It is not just a mater of ejecting high pressure melt into the containment. They are just one facet of the whole issue. As I said before the overall issue is, what is the risk associated with direct containment heating phenomena and what, if any, plant modification should be made to reduce this risk.

This is the real question that we are trying to address with the research. SASM only provides the basis for assuring that the experimental data that we get from our experiments is meaningful. For example, in other words, that it is at the proper scale, that the appropriate initial boundary conditions have been chosen. In fact, when we do get the data we can confidently apply it to validate our codes and then extrapolate these codes up to the large plant.

Right now for DCH I think the only fix -- if I can use that term -- is intentional depressurization. This is where the operator would intentionally open a relief valve to reduce the pressure so that at the time of lower head failure you would not have a very high pressure steam driving the melt into the containment which produces the strong interactions in the containment, the heat transfers and the hydrogen which produce the loads -- temperature and pressure loads which ultimately fail a containment.

MR. CATTON: When you get down to 40 percent of the core, DCH is not a problem, is it? I thought it was, only for higher fractions?

MR. SHERON: Well, again, this gets into the question of -- if the codes can be validated and then if the codes can show us that 40 percent doesn't really produce a large pressurize in the containment that would challenge the containment, then you are correct. Right now the indications are that that's true.

MR. CATTON: We may not need a fix.

MR. SHERON: We still have the question of understanding the in-vessel core melt progression.

MR. CATTON: I understand.

MR. SHERON: There is an uncertainty associated with that. Forty percent is not a clean number. There is an uncertainty on that.

MR. CATTON: I read Sal's report, and it has assumptions, no question.

MR. SHERON: Right now no operating PWR's call for the operators to intentionally depressurize the primary system when no AC power is available. This is very important. I called up all three vendors and they all confirmed that this was indeed the case. The real question that we are trying to answer is, is intentional depressurization a cost beneficial and practical fix for direct containment heating. That is, should we require intentional depressurization.

MR. KERR: Indeed, it's probably illegal for them to depressurize -- I'm sorry, that's depressurizing the reactor vessel.

MR. SHERON: Yes. Currently the approach that we would like to take in addressing this overall issue is one, to establish the likelihood of accidents that proceed to core melt at high pressure. I think 1150 gives us real good insights into this, and there's really not much more effort that needs to be done right now.

The second piece of the puzzle here is to establish the likelihood that the system would be depressurized prior to lower vessel head failure at high pressure. That is, what is the probability that the primary system will be pressurized during this high pressure melt down process due to such things as a stuck open safety or relief valve, keeping in mind that this thing is opening and closing all the time under conditions that are not within the design base. There is, in fact, a likelihood that during this cycling this valve could stick open, in which case you would get a depressurization.

You could also get a pump seal failure which would produce a depressurization. The operators could, in fact, ever though they don't have specific procedures right now in a severe accident, could indeed intentionally depressurize the primary system.

MR. CARROLL: Let me comment on that, Brian. Actually, initiating of feed and bleed on PWR's is based on dry steam generators.

MR. SHERON: They will not initiate feed and bleed if no AC power is available. That is the difference. They will initiate feed and bleed if they have confirmation of AC power being available. What they say is that right now the philosophy is that if I bleed without AC I am depleting the inventory faster. Therefore, I will lead to a core melt.

MR. CARROLL: Okay. The last item is the creep rupture failure of the primary piping. That is that once you start to uncover the core you get very hot gases coming out of the core which will migrate to the colder surfaces just due to the buoyancy differences. We have done a number of calculations, and there is a lot of evidence that says that the surge line will probably heat up and at most likely at 2,500 pounds of pressure, would experience a creep rupture failure.

There is experiments at Westinghouse, one-seventh scale to validate the natural circulation calculations that we are doing. The overall effort is to say taking this as an integral type of approach, what is the likelihood to come up with a number that the system would be depressurized prior to lower head failure.

Last is where SASM comes in, is to establish the likelihood that high pressure melt injection will in fact lead to containment pressures in excess of the ultimate pressure capability of the containment.

The other pieces of this whole puzzle here is one, is then we would have to show that the reduction in containment failure probability, if intentional depressurization were to be required, we would have to show that probability reduction for containment failure and establish what the cost benefit would be before we would consider going to the Commission with such a requirement on the industry.

Of course, as you know, we would have to somehow address the generic applicability of these analyses to all the plants keeping in mind, as you know, there are six CE plants that do not even have a PORV. Lower head failure mechanisms would be different because CE plants do not have lower head penetrations, whereas the Westinghouse plants do.

MR. CARROLL: Not true.

MR. SHERON: Not true?

MR. SHEWMON: True for many of them, but not true for all of them.

MR. SHERON: Some do but some don't. In other words, there are plants that don't have lower head penetrations. As I said before, item three would be determined through the use of code analyses using codes validated against applicable experiments. This is where SASM really will be applied, in ensuring that these experiments can be used for extrapolation to the large plants. That's my presentation. Are there any questions?

MR. CATTON: The big question is the in-vessel melt progression. Can you address that, and what the experiments ought to be?

MR. SHERON: Yes. As a matter of fact, we would like to --

MR. SIESS: Excuse me. Ivan, I am hearing the answers to your questions but I am not hearing the questions.

MR. CATTON: I'm sorry.

MR. SIESS: I have been figuring them out, but I'm tired.

MR. CATTON: I am not sure that I can remember the question. The in-vessel melt progression and use of a scaling approach to try to establish what the experiments ought to be or how you ought to run the ones that you plan.

MR. SHERON: We do have an ongoing program on in-vessel melt progression as you know, and it's probably more difficult than this area because of the need to scale -- in other words, the scale itself, you can't do a whole core obviously. We are doing smaller scales. The melt progression, as you know for PWR, one would predict forming a -- obviously you need something that is large, so we are looking at small chunks of this.

We are right now in the process of putting together a complete review of the in-vessel core melt research program. What we would like to do would be better define what more is needed, whether we have done enough in certain areas like the early phase, whether we should concentrate more on the late phase, whether the experiments that are going on right now will indeed adequately address the issues which I think gets to your question.

MR. CATTON: That is what I am getting at.

MR. SHERON: We want to put together a group of experts in this area that will help us look at this whole thing in a big picture, and try to put together then a comprehensive research program on in-vessel core melt such that everybody would have confidence that by carrying out this program we would, at the end, have computer codes that have been validated against experiments that are defensible and as Novak said, auditable and whatever.

Obviously, we have different experiments to look at BWR progression versus the PWR.

MR. SHEWMON: As you know, there is a fair amount of evidence that whether you have PORV's or not, that you are going to have a rupture of the containment before you go through the bottom of the vessel, whether it is tubing in the steam generator or something else just from heat transfer up there.

MR. SHERON: Yes.

MR. SHEWMON: Is that still part of your program, or you wouldn't like ıt because that's not a controlled --

MR. SHERON I think that was the --

MR. SHEWMON: It could have been. I ducked out.

MR. SHERON: If you look at this viewgraph, item two right here, we have a comprehensive program looking at where the primary system might fail due to the creep rupture failure due to this high temperature circulation.

MR. SHEWMON: Fine.

MR. CATTON: The Westinghouse one-seventh scale doesn't include a steam generator, does it?

MR. SHERON: It does.

MR. CATTON: The scaling of the hot plenum and cold plenum of the steam generator become very important to the tubes, diameters and all sorts of things. I would think that you would want to run it through one of these scaling type exercises before you really get too far along.

MR. SHERON: I actually think there was a scaling analysis done on that. Remember, these tests were sponsored by EPRI. These are not our tests.

MR. CATTON: At that time we had a grant from EPRI. I recollect the early scaling that was done by Squire -- David Squire. Beyond that, I don't know of any scaling that was done. At that time the concern was strictly the core. There was not as much concern for the steam generator tubes at that time. I don't know -- if there has been a subsequent scaling and we are running out of time, I would like to see it.

MR. SHERON: I would like -- Bob, do you have something?

MR. WRIGHT: Bob Wright, Action Evaluation Branch. At Westinghouse they did a rather extensive scaling job on those experiments including the steam generator section and recirculation, scaling the reduced number of tubes to give the right thermal hydraulic property. I am not on top of the results, but it was a careful job. There have been some reviews, but also some questions.

MR. CATTON: I would like to see that scaling analysis.

MR. SHERON: That area right now, the whole natural circulation is with Dr. Shotkin's branch. I would volunteer the --

MR. CATTON: He works for you, and I assume that you could get it for us.

MR. SHERON: I am volunteering that he will come down if you would like to a Subcommittee meeting --

MR. CATTON: What I would like to have is the --

MR. SHERON: Would you like us to provide you with the document?

MR. CATTON: Provide me with the document first.

MR. SHERON: Let me see what we can do.

MR. CATTON: I would also be interested in your schedule for looking at the in-core melt progression.

MR. SHERON: When are we supposed to get a group together, Farouk? We are supposed to have a draft report in the end of December. Are there any other questions?

[No response.]

MR. CATTON: I don't see any. Thank you, Brian. I will give it back to you, Mr. Chairman.

MR. MICHELSON: Okay, gentlemen. The next agenda item is the preparation of ACRS reports.

[Whereupon, at 4:10 p.m., the transcribed portion of the meeting concluded.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission

in the matter of:

NAME OF PROCEEDING: 368th ACRS General Meeting

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Mary C. Larkin

Official Reporter
Ann Riley & Associates, Ltd.

NRR STAFF PRESENTATION TO THE ACRS

(1)

SUBJECT: HYDROGEN GAS BUILDUP IN CHARGING SYSTEM
AUGUST 22, 1990
(INTRODUCTION AND FOLLOWUP ACTIONS)

DATE:

DECEMBER 7, 1990

PRESENTER:

M.A. CARUSO

PRESENTER'S TITLE/BRANCH/DIV:

SECTION CHIEF, REACTOR SYSTEMS BRANCH, NRR

PRESENTER'S NRC TEL. NO.:

492-3235

SUBCOMMITTEE:

NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: HYDROGEN GAS BUILDUP IN CHARGING SYSTEM
AUGUST 22, 1990
(EVENT PRESENTATION)

DATE: DECEMBER 7, 1990

PRESENTER:

DAVID C. FISCHER

PRESENTER'S TITLE/BRANCH/DIV:

SECTION CHIEF, EVENTS ASSESSMENT BRANCH, NRR

PRESENTER'S NRC TEL. NO.:

492-1154

SUBCOMMITTEE:

SEQUOYAH UNITS 1 & 2
HYDROGEN GAS BUILDUP IN THE CHARGING SYSTEM
AUGUST 22, 1990

PROBLEM

THE LICENSEE IDENTIFIED HYDROGEN GAS BUILDUP IN THE CHARGING AND RHR CROSSOVER PIPING IN EXCESS OF THE AMOUNT IDENTIFIED IN THE WESTINGHOUSE LETTER TO THE LICENSEE.

CAUSE

LICENSEE ATTRIBUTED CAUSE TO:

(1) INADEQUATE REVIEW OF IN 88-23, "POTENTIAL FOR GAS BINDING OF HIGH PRESSURE SAFETY INJECTION PUMPS DURING A LOCA,"
(2) INADEQUATE REVIEW OF WESTINGHOUSE LETTER, TVA-88-825, "POTENTIAL GAS BINDING OF SI PUMPS," AND
(3) LICENSEE DID NOT FULLY UNDERSTAND THE MECHANISMS IN WHICH HYDROGEN GAS MAY COME OUT OF SOLUTION.

DISCUSSION

- AUGUST 22, 1990, UNIT 2 AT 70% POWER, CCP "A" OPERATING, CCP "B" IN STANDBY. T/S SURVEILLANCE BEING PERFORMED.

- WHEN "B" PUMP WAS STARTED, OPERATOR OBSERVED FLUCTUATION IN PUMP'S FLOW AND AMPERAGE. SUSPECTED GAS BINDING. PUMP STOPPED, VENTED, AND RESTARTED.

- LATER, LICENSEE IDENTIFIED GAS BUILDUP IN SUCTION PIPING OF IDLE CHARGING TRAIN (B-TRAIN) OF APPROXIMATELY 10 CU FT.

- GAS BUILDUP ALSO EXISTED IN RHR CROSSOVER PIPING, BUT LICENSEE WAS NOT ABLE TO VENT THIS GAS BUILDUP (4.75 CU FT.).

- LICENSEE HAD CONSULTED WESTINGHOUSE, AND DETERMINED THAT CONTINUED OPERATION WAS ACCEPTABLE PROVIDED GAS ACCUMULATION DOES NOT EXCEED 6 CUBIC FEET IN THE SUCTION PIPING TO THE CCP's.

- LICENSEE ANALYZED THE GAS TO BE 98% HYDROGEN.

- LICENSEE CALCULATED THAT VENTING WAS REQUIRED EVERY 8 HRS. TO MAINTAIN HYDROGEN ACCUMULATION BELOW 6 CF WHILE AT POWER.

- ON SEPT. 6, 1990, UNIT 1 EXPERIENCED NEAR-IDENTICAL EVENT. GAS WAS ALSO ACCUMULATING IN CCP SUCTION AND RHR CROSSOVER PIPING.

- LICENSEE STATED THAT GAS FORMATION WAS A RESULT OF GAS STRIPPING BY THE CCP MINIFLOW ORFICES.

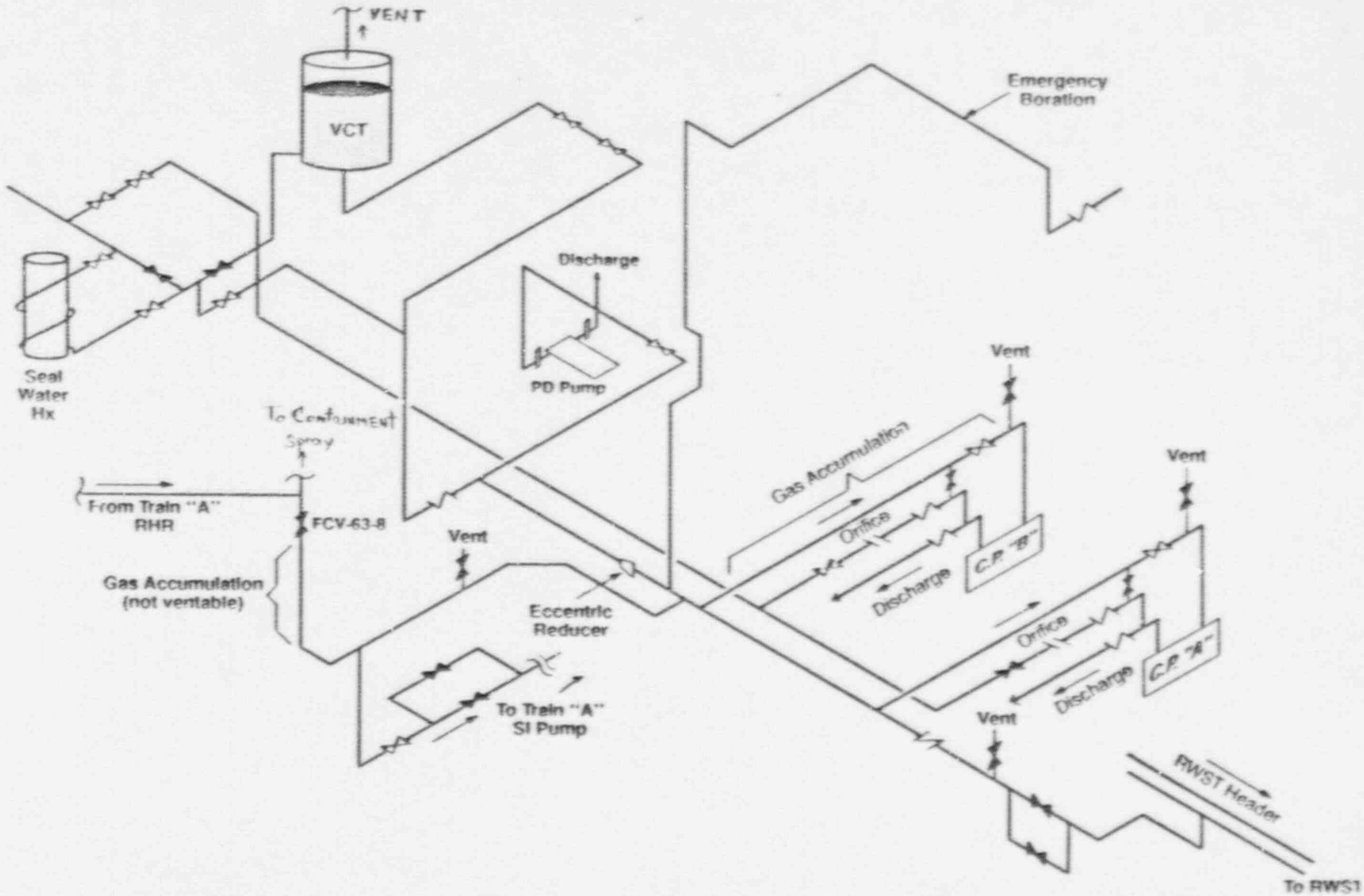
- LICENSEE CONCLUDED THAT PROCEDURAL AND PLANT MODIFICATIONS WOULD BE NEEDED TO PREVENT THE ACCUMULATION OF HYDROGEN IN THE CHARGING AND RHR CROSSOVER SYSTEMS.

<u>FOLLOWUP</u>

- IN 88-23, SUPPLEMENT 3, "POTENTIAL FOR GAS BINDING OF HIGH-PRESSURE SI PUMPS DURING A LOCA," TO BE ISSUED.

- RSB HAS LEAD TO DETERMINE SAFETY SIGNIFICANCE AND ANY FURTHER GENERIC ACTION THAT MAY BE NEEDED.

Charging Pumps and RHR Crossover for SQN Units 1 & 2



NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: HYDROGEN GAS BUILDUP IN CHARGING SYSTEM
AUGUST 22, 1990
(TECHNICAL EVALUATION)

DATE: DECEMBER 7, 1990

PRESENTER:
STEVEN M. MIRSKY

PRESENTER'S TITLE/BRANCH/DIV:
NRC CONTRACTOR, SAIC

PRESENTER'S NRC TEL. NO.:

SUBCOMMITTEE:

NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: MSIV CLOSURE AT FULL POWER
AUGUST 19, 1990

DATE: DECEMBER 7, 1990

PRESENTER: G. A. BELISLE

PRESENTER'S TITLE/BRANCH/DIV:

CHIEF, TEST PROGRAMS SECTION, ENGINEERING BRANCH, RII
AIT LEADER

PRESENTER'S NRC TEL. NO.:

FTS 841-5596

SUBCOMMITTEE:

BRUNSWICK 2
MSIV CLOSURE AT FULL POWER (AIT)
AUGUST 19, 1990

PROBLEM

SCRAM WITH DEGRADED PERFORMANCE OF SEVERAL VALVES (SRVs, RCIC, FW).

CAUSE

VIOLATION OF PLANT PROCEDURE; ISOLATED INSTANCE.

SAFETY SIGNIFICANCE

UNNECESSARY CHALLENGE TO PLANT SAFETY SYSTEMS.

DISCUSSION

- ON 8/19/90, WHILE AT 100% POWER, A SINGLE TECHNICIAN WAS TESTING THE PRIMARY CONTAINMENT ISOLATION SYSTEM ALTHOUGH TWO TECHNICIANS WERE REQUIRED. SUBSEQUENTLY ANOTHER TECHNICIAN PROVIDED FALSE VERIFICATION OF THE WORK.
- CHANNEL B2 WAS TRIPPED BY THE TECHNICIAN BEFORE CHANNEL A2 WAS RESET BY THE CONTROL ROOM OPERATORS CAUSING THE MSIVs TO CLOSE.
- REACTOR PRESSURE REACHED 1133 PSIG. HIGH PRESSURE AND LOW LEVEL SCRAM SIGNALS WERE GENERATED AND THE REACTOR SCRAMMED.
- LOW REACTOR VESSEL WATER LEVEL ALSO CAUSED AN ATWS SIGNAL WHICH TRIPPED THE RECIRCULATION PUMPS
- FIVE SRVs DID NOT OPEN AND ONE FAILED TO INDICATE OPEN. THREE WERE OUTSIDE THE 1% PRESSURE BAND.

- THE FEEDWATER STARTUP LEVEL CONTROL VALVE WAS NOT OPERATED PROPERLY.
- THE RCIC THROTTLE VALVE WAS OPENED AND CLOSED SEVERAL TIMES EXCEEDING ITS DUTY CYCLE AND FAILED ON THERMAL OVERLOAD.

AIT CONCLUSION

- REACTOR SCRAM RESULTED FROM INTENTIONAL DEPARTURE FROM STEP BY STEP PROCEDURAL COMPLIANCE/VERIFICATION EXACERBATED BY LACK OF COMMAND AND CONTROL BY OPERATIONS PERSONNEL.
- REACTOR TRANSIENT COMPLICATED BY
  - ° EQUIPMENT FAILURES
  - ° POOR PROCEDURAL AIDS
  - ° NEGATIVE TRAINING ON THE SIMULATOR

CORRECTIVE ACTION

- TECHNICIANS TERMINATED
- RE-PERFORMED SURVEILLANCE TEST
- NEW MAINTENANCE PRE- AND POST-JOB BRIEFING REQUIREMENTS
- PLANT MANAGER CONDUCTED PERSONAL MEETINGS WITH ALL PLANT WORK GROUPS
- FORMALIZED COMMUNICATIONS TRAINING ONGOING
- STANDARDS OF EXCELLENCE ADOPTED BY MAINTENANCE
- PROCEDURES UPGRADED
  - ° OPERATOR AIDS
  - ° OPERATING PROCEDURES
- SIMULATOR REMODELED
  - ° STARTUP LEVEL CONTROL VALVE
  - ° 5-SECOND HOLD FOR RCIC TRIP AND THROTTLE VALVE

NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: LOSS OF OFFSITE POWER
JUNE 17, 1989

DATE: DECEMBER 7, 1990

PRESENTER: R. O. KARSCH

PRESENTER'S TITLE/BRANCH/DIV:

REACTOR SYSTEM ENGINEER, EVENTS ASSESSMENT BRANCH, NRR

PRESENTER'S NRC TEL. NO.:

492-1178

SUBCOMMITTEE:

BRUNSWICK UNIT 2
LOSS OF OFFSITE POWER
JUNE 17, 1989

PROBLEM

THREE HUMAN ERRORS LED TO LOCKOUT OF THE STARTUP TRANSFORMER, TRIP OF THE REACTOR AND A SUBSEQUENT LOSS OF OFFSITE POWER.

SAFETY SIGNIFICANCE

A LOSS OF OFFSITE POWER CHALLENGED THE EMERGENCY POWER SYSTEM.

DISCUSSION

- o UNIT 2 WAS AT 100% POWER, A GROUND FAULT ALARM WAS RECEIVED IN THE CONTROL ROOM.
- o THE RELAY CREW INITIATED TROUBLE SHOOTING IN THE SWITCHYARD.
- o THE PLANT MANAGER (CALLED AT HOME) ADVISED THE OPERATORS TO REDUCE POWER IN CASE THERE WAS A TRANSFORMER LOCKOUT. HIS INTENT WAS TO DRIVE RODS IN TO MINIMIZE INSTABILITY/CORE OSCILLATIONS IF RECIRC PUMPS WERE LOST DUE TO A TRANSFORMER LOCKED.
- o THE OPERATORS, NOT UNDERSTANDING THE REASON FOR THE POWER REDUCTION, REDUCED POWER TO 73% BY REDUCING RECIRCULATION PUMP FLOW RATHER THAN ROD LINE ADJUSTMENT.
- o THE RELAY CREW CAUSED A PHASE TO GROUND SHORT BY IMPROPER TROUBLESHOOTING PROCEDURES. THIS LOCKED OUT THE STARTUP TRANSFORMER.
- o RECIRCULATION PUMPS TRIPPED.
- o THE REACTOR WAS MANUALLY TRIPPED TO PREVENT POSSIBLE INSTABILITIES/CORE OSCILLATIONS AS ADDRESSED IN NRC BULLETIN 88-07.

- A NINE HOUR LOSS OF OFFSITE POWER ENSUED.
- THE UNIT 2 EDG's OPERATED SATISFACTORILY.
- PER EMERGENCY PROCEDURES, SOME LIMITED LOADS ON THE EMERGENCY BUSES COULD HAVE BEEN REPOWERED VIA A CROSSTIE FROM UNIT 1 AT ANY TIME IF NEEDED.

NRR STAFF PRESENTATION TO THE
ACRS

SUBJECT: FEEDWATER SYSTEM MALFUNCTION AND RCIC FAILURE
SEPTEMBER 2, 1990

DATE: DECEMBER 7, 1990

PRESENTER: R. O. KARSCH

PRESENTER'S TITLE/BRANCH/DIV:

REACTOR SYSTEM ENGINEER, EVENTS ASSESSMENT BRANCH, NRR

PRESENTER'S NRC TEL. NO.:

492-1178

SUBCOMMITTEE:

PILGRIM
FEEDWATER SYSTEM MALFUNCTION
AND RCIC FAILURE
SEPTEMBER 2, 1990

PROBLEM

- o FEEDWATER CONTROL WAS LOST AND AFTER THE PLANT WAS MANUALLY TRIPPED THE RCIC FAILED TO RUN.
- o SEVERAL FAILURES OR MALFUNCTIONS OF NON-SAFETY GRADE EQUIPMENT COMPLICATED OPERATOR RESPONSE TO THE EVENT.

CAUSE

COMPONENT FAILURE IN THE FEEDWATER SYSTEM WITH CONTRIBUTION FROM MAINTENANCE OVERSIGHTS AND A DEFECTIVE PROCEDURE COMBINED TO CAUSE THIS EVENT.

SAFETY SIGNIFICANCE

REACTOR SCRAM WITH COMPLICATIONS

DISCUSSION

- o THE REACTOR WAS AT 100% POWER WHEN A PRESSURE SWITCH FAILURE RESULTED IN THE FEEDWATER REGULATING VALVES OPENING/OVERFEEDING THE REACTOR VESSEL.
- o PER LOSS OF FEEDWATER CONTROL PROCEDURE THE FEEDWATER CONTROL SYSTEM WAS PLACED IN MANUAL CONTROL. MINIMAL RESPONSE TO MANUAL CONTROL WAS NOTED BY OPERATORS DUE TO THE COMPONENT FAILURE. SOME LEVEL CONTROL WAS ACHIEVED BY DIVERTING FEED FLOW TO THE CONDENSER.
- o LATER, THE OPERATORS TRIPPED ONE OF THREE MAIN FEED PUMPS TO PREVENT OVERFEED. LEVEL THEN DECREASED. OPERATORS THEN TRIPPED THE REACTOR WHEN IT BECAME OBVIOUS THAT FEEDWATER CONTROL DID NOT EXIST.
- o THE PLANT WAS OPERATED FOR APPROXIMATELY 30 MINUTES BETWEEN THE TIME OF THE INITIAL HIGH LEVEL ALARM UNTIL THE MANUAL TRIP AND MAIN FEED ISOLATION AT 99% POWER.

- AFTER THE TRIP THE OPERATORS ATTEMPTED TO MANUALLY START RCIC TO PROVIDE FEED. THE RCIC TURBINE STARTED THEN TRIPPED ON OVERSPEED BECAUSE THE MANUAL START PROCEDURE WAS FLAWED.
- TWO ATTEMPTS WERE MADE TO RESTART RCIC. THE TURBINE COULD NOT BE KEPT RUNNING BECAUSE OF DAMAGE TO THE OVERSPEED TRIP ASSEMBLY POSSIBLY CAUSED BY PREVIOUS REPETITIVE OVERSPEED TRIPS, AND INADEQUATE MAINTENANCE. AS A RESULT RCIC WAS CONSIDERED INOPERABLE.
- THE OPERATORS THEN ATTEMPTED TO USE THE STARTUP FEED SYSTEM. THE STARTUP FEED REGULATING VALVE FAILED TO THE FULL OPEN POSITION DUE TO A DEGRADED BOOSTER RELAY IN THE CONTROL AIR SYSTEM.
- VESSEL LEVEL WAS CONTROLLED BY DIRECTING FLOW THROUGH THE FULLY OPEN START UP FEEDWATER REGULATION VALVE AND CYCLING THE MAIN FEED PUMPS INDIVIDUALLY.
- A MSIV CLOSURE OCCURRED 47 MINUTES AFTER THE REACTOR TRIP.
- HPCI WAS STARTED TO INJECT INTO THE VESSEL. HOWEVER, HPCI EVENTUALLY TRIPPED ON HIGH LEVEL.
- AFTER THE ISOLATION, SRVs AND HPCI RUNNING IN THE TEST MODE CONTROLLED PRESSURE.
- THE MSIV CLOSURE WAS LATER RESET. WITH THE MSIVs REOPENED NORMAL DEPRESSURIZATION VIA THE MAIN CONDENSER WAS ESTABLISHED.
- THE LEVEL WAS LATER CONTROLLED USING THE CONDENSATE PUMPS OR CONTROL ROD DRIVE PUMPS AND REACTOR WATER CLEAN UP SYSTEM PUMPS.
- RHR WAS ISOLATED BRIEFLY DUE TO A SUCTION SIDE PRESSURE SPIKE DURING LINEUP OF SHUTDOWN COOLING.
- SUBSEQUENT TO THE EVENT IT WAS DETERMINED THAT RCIC SUCTION PIPING WAS PRESSURIZED FOR APPROXIMATELY 50 SECONDS DURING THE SECOND RCIC START ATTEMPT. THE PEAK PRESSURE WAS BETWEEN 600-800 PSI. AN ENGINEERING ANALYSIS CONDUCTED BY THE LICENSEE ASSUMED 900 PSI.

(2)

SEQUOYAH UNITS 1 & 2
HYDROGEN GAS BUILDUP IN THE CHARGING SYSTEM

NRC STAFF FOLLOW-UP

- INFORMATION NOTICE 88-23 SUPPLEMENT 3 TO BE ISSUED DECEMBER 10, 1990 DESCRIBING SEQUOYAH EVENTS

- STAFF DEVELOPING GENERIC COMMUNICATION WHICH REQUESTS:

  - EVALUATE AND INSPECT PIPING SYSTEMS TO DETERMINE EXTENT OF PROBLEM, IF ANY

  - IMPLEMENT APPROPRIATE SHORT AND LONG TERM CORRECTIVE ACTIONS, IF NOT ALREADY COMPLETED

3

Technical Evaluation of PWR ECCS Centrifugal Charging Pump (CCP) Operability With Hydrogen in the Crossover Piping

Steven M. Mirsky

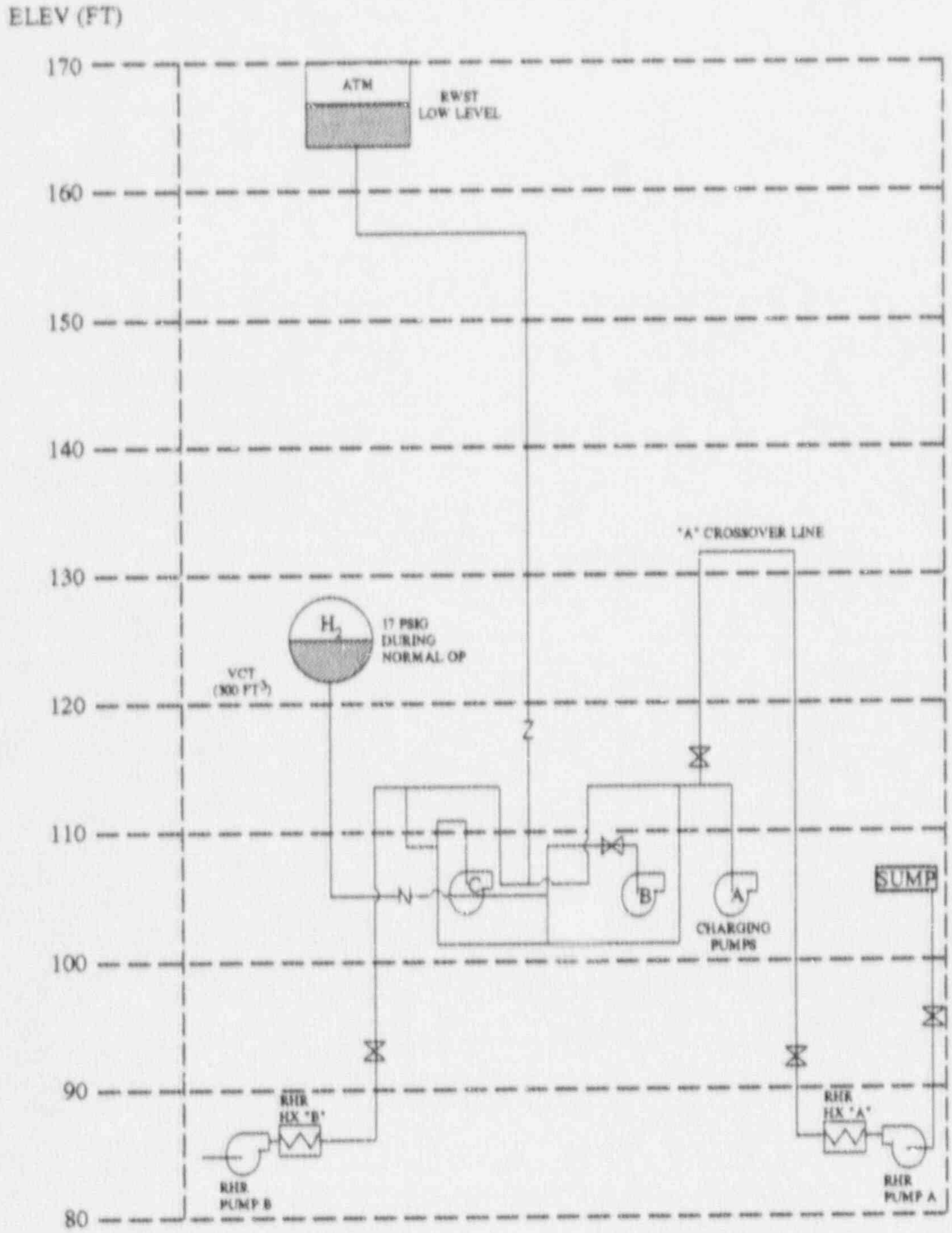
ACRS Meeting

December 7, 1990

SAIC
An Employee-Owned Company

PLANT DESCRIPTION

- o 3 Loop PWR
- o 3 HHSI Centrifugai Charging Pumps (CCP) With 11 Stages And 0.8 Cubic Foot Internal Volume Per Pump
- o 2 LHSI RHR Pumps
- o "A" RHR Pump - To - CCP Crossover Pipeline Includes A Long (>150 Ft) Horizontal Run Above Pump And VCT Elevation
- o "A" Crossover Line is Filled With 62.5 Cubic Feet of Hydrogen



RHR Pump and Centrifugal Charging Pump Simplified Elevation and Flow Diagram

SAIC
An Employee-Owned Company

SEQUENCE OF EVENTS

- Small Break LOCA (1 Inch $\leq$ Break Dia. $\leq$ 4 inches)
- RWST Inventory Depleted
- RCS Pressure > RHR Pump Shutoff Head ($\sim$150 psia)
- Switchover From Injection to Recirculation Phase
- RHR Pump Suction Aligned to Containment Sump
- RHR Pump Discharge Aligned to CCP Suction Through Crossover Line
- RHR Pumps Startup (T = 0.0)

SAIC
An Employee-Owned Company

TRANSIENT HYDRAULIC RESPONSE

- o Detailed Time Sequence Analysis

- o RHR Pump Discharge Pressure Shuts Check Valve on RWST Line

- o RHR Flow Through Crossover Line Characterized by High (>0.7) Froude Number (Inertial/Gravity Forces)

  - Columnar Fluid Flow

  - Hydrogen Pushed Through Crossover Pipe As a Uniform Unmixed Volume

  - Hydrogen Volume Compressed to 23 Cubic Feet

- o 85% Hydrogen Void Fraction Two-Phase Mixture Enters CCP "A" at T $\simeq$ 6.0 Seconds

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An Employee-Owned Company

ANALYSIS RESULTS

- o CCP "A" Stalls At T $\simeq$ 6.5 Seconds (0.5 Sec. After H_2 Mixture Enters CCP !)
- o Last 2 CCP Stages Are Filled With Water
- o First 9 CCP Stages Are Filled With Hydrogen

CONCLUSIONS

- o Charging Pump Fails Within Seconds

  Failure Mechanisms:

  - Pump Seizure Due To:

    Interstage Bushing Contact,
    Wear Ring Contact,
    Balancing Drum Contact
    (0.01 to 0.015 Inch Clearance)

  - Inboard Mechanical Seal Failure
  - Catastrophic Pump Shaft Deflection From Pressure Swing or Hydraulic Unbalance

- o Results Are Plant and Sequence Specific

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(4)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

December 10, 1990

NRC INFORMATION NOTICE NO. 88-23, SUPPLEMENT 3: POTENTIAL FOR GAS BINDING OF HIGH-PRESSURE SAFETY INJECTION PUMPS DURING A LOSS-OF-COOLANT ACCIDENT

Addressees:

All holders of operating licenses or construction permits for pressurized-water reactors (PWRs).

Purpose:

This information notice supplement is intended to alert addressees to the potential for common-mode failure caused by hydrogen gas binding of the high-head safety injection pumps (charging pumps) during a loss-of-coolant accident (LOCA). It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice supplement do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

On August 22, 1990, Unit 2 of the Sequoyah Nuclear Power Plant was at 70-percent power (in coastdown). The licensee was attempting to switch operation of the charging pumps from the "A" to "B" pump in order to perform surveillance (see Attachment 1). Upon start of the "B" charging pump, the licensee observed fluctuation of the pump's motor amperage and rate of flow. The licensee suspected that gas was accumulating on the suction-side of the "B" pump and secured the pump. Further investigation and analysis by the licensee revealed that hydrogen gas was accumulating in the suction piping of the "B" pump and in the RHR crossover piping to the charging header. The licensee was able to vent approximately 5.3 cubic feet of gas. An additional 4.75 cubic feet of gas could not be vented from the RHR crossover piping.

On September 6, 1990, with Unit 1 at 100-percent power, the licensee identified the presence of a hydrogen gas bubble on the suction-side of the charging pumps in Unit 1. The gas was collecting in the piping between the "A" residual heat removal (RHR) pump and the charging pumps. The licensee calculated that hydrogen was accumulating at a rate of 0.5 cubic feet per hour. The gas came out of solution (in part) due to localized reductions in pressure because of piping elevation differences and eccentric pipe reducers (see Attachment 1). Immediate corrective action taken by the licensee for both units included venting the suction piping of the idle charging train every 8 hours.

9012040239

Discussion:

These events at Sequoyah are significant because hydrogen gas accumulation in the suction piping to the charging pumps has the potential to affect multiple trains of pumps in the emergency core cooling system (ECCS). Loss of all high-pressure recirculation capability at Sequoyah during a small-break LOCA is the dominant risk contributor to the core damage frequency as identified in Section 5, Sequoyah Plant Results, NUREG-1150, Volume 1, "Severe Accident Risks: An Assessment For Five U.S. Nuclear Power Plants."

During a LOCA, suction of the ECCS pumps must be switched from the refueling water storage tank (RWST) to the containment sump before the RWST is depleted. If the reactor coolant system (RCS) has not yet depressurized to the point that the low-pressure injection pumps (i.e., RHR pumps) can inject into the vessel, then the discharge of the RHR pumps must be directed to the suction of the centrifugal charging pumps (CCPs) and the safety injection (SI) pumps. Successful recirculation of water from the containment sump (with the RCS at high pressure) requires operation of one RHR pump and one of the high head pumps. At Sequoyah, the "A" RHR pump supplies the suction of both CCPs and the "A" SI pump. The "B" RHR pump supplies the suction to the "B" SI pump.

Noncondensible gases accumulating in the piping between the "A" RHR pump and the charging pump suction header creates the potential for gas binding of both charging pumps during the switchover from high-pressure injection to high-pressure recirculation. In addition, because the valves isolating the "A" RHR and "A" SI pumps from the charging pump suction header are periodically stroke-time tested, gas may also enter sections of piping normally isolated from this header. Thus, the gas accumulation in the charging pump suction header potentially affects three of the four high-pressure pumps.

In recent NRC information notices, the staff addressed gas binding of ECCS pumps. Information Notice (IN) 88-23, "Potential For Gas Binding of High-Pressure Safety Injection Pumps During A Loss-Of-Coolant-Accident (LOCA)," addressed gas-binding problems in the high-pressure safety injection system at the Farley Nuclear Power Plant. The staff issued two supplements to that information notice to address gas accumulation affecting ECCS pumps because of various root causes. IN 90-64, "Potential For Common-mode Failure Of High Pressure Safety Injection Pumps Or Release Of Reactor Coolant Outside Containment During A Loss-Of-Coolant Accident," discusses another mechanism that could lead to gas binding of both CCPs.

The two gas-binding events at Sequoyah had root causes that were attributed by the licensee, in part, to inadequate review of IN 88-23. Although most gas accumulation in ECCS systems has been hydrogen, in at least one instance, a mixture of air and hydrogen was found. It is important to consider all potential sources of gas intrusion to the ECCS suction piping, such as leaking bladders on the pulsation dampeners for positive displacement charging pumps, ineffective check valves in highpoint venting systems that lead back to the air space in the volume control tank (VCT), any flow restrictions (e.g., orifices) which may cause gases to come out of solution, and improper venting and filling operations following maintenance of ECCS flowpaths. Since most plants have no technical specification surveillance requirement for periodic venting of ECCS suction piping (only pump casings and discharge piping), gas may accumulate and remain undetected for extended periods of time, subjecting the plant to a possible common mode failure of the ECCS pumps.

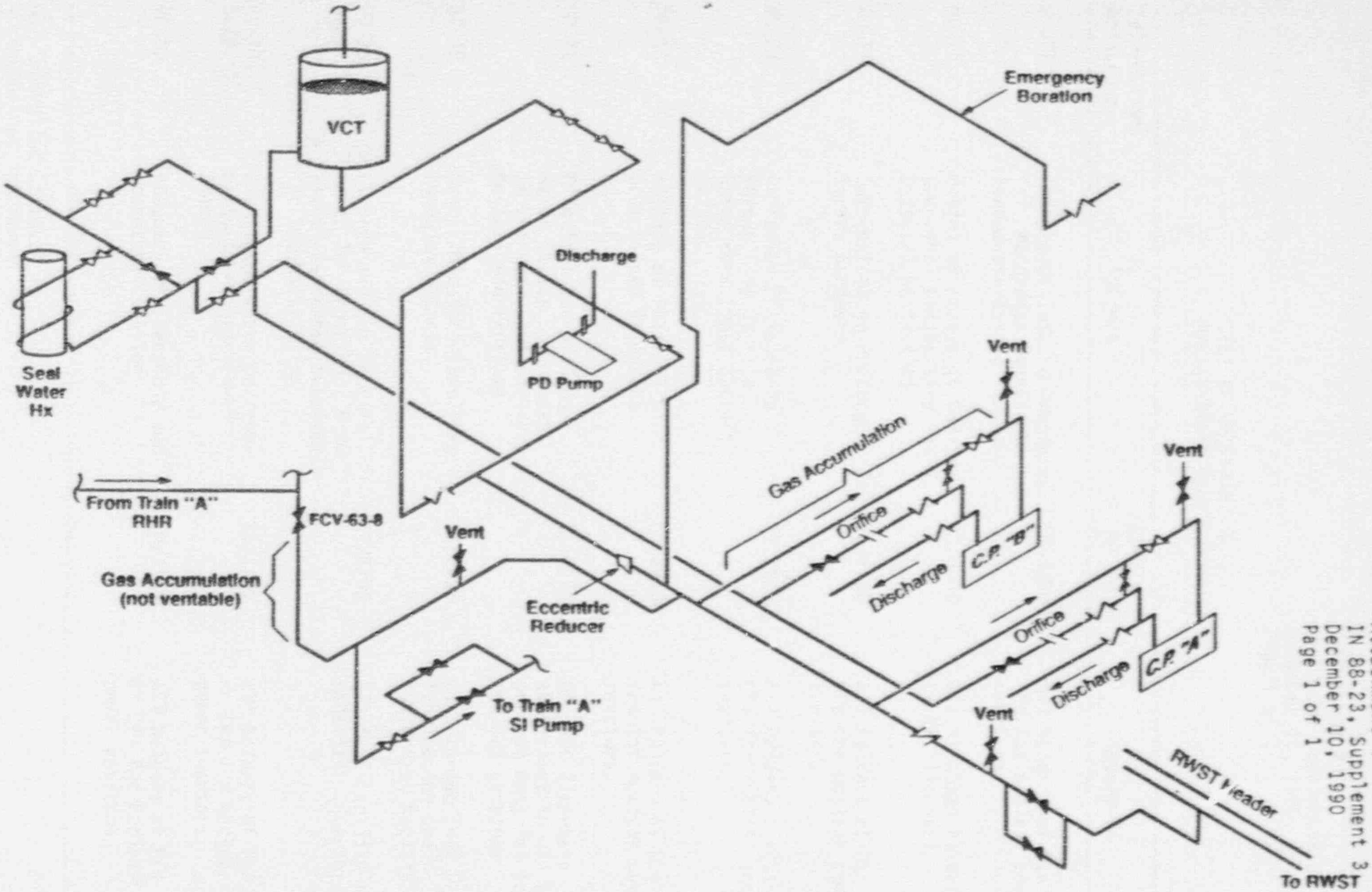
This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact the technical contact listed below or the appropriate NRR project manager.

Charles E. Rossi
Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contact: John Thompson, NRR
(301) 492-1171

Attachments:
1. Charging Pumps and RHR Crossover for SQN Units 1 and 2
2. List of Recently Issued NRC Information Notices

Charging Pumps and RHR Crossover for SQN Units 1 & 2



ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

NEW STANDARD TECHNICAL SPECIFICATIONS (STS)

MARK REINHART
(301) 492-3139
SENIOR OPERATIONS ENGINEER
TECHNICAL SPECIFICATIONS BRANCH
DIVISION OF OPERATIONAL EVENTS ASSESSMENT
OFFICE OF NUCLEAR REACTOR REGULATION

FRIDAY, DECEMBER 7, 1990

1:00 - 2:30 P.M.

INFORMATION BRIEFING ON NEW STANDARD TECHNICAL SPECIFICATIONS (STS)

• OVERVIEW OF PROGRAM AND PROGRESS	TODAY
• RELEASE FINAL DRAFT FOR YOUR INFORMATION	JAN 91

CHRONOLOGY: STANDARD TECHNICAL SPECIFICATIONS (STS)

- BACKGROUND

COMMISSION'S INTERIM POLICY STATEMENT	FEB 87
"SPLIT REPORT"	MAY 88
OWNERS GROUPS PROPOSED NEW STS	MAR 89 TO JUN 89
STAFF'S REVIEW AND DISCUSSIONS WITH OWNERS GROUPS	APR 89 TO DEC 90

- PROGRESS

STAFF TO ISSUE FINAL DRAFT NEW STS AND THEIR BASES	JAN 91
OWNERS GROUPS' AND NRC STAFF'S FINAL REVIEW	

- FUTURE

APPLY LESSONS LEARNED FROM LEAD PLANT CONVERSIONS TO NEW STS	
ISSUE NEW STS AND THEIR BASES	SPRING 91

EXTENT OF PARTICIPATION IN PROGRAM

- Industry Participation (30 persons)
  - NUMARC
  - NSSS Owners Groups
  - Lead Plant Licensees
  - Other Licensees
- NRC Staff Participation (65 persons)
  - Technical Specifications Branch
  - NRR Technical Branches (Including Risk and Human Factors)
  - Projects
  - Regions
  - Technical Training Center
- NRC Contractors (25 persons)
  - Lawrence Livermore National Laboratory
  - Idaho National Engineering Laboratory
  - Pacific Northwest Laboratories
  - Science Applications International Corporation

LEAD PLANT CONVERSIONS TO NEW STS

North Anna 1 and 2	Westinghouse
Crystal River 3	Babcock and Wilcox
San Onofre 2 and 3	Combustion Engineering
Hatch 2	GE BWR-4
Grand Gulf 1	GE BWR-6

CONTENTS OF NEW STS

HIGHLIGHTS OF CHANGES

- Technical Changes

  Relocated 40% of requirements to licensee controlled documents
  Licensees to provide controls for relocated requirements
  Reduced Surveillance Testing
  Line Item Improvements

- Risk Insights
  Split (3 Criteria + risk insights)
  Topical Reports on Instrumentation Completion Times and Surveillance Frequencies
  SAIC evaluation

- Human Factors
  Writers Guide

SUMMARY OF IMPROVEMENTS

- Focused on operational safety
- More Operator oriented
- Streamlined LCO's and SR's
- High degree of consistency within each and among all STS
- Bases provide
  - Reasons for LCO and SR requirements
  - Link with Safety Analysis
- Promote better understanding of technical specifications
- Allow more efficient use of NRC and industry resources

6

AN INTEGRAL STRUCTURE AND SCALING METHODOLOGY FOR SEVERE ACCIDENT TECHNICAL ISSUE RESOLUTION

Developed by: Technical Program Group

Presented by: Novak Zuber

ACRS COMMITTEE MEETING

Bethesda, Maryland

December 7, 1990

Technical Program Group

B. Boyack	(LANL)
A. Dukler	(UH)
P. Griffith	(MIT)
J. Healzer	(SLI)
R. Henry	(FAI)
M. Ishii	(Purdue)
J. Lehner	(BNL)
S. Levy	(SLI)
F. Moody	(GE)
M. Pilch	(SNL)
B. Sehgal	(EPRI)
B. Spencer	(ANL)
T. Theofanous	(UCSB)
J. Valente	(BNL)
W. Wulff	(BNL)
N. Zuber	(NRC)

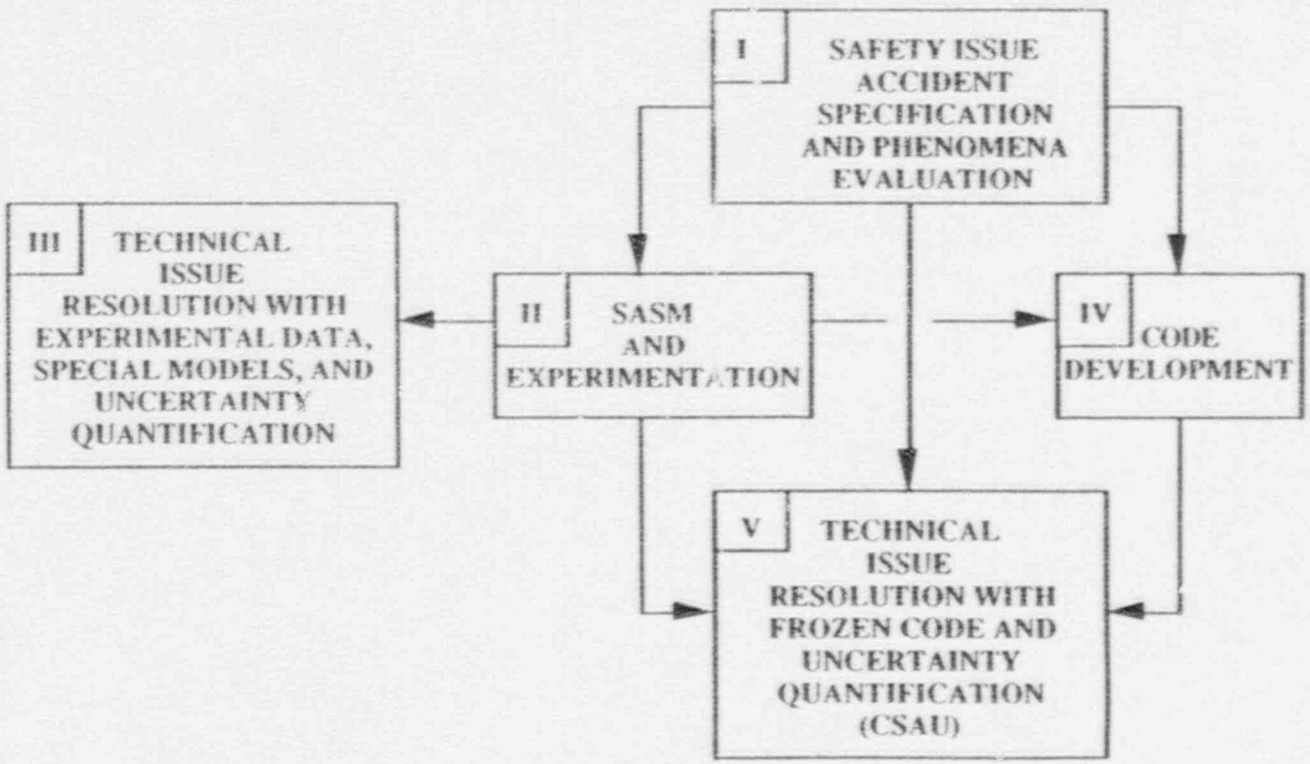
TOPICS

Topics that will be covered in this presentation include:

- OVERVIEW OF INTEGRATED STRUCTURE FOR TECHNICAL ISSUE RESOLUTION (ISTIR)
- BRIEF DESCRIPTION OF ISTIR COMPONENTS
- OVERVIEW OF SEVERE ACCIDENTS SCALING METHODOLOGY (SASM)
- BRIEF DESCRIPTION OF SASM COMPONENTS
- OVERVIEW OF THE TWO-TIER SCALING ANALYSIS
- APPLICATION TO DCH TRANSIENTS
- CONTENT OF REPORT

1. OVERVIEW OF ISTIR AND SASM

INTEGRATED STRUCTURE FOR TECHNICAL ISSUE RESOLUTION



THE MAJOR ATTRIBUTES OF THE ISTIR ARE:

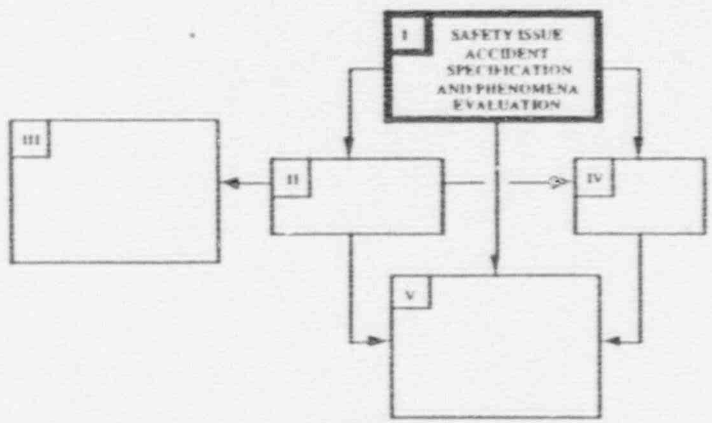
- - OBJECTIVE: PROVIDE SEVERE ACCIDENT TECHNICAL ISSUE RESOLUTION HAVING:
  * - PROPER BALANCE OF ANALYSIS WITH EXPERIMENTS
  * - TECHNICAL SUFFICIENCY
  * - PROGRAM EFFICIENCY

- - STRUCTURE: INTEGRATES THE FIVE COMPONENTS OF TECHNICAL ISSUE RESOLUTION:
  * - TECHNICAL ISSUE SPECIFICATION (COMPONENT I)
  * - SCALING OF EXPERIMENTS (COMPONENT II)
  * - SPECIAL RESOLUTIONS DIRECTLY FROM EXPERIMENTAL DATA (COMPONENT III)
  * - COMPUTER CODE DEVELOPMENT (COMPONENT IV)
  * - TECHNICAL ISSUE RESOLUTION WITH FROZEN CODES (COMPONENT V)

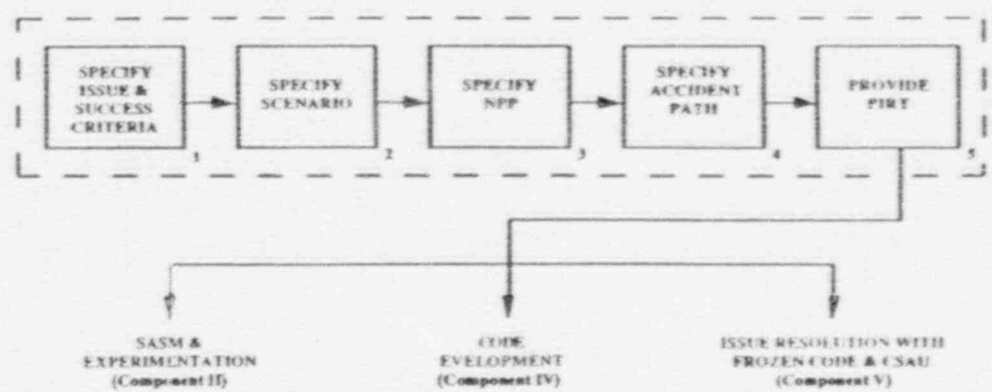
COMPONENT I, SAFETY ISSUE ACCIDENT SPECIFICATION & PHENOMENA EVALUATION, IS FOUNDATION OF ISTIR

- OBJECTIVE: PROVIDE A WELL DEFINED PROBLEM IN THE CONTEXT OF THE TECHNICAL ISSUE, PLANT, SCENARIO & RELATIVE IMPORTANCE OF PHENOMENA

- STRUCTURE: CONSISTS OF FIVE STEPS TO SPECIFY THE ABOVE KEY ELEMENTS.
  * - REQUIRES DEFINITION OF CRITERIA FOR SUCCESSFUL TECHNICAL ISSUE RESOLUTION
  * - PLAUSIBLE PHENOMENA & RELATIVE IMPORTANCE DETERMINED VIA TOP-DOWN APPROACH



ISTIR

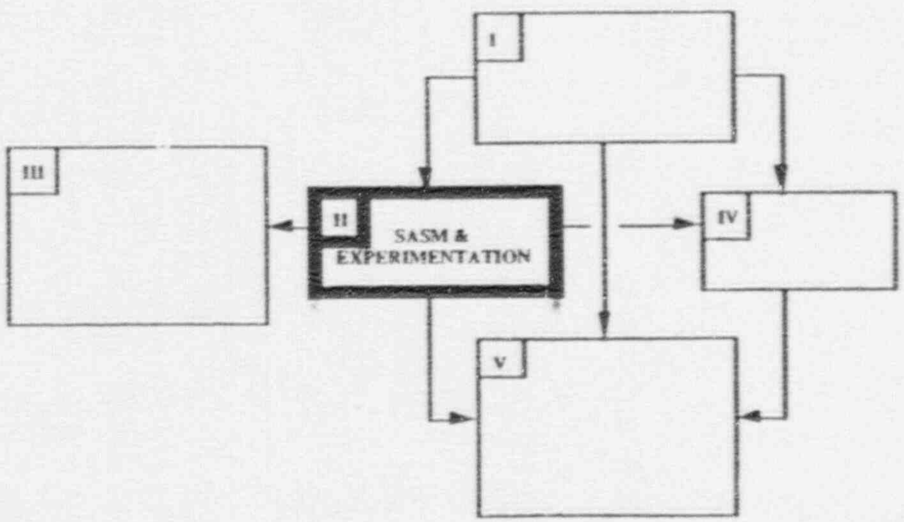


COMPONENT I

COMPONENT II, SEVERE ACCIDENT SCALING METHODOLOGY, ADDRESSES THE PARTICULARLY IMPORTANT ELEMENT OF WELL SCALED EXPERIMENTAL DATA

- \- OBJECTIVE: PROVIDE SCALING RATIONALE & CRITERIA, FACILITY DESIGN & TEST SPECIFICATION REVIEWS, & ASSESSMENT OF SCALE DISTORTIONS

- \- STRUCTURE: METHODOLOGY CONSISTS OF 11 STEPS GROUPED IN 3 KEY ELEMENTS RELATED TO REQUIREMENTS, EVALUATION, TESTING, & DOCUMENTATION OF EXPERIMENTS



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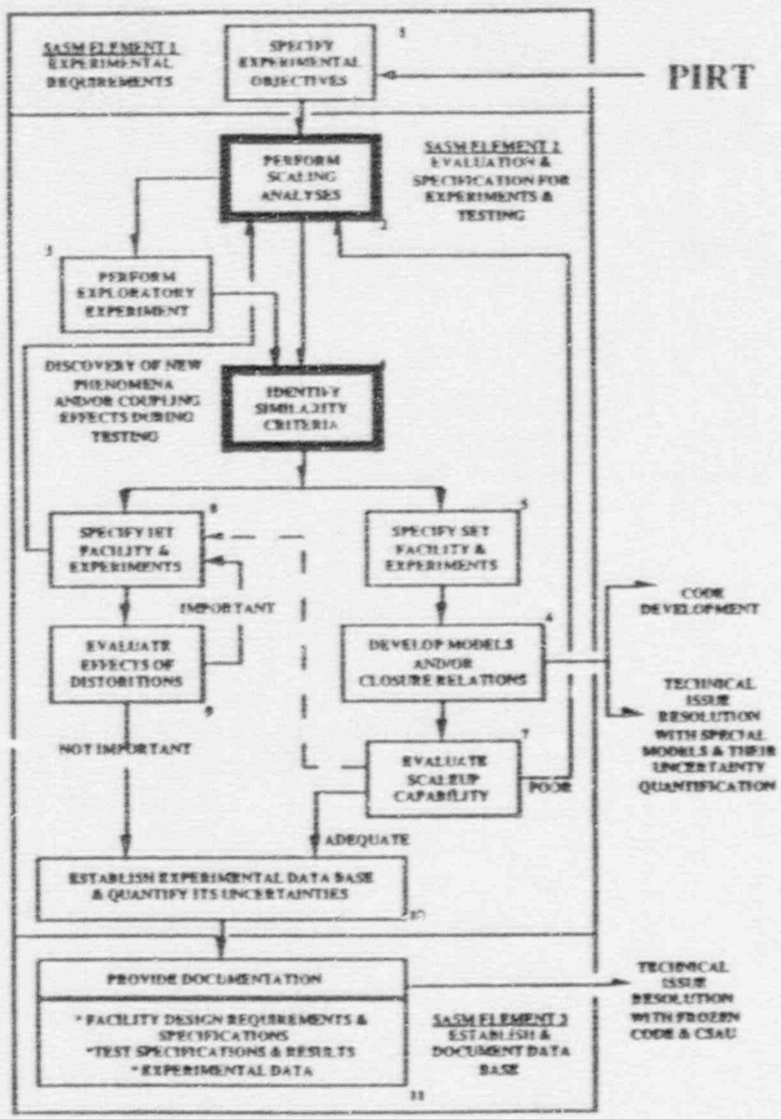
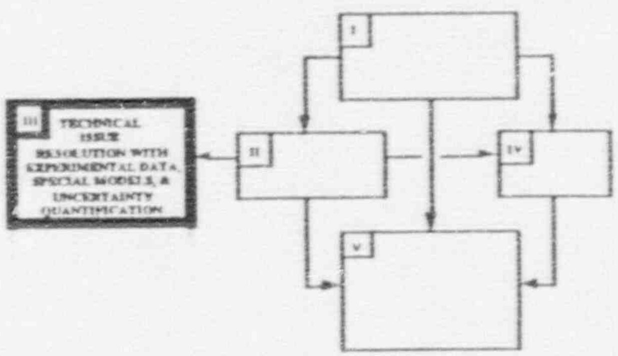


COMPONENT II

COMPONENT III, TECHNICAL ISSUE RESOLUTION WITH EXPERIMENTAL DATA, SPECIAL MODELS & UNCERTAINTY QUANTIFICATION, PROVIDES FOR POSSIBILITY OF ISSUE RESOLUTION DIRECTLY FROM EXPERIMENTAL DATA

- \- INVOLVES INNOVATIVE APPROACHES
- \- ACCOMMODATES "FLASHES" OF INSIGHT
- \- REQUIRES MATURE SOLUTIONS EFFECTED BY TESTING, VALIDATION AND TECHNICAL COMMUNITY PEER REVIEW & ACCEPTANCE
- \- PROCESS CAN BE PRESCRIBED, BUT DETAILS MUST REMAIN FLEXIBLE



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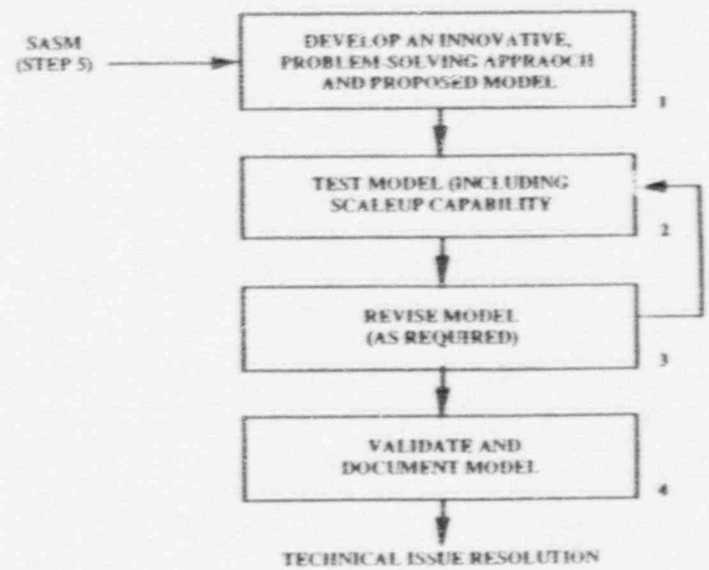


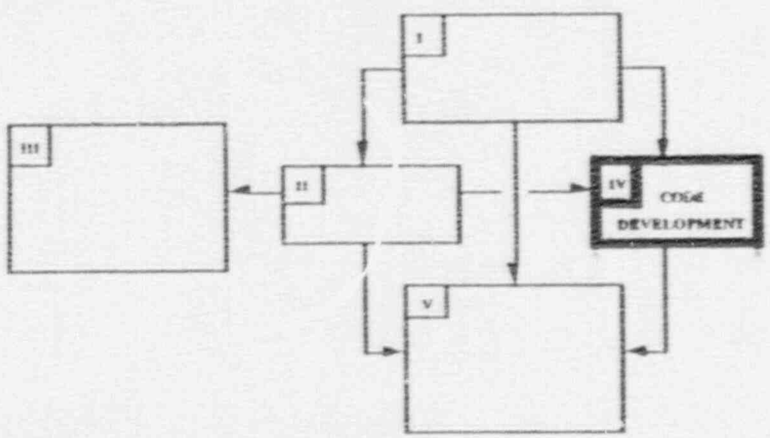
COMPONENT III

COMPONENT IV, CODE DEVELOPMENT IS ONE OF TWO PRIMARY SUPPORTS TO ANALYTICAL TECHNICAL ISSUE RESOLUTION (COMPONENT V)

- OBJECTIVE: PROVIDE CODES THAT ARE:
  - * - ABLE TO ADDRESS TECHNICAL ISSUES
  - * - APPLICABLE TO FULL SCALE REACTORS

- STRUCTURE: CONSISTS OF SIX STEPS THAT:
  - * - ESTABLISH CODE REQUIREMENTS EARLY BASED ON PHENOMENA
  - * - PROVIDE V & V OF CODE (TRACEABILITY & AUDITIBILITY)

8-1



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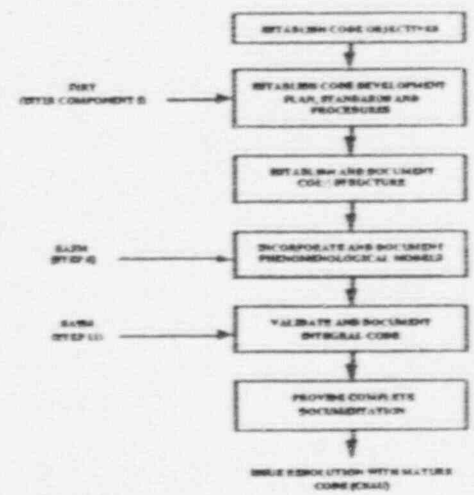
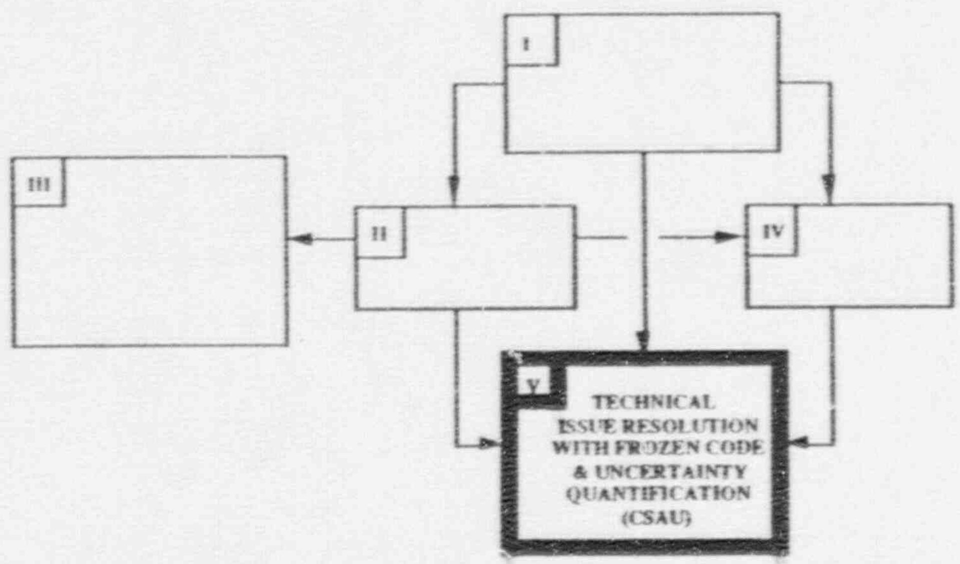


COMPONENT IV

COMPONENT V, TECHNICAL ISSUE RESOLUTION WITH FROZEN CODE & UNCERTAINTY QUANTIFICATION CAN BE EXPECTED TO BE PREFERRED METHOD

- \- OBJECTIVE: TO DETERMINE CODE APPLICABILITY & UNCERTAINTY IN THE CONTEXT OF PROVIDING TECHNICAL ISSUE RESOLUTIONS HAVING PRUDENT SAFETY MARGINS

- \- STRUCTURE: COMPONENT ANALYSIS BASED ON THE CODE SCALING, APPLICABILITY & UNCERTAINTY (CSAU) METHODOLOGY DOCUMENTED IN NUREG/CR-5249



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2. OVERVIEW

OF

THE TWO-TIER SCALING METHODOLOGY

TOPICS THAT WILL BE COVERED IN THIS PRESENTATION INCLUDE:

- OBJECTIVES
- FLOW DIAGRAM FOR THE TWO-TIER SCALING ANALYSIS
- CHARACTERISTICS OF SEVERE ACCIDENTS SCENARIOS
- A HIERARCHICAL POINT OF VIEW
- SYSTEM DECOMPOSITION AND HIERARCHY
- CHARACTERISTIC SPATIAL SCALES
- CHARACTERISTIC TEMPORAL SCALES
- CHARACTERISTIC TIME RATIOS
- SCALE DISTORTIONS
- CONCLUSIONS

OBJECTIVES

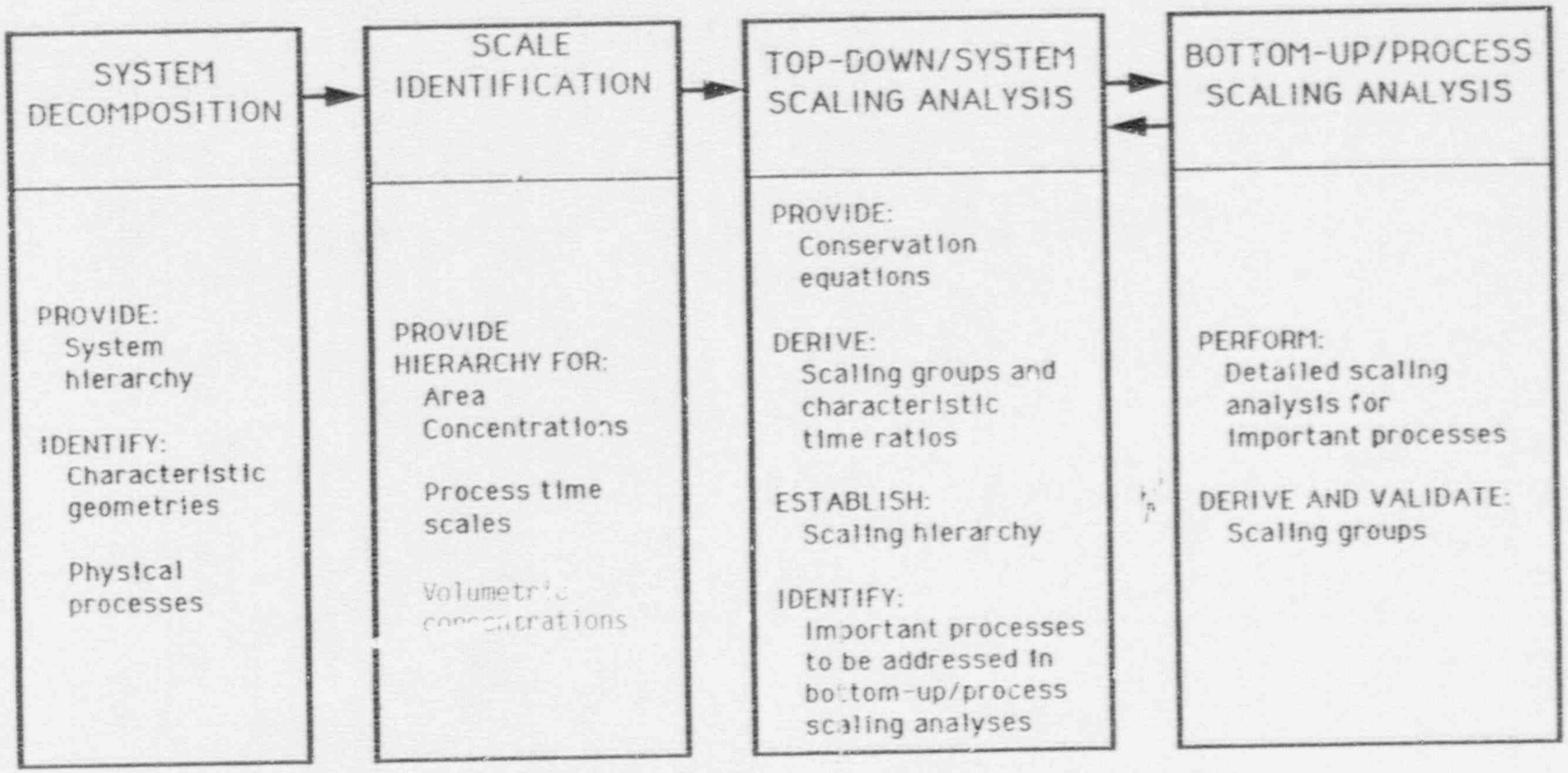
1. TO ENSURE THE PROTOTYPICALITY OF THE EXPERIMENTAL DATA.

2. TO PROVIDE A SCALING METHODOLOGY THAT IS SYSTEMATIC AND PRACTICAL, AUDITABLE AND TRACEABLE.

3. TO PROVIDE THE SCALING RATIONALE AND SIMILARITY CRITERIA

4. TO PROVIDE A PROCEDURE FOR CONDUCTING COMPREHENSIVE REVIEWS OF FACILITY DESIGN, OF TEST SPECIFICATION AND RESULTS, AND

5. TO QUANTIFY BIASES DUE TO SCALE DISTORTIONS OR DUE TO NON-PROTOTYPICAL CONDITIONS



FLOW DIAGRAM FOR THE TWO-TIERED SCALING ANALYSIS

CHARACTERISTICS OF SEVERE ACCIDENTS (SA) SCENARIOS

- SA SCENARIOS ARE CHARACTERIZED BY TRANSIENT PROCESSES ASSOCIATED WITH INTERACTING AND REACTING MEDIA, CONSISTING OF MANY CONSTITUENTS, OF DIFFERENT PHASES EXCHANGING MASS, ENERGY AND MOMENTUM

- EACH SYSTEM COMPONENT HAS ITS OWN CHARACTERISTIC RESPONSE TIME AND GEOMETRY.

- PHYSICAL AND CHEMICAL INTERACTIONS ARE PROCESSES CHARACTERIZED BY PARTICULAR SCALES FOR GEOMETRY AND TIME.

- THEREFORE, THE PROBLEM IS ONE OF MULTIPLE SPATIAL AND TEMPORAL SCALES.

- SYNERGETIC EFFECTS NECESSITATE GLOBAL CONSIDERATIONS.

- THIS SUGGESTS A HIERARCHICAL APPROACH TO THE PROBLEM TO MAKE IT TRACTABLE.

A HIERARCHICAL POINT OF VIEW

- CENTRAL TO THE APPROACH IS THE CONCEPT THAT A HIERARCHY, (ORGANIZATION) CAN BE ESTABLISHED FROM DIFFERENCES IN TEMPORAL AND SPATIAL SCALES.

- PROCESSES CAN BE GROUPED INTO CLASSES WITH SIMILAR TIME SCALES. IF CLASSES ARE SUFFICIENTLY DISTINCT THEY CAN BE DECOUPLED ONE FROM ANOTHER RESULTING IN A HIERARCHICAL ORGANIZATION.

- LEVELS IN A HIERARCHY RE ISOLATED FROM EACH OTHER BECAUSE THEY OPERATE AT DISTINCTLY DIFFERENT TIME SCALES.

- A LOWER LEVEL IN THE HIERARCHY COMMUNICATES ONLY ITS AVERAGE TO THE HIGHER LEVEL (LESS DETAILED INFORMATION IS NEEDED AT HIGHER LEVELS).

- LARGER CHARACTERISTIC SPATIAL SCALES ARE ASSOCIATED WITH CHARACTERISTIC LONGER TIME SCALES.

- EACH LOWER LEVEL PROVIDES MORE DETAILED INFORMATION (SPECIFICITY)

A HIERARCHICAL POINT OF VIEW (CON'T)

- o A HIERARCHICAL (STRUCTURED) APPROACH TO SCALING WAS DEVELOPED. STARTING FROM A GLOBAL, TOP VIEWPOINT, COMPLEXITY AND DETAIL ARE INTRODUCED AT EACH LOWER LEVEL.

- o THE RESULT IS A TWO-TIER APPROACH.

THE TOP-DOWN SYSTEM APPROACH

- o PROVIDES A SCALING HIERARCHY BASED ON RELATIVE IMPORTANCE OF VARIOUS TRANSFER PROCESSES.

- o PROVIDES THE ORDER IN WHICH TO MAINTAIN SIMILARITY BETWEEN TEST AND PLANT CONDITIONS.

- o IDENTIFIES IMPORTANT PROCESSES WHICH NEED TO BE EXAMINED IN MORE DETAIL.

THE BOTTOM-UP PROCESS APPROACH

- o PROVIDES A DETAILED SCALING ANALYSIS OF IMPORTANT PROCESSES.

IMPORTANT FEATURES

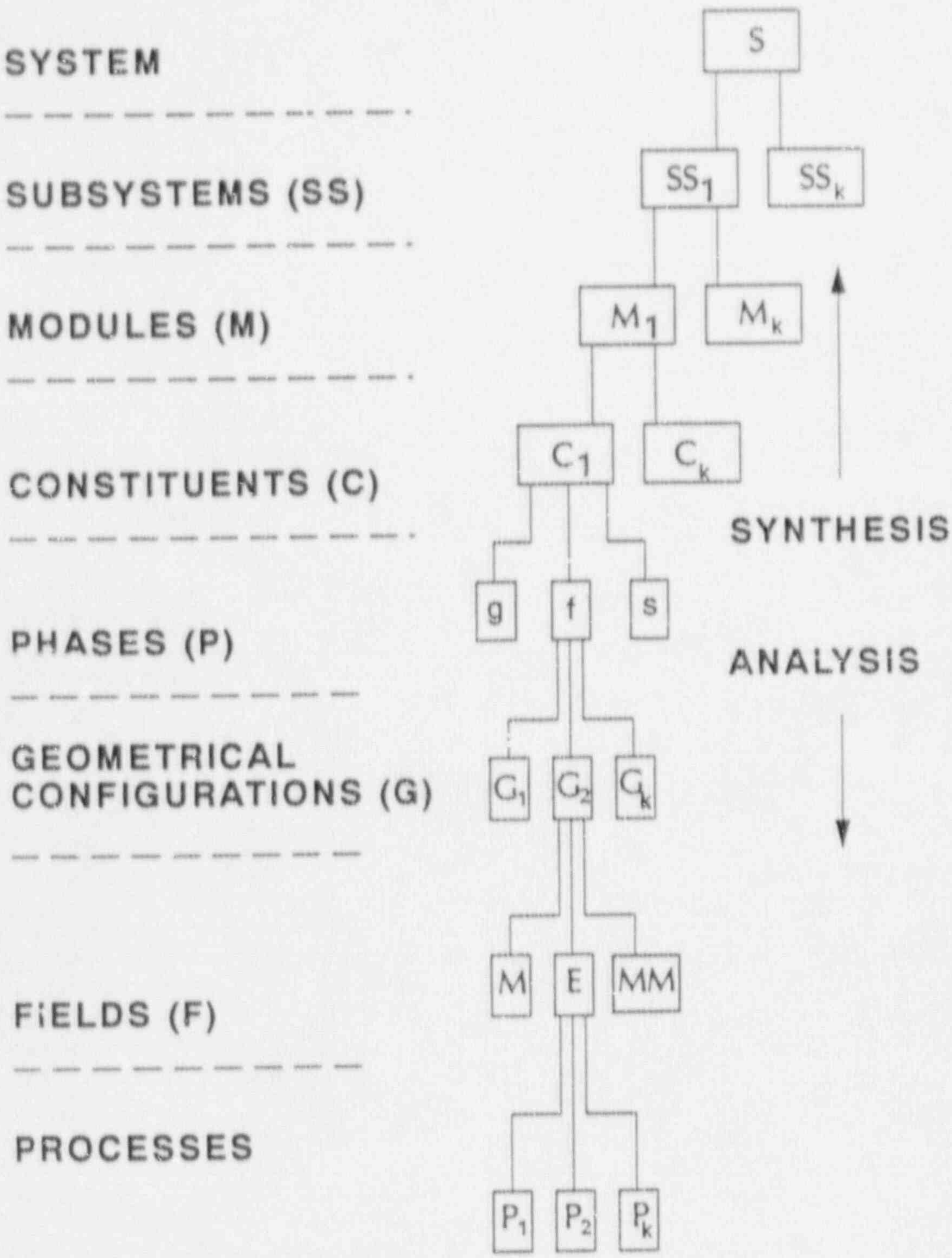
- o THE TOP-DOWN SYSTEM SCALING PROVIDES THE EFFICIENCY WHEREAS THE BOTTOM-UP PROCESS SCALING ENSURES THE SUFFICIENCY OF THE ANALYSIS.

- o TOGETHER, THE TWO APPROACHES PROVIDE A SCALING METHODOLOGY THAT IS PRACTICAL.

SYSTEM DECOMPOSITION AND HIERARCHY

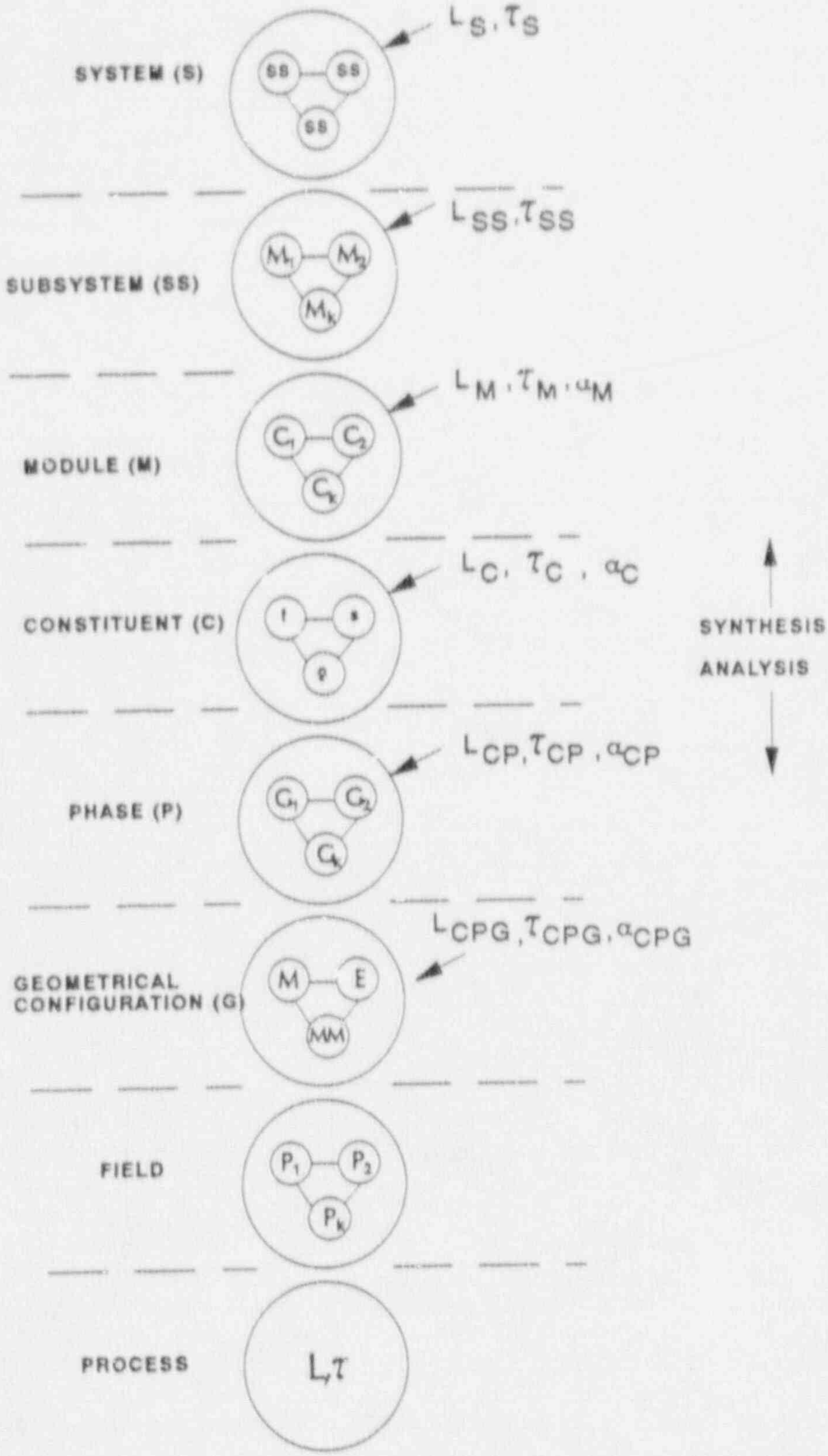
THE BASIC PARADIGM:

- o EACH SYSTEM CAN BE DIVIDED INTO (INTERACTING) SUBSYSTEMS.
- o EACH SUBSYSTEM CAN BE DIVIDED IN (INTERACTING) MODULES.
- o EACH MODULE CAN BE DIVIDED IN (INTERACTING) CONSTITUENTS (MATERIALS).
- o EACH CONSTITUENT CAN BE DIVIDED IN (INTERACTING) PHASES.
- o EACH PHASE CAN BE CHARACTERIZED BY ONE OR MORE GEOMETRICAL CONFIGURATIONS.
- o EACH GEOMETRICAL CONFIGURATION CAN BE DESCRIBED BY THREE CONSERVATION EQUATIONS.
- o EACH FIELD CAN BE CHARACTERIZED BY SEVERAL PROCESSES.



SYSTEM DECOMPOSITION AND HIERARCHY

PROCESSES

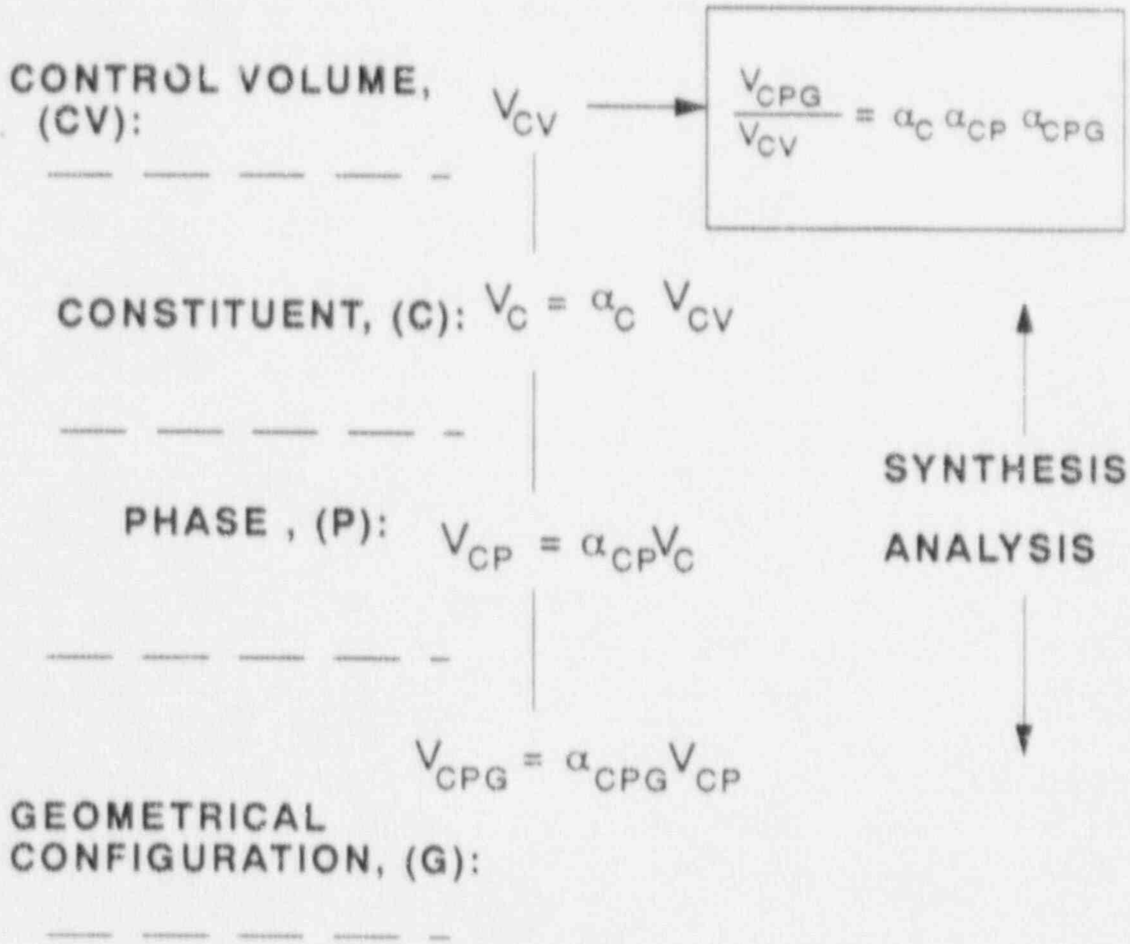


SYSTEM DECOMPOSITION AND HIERACHY

LENGTH, TIME AND CONCENTRATION CHARACTERISTICS

VOLUMETRIC CONCENTRATIONS

* VOLUMETRIC CONCENTRATIONS SCALE (ACCOUNT FOR) THE RELATIVE AMOUNT OF A CONSTITUENT, OF A PHASE AND OF A PARTICULAR GEOMETRY IN THE CONTROL VOLUME



Hierarchy for volume fraction of geometric configuration G in control volume V_{CV}.

CHARACTERISTIC SPATIAL SCALES

- A TRANSFER AREA IS ASSOCIATED WITH EACH TRANSFER PROCESS.

- CONSEQUENTLY, THE CHARACTERISTIC SPATIAL SCALE FOR A PARTICULAR TRANSFER PROCESS IS ITS AREA CONCENTRATION.

CHARACTERISTIC SPATIAL SCALES

CONSIDER DIFFERENT CONSTITUENTS (PHASES) ARE PRESENT IN THE CONTROL VOLUME

DEFINE VOLUME FRACTION OCCUPIED BY CONSTITUENT C

$$\alpha_c = \frac{V_c}{V_{cv}}$$

AREA CONCENTRATION FOR CONSTITUENT C

$$\frac{A_{ic}}{V_{cv}} = \frac{V_c}{V_{cv}} \frac{A_{ic}}{V_c} = \alpha_c \frac{1}{L_c}$$

α_c CHARACTERIZES THE AMOUNT (PRESENCE) OF CONSTITUENT C IN CONTROL VOLUME

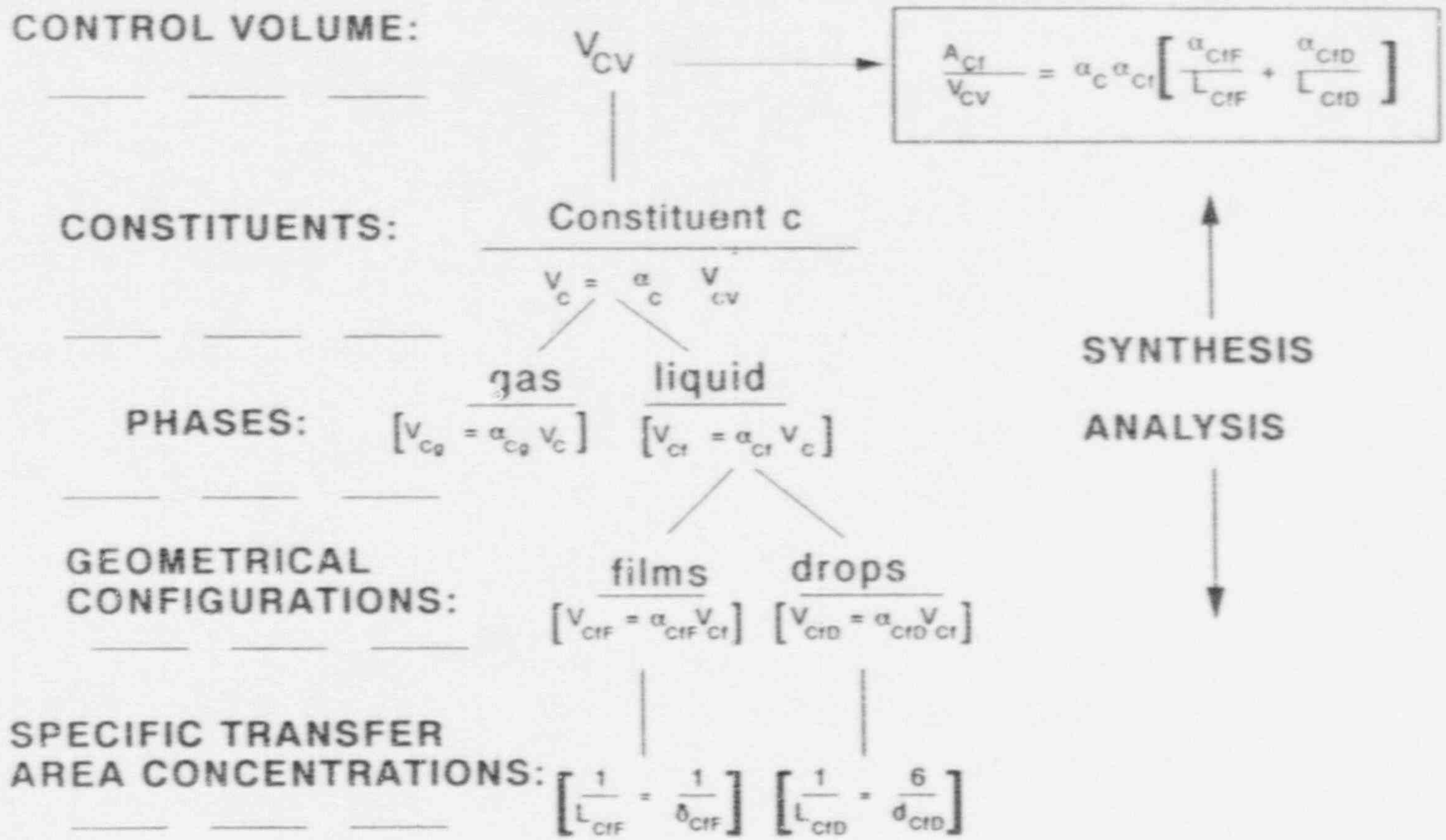
$\frac{A_{ic}}{V_c} = \frac{1}{L_c}$ CHARACTERIZES THE GEOMETRY FOR TRANSFER FROM CONSTITUENT C

FOR SPHERES:

$$\frac{A_{ic}}{V_c} = \frac{6}{d}$$

FOR FILMS:

$$\frac{A_{ic}}{V_c} = \frac{1}{\delta}$$



Total transfer area concentration (A_{Cf} /V_{CV}) for liquid of constituent C in control volume V_{CV}.

wilson\fig6

CHARACTERISTIC SPATIAL SCALES (CONT'D)

NOTE:

A) VOLUMETRIC CONCENTRATIONS ACCOUNT FOR THE EFFECTS OF VARIOUS CONSTITUENTS AND/OR PHASES.

B) THE EFFECTS OF DIFFERENT GEOMETRIES ARE DIRECTLY ACCOUNTED FOR IN THE AREA OF CONCENTRATION.

CHARACTERISTIC TIME SCALES

A. TIME SCALE FOR CONTROL VOLUMES

CONSIDER A CONTROL VOLUME V_{CV}, WITH A FLOW AREA A_f AND A VOLUME FLOW RATE Q.

THEN THE RESIDENCE TIME IN THE CONTROL VOLUME IS:

$$\tau_{CV} = \frac{V_{CV}}{Q}$$

NOTE:

$$\frac{1}{\tau_{CV}} = \frac{Q}{V_{CV}} = \omega_{CV} = \underline{frequency}$$

ω_{CV} = NUMBER OF CONTROL VOLUMES CHANGED PER SECOND

IT SCALES SOURCE STRENGTH AND SYSTEM VOLUME (GEOMETRY)

CHARACTERISTIC TIME SCALES (CONT'D.)

B. PROCESS TIME SCALE

CONSIDER PROPERTY Ψ PER UNIT VOLUME:

$$\psi = \rho,\ \rho v,\ \rho u,\ \rho_k\ ..$$

THEN

$$\psi_r V_{CV} = \textit{total amount of } \psi_r \textit{ in control volume } V_{CV}$$

CONSIDER A PROCESS IN WHICH Ψ IS BEING TRANSFERED ACROSS THE AREA A_T. FOR A GIVEN FLUX j_Ψ, THEN

$$j_\psi A_T = \textit{total transfer rate of } \psi$$

CHARACTERISTIC TIME SCALE (CONT'D.)

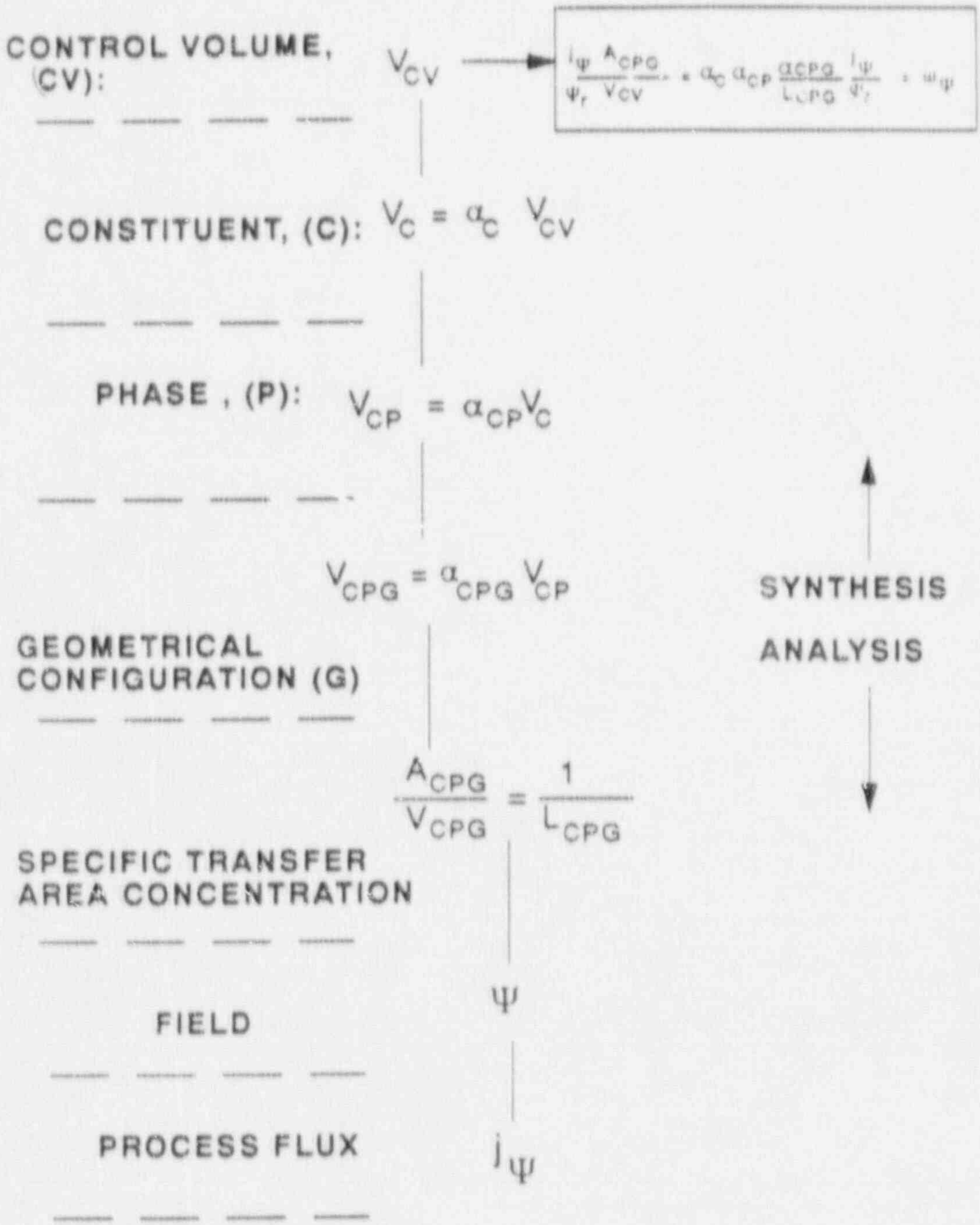
THEN

$$\frac{j_\psi A_T}{\psi_r V_{CV}} = \omega_\psi = \frac{1}{\tau_\psi} =$$

ω_Ψ = CHARACTERISTIC FREQUENCY FOR A PARTICULAR TRANSFER PROCESS

NOTE:

ω_Ψ = NUMBER OF TIMES THE (REFERENCE) AMOUNT OF Ψ_r, IN CONTROL VOLUME V_{CV}, HAS CHANGED PER SECOND



Hierarchy for the characteristic frequency ω_ψ of the transfer process j_ψ in control volume V_{CV}.

CHARACTERISTIC TIME SCALES (CONT'D)

NOTE:

A) THE EFFECTS OF A PARTICULAR RATE PROCESS ON THE SYSTEM CANNOT BE PROPERLY SCALED WITHOUT CONSIDERING THE PRESENCE OF OTHER CONSTITUENTS AND/OR PHASES (ACCOUNTED FOR BY VOLUMETRIC CONCENTRATIONS).

B) THE IMPACT OF A PARTICULAR RATE PROCESS IS BEING ATTENUATED/MODIFIED AT EACH HIGHER LEVEL OF THE HIERARCHY.

CHARACTERISTIC TIME RATIOS

FOR A GIVEN CONTROL VOLUME V_{CV}, AND GIVEN INPUT/OUTPUT VOLUMETRIC FLOW RATE Q, THE SYSTEM CHARACTERISTIC (RESIDENCE) TIME IS

$$\tau_{CV} = \frac{V_{CV}}{Q}$$

EACH PROCESS IS CHARACTERIZED BY A FREQUENCY:

$$\omega_P = \frac{j_\psi A_T}{\psi_r V_{CV}} = \frac{1}{\tau_P}$$

THE RATIO τ_{CV}/τ_P MEASURES (SCALES) THE RELEVANCE OF THE PROCESS.

CHARACTERISTIC TIME RATIOS (CONT'D)

NOTE:

$$\Pi_\tau = \frac{\tau_{CV}}{\tau_P} = \omega_P \tau_{CV}$$

Π_τ = THE TOTAL CHANGE OF REFERENCE AMOUNT ($\Psi_r V_{CV}$) DURING RESIDENCE TIME τ_{CV}

FOR CONSTITUENTS K:

$$\Pi_{\tau K} = \frac{\tau_{CV}}{\tau_{PK}} = \omega_{PK} = \frac{\alpha_K}{L_{PK}} \frac{j_P}{\psi_r} \tau_{CV}$$

CHARACTERISTIC TIME RATIOS (CONT'D)

NOTE:

A) FOR EACH PROCESS AND CONSTITUENT, THE CHARACTERISTIC TIME RATIO INCORPORATES THE CHARACTERISTIC TEMPORAL AND SPATIAL SCALES OF THE SYSTEM AND OF THE PROCESS.

B) EACH PROCESS IS EVALUATED IN TERMS OF THE SYSTEM (CONTROL VOLUME) RESPONSE, I.E., EACH PROCESS IS MEASURED BY THE SAME YARDSTICK.

C) FOR A PROCESS TO BE SIMILAR IN TWO FACILITIES, THE CHARACTERISTIC TIME RATIO MUST BE PRESERVED.

D) THE CHARACTERISTIC TIME RATIO COMBINES THE SYSTEM AND PROCESS VIEW POINTS.

E) THE CHARACTERISTIC TIME RATIOS PROVIDE A CRITERION FOR EVALUATING THE IMPORTANCE OF A PARTICULAR PROCESS:

$$\Pi = \omega_P \tau_{CV}$$

$\Pi_1 > \Pi_2$ *more important*

$\Pi_1 < \Pi_2$ *less important*

CONSEQUENTLY: THE CHARACTERISTIC TIME RATIOS Π PROVIDE THE TOOL FOR PRIORITY DISCRIMINATION AND RANKING

CHARACTERISTIC TIME RATIOS (CON'T)

NOTE:

- o THE PROPOSED CHARACTERISTIC RATIOS CAN BE DERIVED DIRECTLY FROM THE GENERAL BALANCE EQUATION.

CONSEQUENTLY:

- o ALL PROCESSES MODELED IN THE CONSERVATION EQUATIONS (MASS, MOMENTUM, ENERGY) CAN BE EXPRESSED AND THEREFORE EVLAUATED IN TERM OF A SINGLE MEASURE (CRITERION), THAT IS, IN TERMS OF TIME.

- o WITH A SINGLE MEASURE TO EVALUATE ALL PROCESSES, THE CHARACTERISTIC TIME RATIOS CAN BE USED TO ESTABLISH A SCALING HIERARCHY.

NOTE:

- o AT EACH LEVEL OF THE SCALING HIERARCHY, THE FUNCTION OF EACH ELEMENT (TRANSFER PROCESS) CAN BE EXAMINED AND ASSESSED.

CONSEQUENTLY:

- o THE FIRST TIER OF THE PROPOSED METHODOLOGY, THAT IS, THE TOP-DOWN OR SYSTEM SCALING APPROACH, PROVIDES FOR AN ANALYSIS THAT IS COMPREHENSIVE YET PRACTICAL, AUDITABLE AND TRACEABLE.

NOTE:
THE SCALING HIERARCHY HAS TWO IMPORTANT FUNCTIONS:

1) TO PROVIDE A TECHNICALLY JUSTIFIABLE RATIONALE FOR ESTABLISHING THE ORDER IN WHICH SMILARITY BETWEEN TEST AND PLANT CONDITIONS SHOULD BE PRESERVED, AND

2) TO IDENTIFY IMPORTANT PROCESSES WHICH NEED TO BE ADDRESSED IN GREATER DETAIL BY CONDUCTING A BOTTOM-UP/PROCESS SCALING ANALYSIS.

CONSEQUENTLY:

- o THE SECOND TIER OF THE PROPOSED SCALING METHODOLOGY, THAT IS, THE BOTTOM-UP/PROCESS APPROACH ENSURES THE SUFFICIENCY OF THE ANALYSIS.

EFFECTS OF DISTORTIONS

$$\Pi_p = \omega_r \tau_{CV}$$

= THE RATE AT WHICH A PARTICULAR RATE PROCESS CHANGES A REFERENCE QUANTITY DURING THE RESIDENCE TIME

$$D = \frac{\Pi_p - \Pi_m}{\Pi_p}$$

= THE % DIFFERENCE A PARTICULAR RATE PROCESS CHANGES A REFERENCE QUANTITY DURING THE TRANSIT TIME IN THE PROTOTYPE AND THE MODEL.

3. APPLICATION
TO
DCH TRANSIENTS

TOPICS

- APPLICATION OF ISTIR: COMPONENT I
    - SCENARIO
    - PLANT
    - ACCIDENT PATH
    - PROCESS IDENTIFICAITON AND RANKING
- APPLICATION OF SASM
    - FLOW DIAGRAM
    - RPV FAILURE CONDITIONS
    - RPV DISCHARGE PHENOMENA
    - REACTOR CAVITY PHENOMENA

APPLICATION OF ISTIR: COMPONENT I

THE 1ST COMPONENT OF THE ISTIR HAS BEEN APPLIED TO A DCH TRANSIENT (1 OF 3)

TECHNICAL ISSUE: DETERMINE POTENTIAL FOR CONTAINMENT OVERLOAD

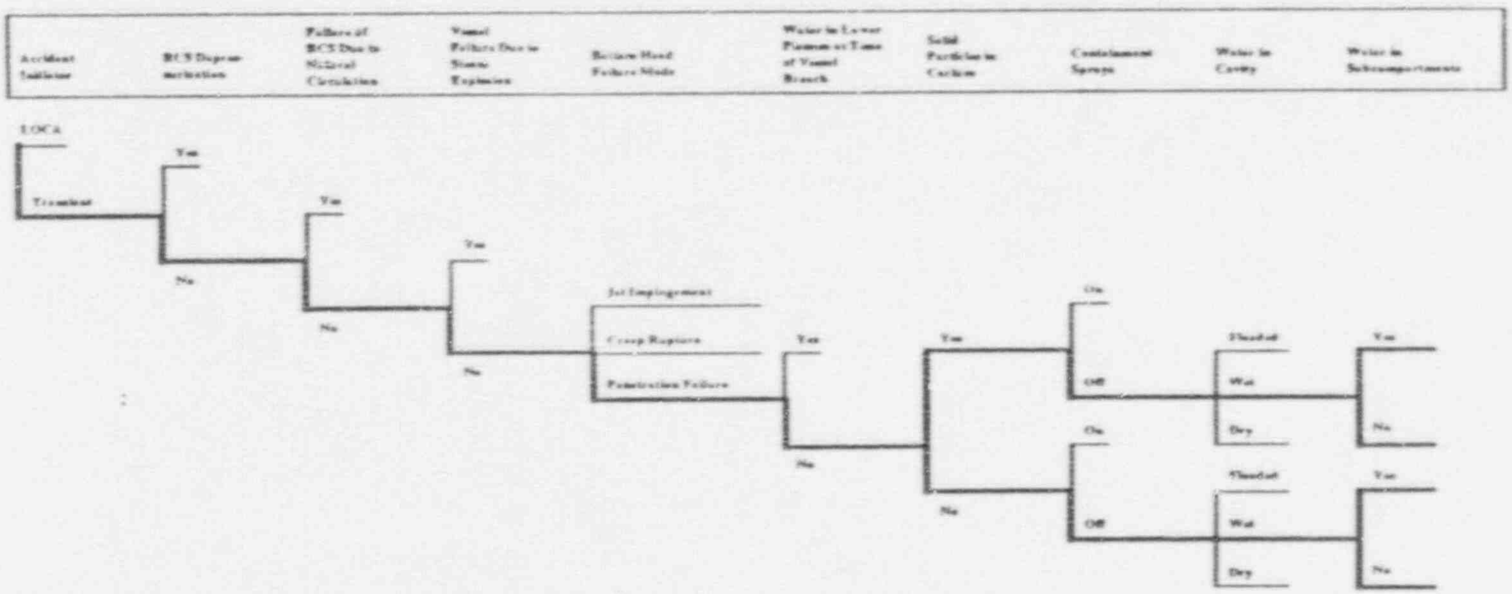
SUCCESS CRITERIA: ESTABLISH CONTAINMENT PRESSURE, TEMPERATURE & CONTAMINATION RESPONSE AT 95% PROBABILITY LEVEL

SCENARIO: DIRECT CONTAINMENT HEATING IN THE CONTAINMENT

NPP: REFERENCE PLANTS - ZION, SURRY & WATTS BAR

THE 1ST COMPONENT OF THE ISTIR HAS BEEN APPLIED TO A DCH TRANSIENT (2 OF 3)

ACCIDENT PATH:



THE 1ST COMPONENT OF THE ISTIR HAS BEEN APPLIED TO A DCH TRANSIENT (3 OF 3)

- - NPP HAS BEEN PARTITIONED INTO LOGICAL COMPONENTS TO AID IN IDENTIFICATION OF PLAUSIBLE PHENOMENA:

  * - RPV
  * - CONTAINMENT SUBCOMPARTMENTS
  * - REACTOR CAVITY
  * - UPPER CONTAINMENT

- - PLAUSIBLE PHENOMENA HAVE BEEN IDENTIFIED & RANKED FOR RELATIVE IMPORTANCE TO OVERLOAD, BY SCENARIO PHASE & COMPONENT

Table 2-2 Summary of Ranking[a] of the importance of plausible phenomena to containment loads during a DCH transient

Component/Phenomena	Initial TPG Ranking by Transient Phase		
	Corium Discharge	Multiphase Discharge	Phase-1 Discharge
RPV:			
Hole ablation	H	H	--
Flow through hole	H	H	H
Depressurization	L	--	--
Gas blowthrough	H	--	--
Oxidation reactions	--	L	--
Reactor Cavity:			
Corium distribution	H	H	H
Concrete ablation	L	--	--
Concrete decomposition	L	M	--
Oxidation reactions	M	H	H
Debris/water HT	M	H	H
Debris/gas HT	L	H	H
Debris/structures HT	M	L	L
Gas/structures HT	L	L	L
Hydrogen combustion	L	L	L
Containment Subcompartments:			
Hydrogen mixing	--	M	M
Oxygen content	--	M	M
Hydrogen combustion	--	M	M
Other combustibles	--	M	M
3D dispersed flow	H	H	H
Oxidation reactions	--	H	H
Debris/gas HT	--	H	H
Debris/structures HT	--	H	H
Debris/water HT	--	H	H
Concrete decomposition	--	H	H
Gas/structure HT	--	M	M
Upper Containment:			
Hydrogen mixing & combustion	--	H	H
Other combustibles	--	L	L
Oxidation reactions	--	L	L
Debris/gas HT	--	H	H
Debris/structures HT	--	L	L
Gas/structures HT	--	L	L

a. L = Low importance M = Medium importance H = High importance

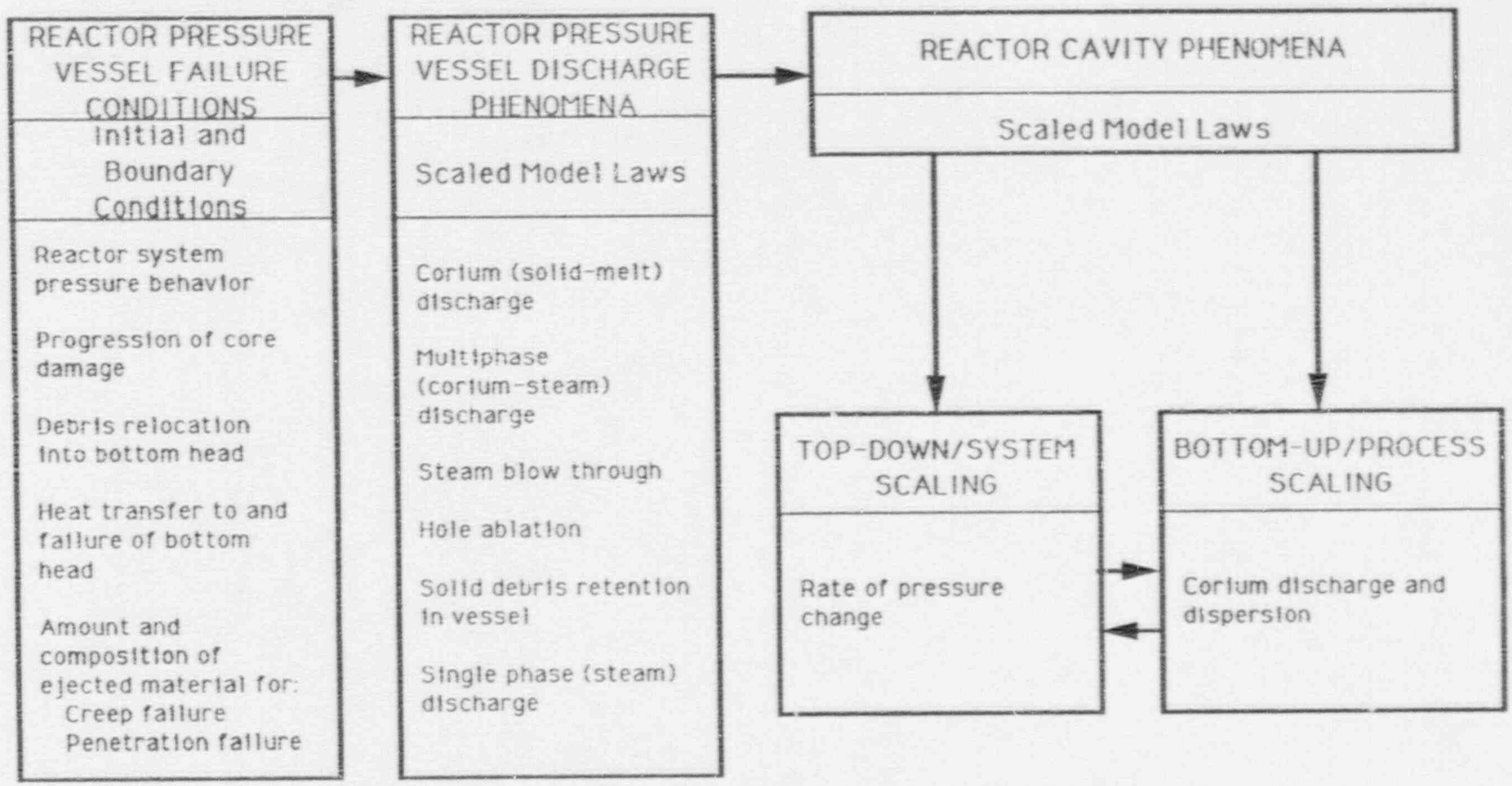
-- = Insignificant importance or not active during phase.

APPLICATION OF SASM

APLICATION TO DCH

THE TWO-TIER SCALING METHODOLOGY ONE BASED ON THE SYSTEM (TOP-DOWN) APPROACH THE OTHER ON THE PROCESS (BOTTOM-UP) APPROACH WAS APPLIED TO THE DCH PROBLEM.

THE TOPICS ADDRESSED IN THE REPORT ARE LISTED IN THE FIGURES THAT FOLLOW



FLOW DIAGRAM AND TOPICS ADDRESSED IN APPLYING SASM TO DCH

REACTOR PRESSURE VESSEL

FAILURE CONDITIONS

Appendix

AMOUNT OF MATERIAL INVOLVED IN DIRECT CONTAINMENT HEATING DURING A PRESSURIZED WATER REACTOR STATION BLACKOUT

Prepared for

Technical Program Group (TPG)

Severe Accident Scaling Methodology (SASM)

Prepared by

Salomon Levy*

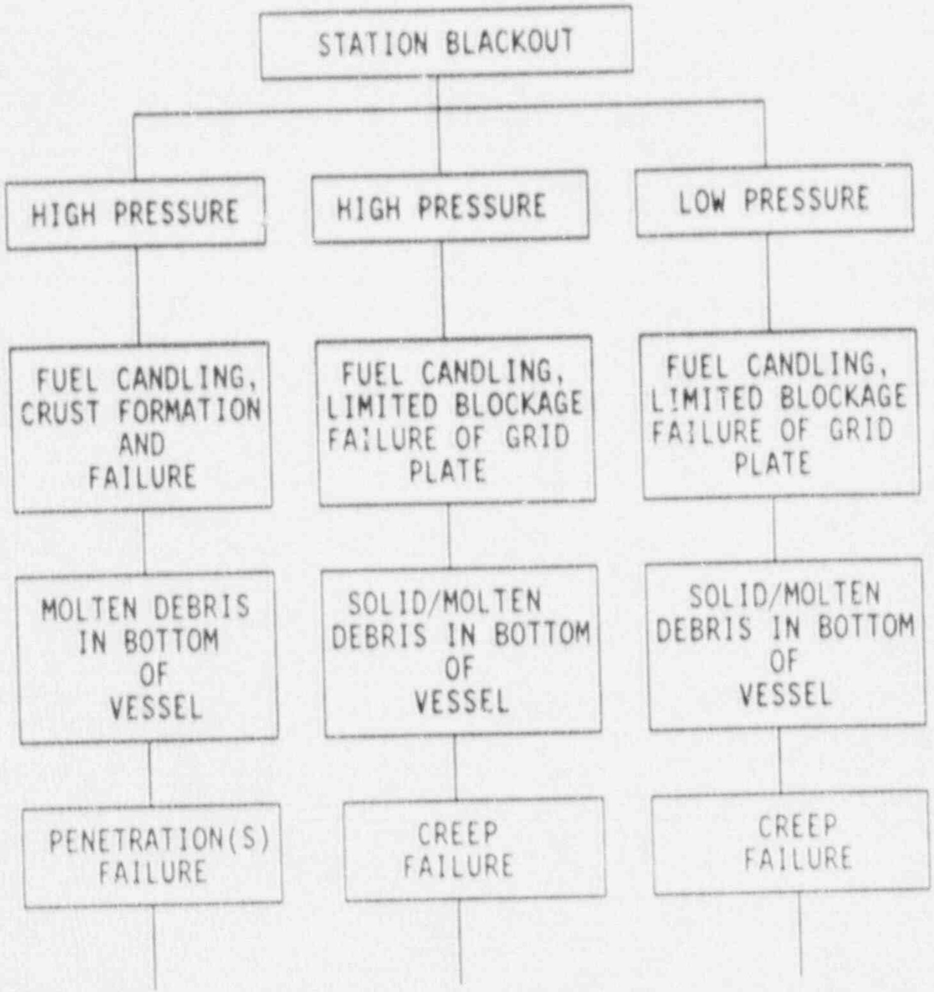
S. Levy Incorporated

November 1989

Updated April 1990

* The author wishes to acknowledge the detailed comments and suggestions received on this report by T. Heames and J. E. Kelly from Sandia National Laboratories.

TABLE OF CONTENTS



INITIAL CONDITIONS			
TIME OF FAILURE	~3 HOURS	~4 HOURS	~10 HOURS
EJECTED KGS	~40,000	~70,000	~80,000
MOLTEN KGS	~40,000	~40,000	~40,000
OXIDIZED ZR	~40%	~40-50%	~60-70%
EJECTED METALLIC CONTENT	~30-40%	~40-60%*	~50-70%*
TEMPERATURE	~2500 K	~2500 K	~2500 K

*INCREASED METALLIC CONTENT DUE TO MOLTEN STEEL

Fig. 3.2.2 Initial material conditions for direct containment heating.

TOP-DOWN/SYSTEM SCALING

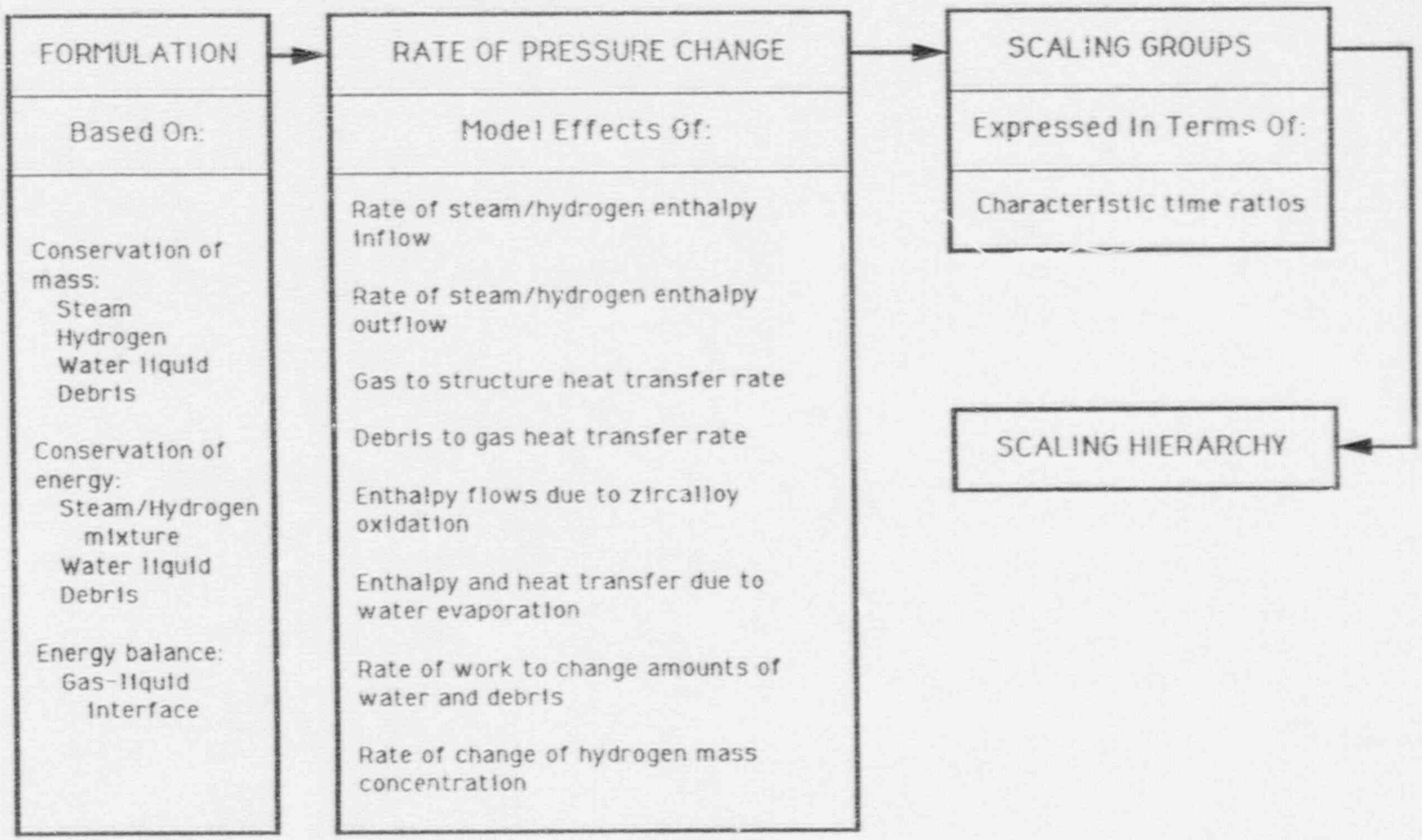
OF

REACTOR DAVITY PHENOMENA

RATE OF PRESSURE CHANGE

Prepared by

NOVAK ZUBER AND WULFGANG WULFF



FLOW DIAGRAM AND TOPICS ADDRESSED IN TOP-DOWN/SYSTEM SCALING

PRESSURE RATE OF CHANGE EQUATION

FORMULATION BASED ON:

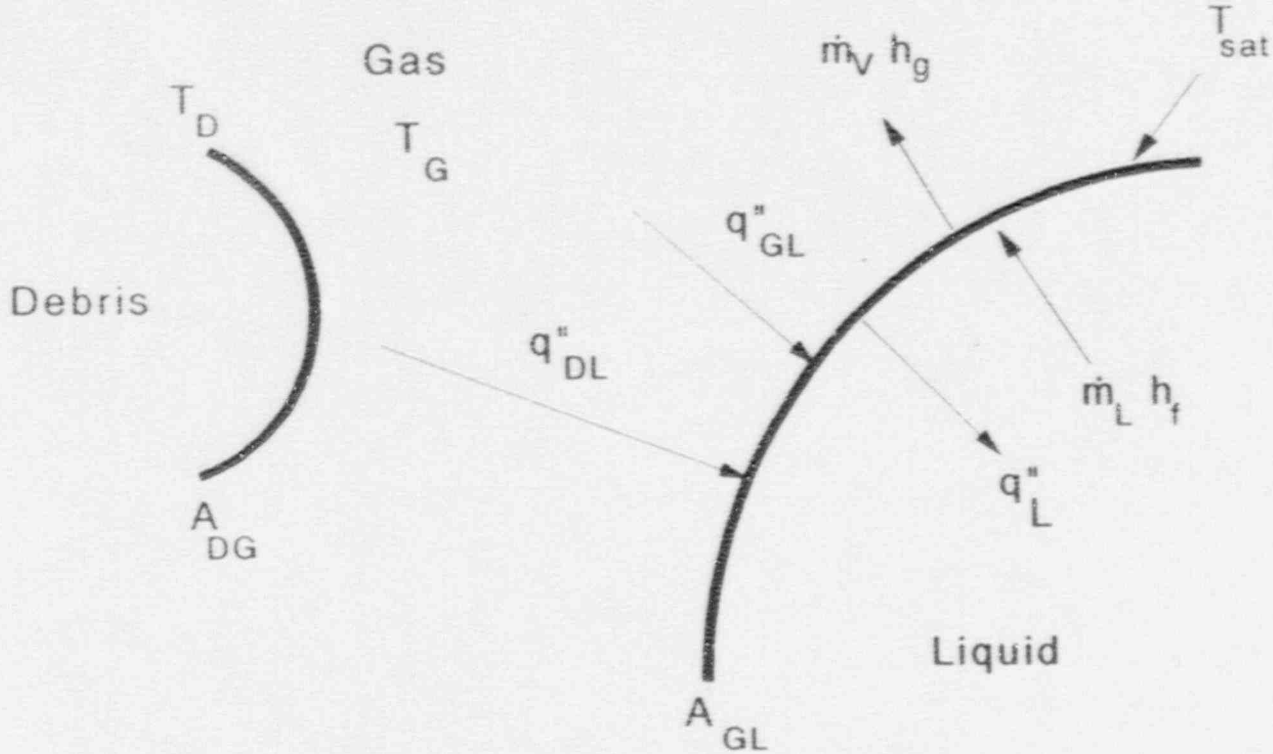
MASS CONSERVATION EQUATIONS:

- STEAM
- WATER LIQUID
- HYDROGEN
- DEBRIS

ENERGY CONSERVATION EQUATIONS

- GAS (STEAM-HYDROGEN) MIXTURE
- WATER LIQUID
- DEBRIS

MASS AND ENERGY BALANCES AT PHASE INTERFACES



$$\dot{m}_V = \dot{m}_L$$

$$\dot{m}_V h_g - q''_{GL} = \dot{m}_L h_f - q''_L + q''_{DL}$$

Mass and energy balance at the vapor-liquid interface.

gew-7A

Pressure Rate-of-Change Equation (1 of 2):

‖1‖ ‖2‖

$$\frac{V_g}{\gamma_m - 1}\frac{dP}{dt} = \left[W_{wg}H_{wg} + W_h H_h\right]_i - \left[W_{wg}H_{wg} + W_h H_h\right]_e$$

‖3‖ ‖4‖

$$-h_{gs}\left[T_g - T_s\right]A_{gs} + h_{dg}\left[T_d - T_g\right]A_{dg}$$

‖5‖

$$+\left[\dot{m}_h'' H_h - \dot{m}_{wg}'' H_{wg}\right]A_{zr}$$

‖6‖

$$+\left[\dot{m}_v'' H_v - h_{gl}\left(T_g - T_v\right)\right]A_{gl}$$

‖7‖

$$+\frac{P}{\gamma_m - 1}\left[\frac{1}{\rho_{wl}}\frac{dM_{wl}}{dt} + \frac{1}{\rho_d}\frac{dM_d}{dt}\right]$$

‖8‖

$$+PV_g\frac{C_{v,wg}C_{v,h}\left(\gamma_h - \gamma_{wg}\right)}{R_m^2}\frac{dC}{dt}$$

Pressure Rate-of-Change Equation (2 of 2):

$$\gamma_m = \frac{C_{p,m}}{C_{v,m}} = \frac{(1-C)C_{p,wg} + CC_{p,h}}{(1-C)C_{v,wg} + CC_{v,h}} \qquad 2$$

$$R_m = (1-C)R_{wg} + CR_h = C_{p,m} - C_{v,m} \qquad 3$$

$$V_g = \alpha_g V_{cv} = \left(\alpha_w \alpha_{wg} + \alpha_h\right)V_{cv} \qquad 4$$

Processes Modeled in the Pressure Rate of Change (PRC) Equation

Term No.	:	Models the Effects of:
1	:	Rate of steam/hydrogen enthalpy inflow
2	:	Rate of steam/hydrogen enthalpy outflow
3	:	Heat transfer rate - gas to structures
4	:	Heat transfer rate - debris to gas
5	:	Enthalpy flows due to zirconium oxidation
6	:	Enthalpy and heat transfer rates due to water evaporation
7	:	Rate of work to change the amounts of water liquid and of debris
8	:	Rate of change of hydrogen mass concentration in the mixture

PRC EQUATION (CONT'D)

- THE PRESSURE RATE OF CHANGE (PRC) EQUATION WAS EXPRESSED IN NON-DIMENSIONAL FORM BY USING INITIAL CONDITIONS AND THE INITIAL GAS ENTHALPY FLOW FROM VESSEL.

- THE RESULTING Π (TIME-RATIO) GROUPS WERE THEN USED TO ASSESS THE IMPORTANCE OF THE PROCESSES MODELED IN THE PRC EQUATION.

- SOME OF THESE Π GROUPS ARE SHOWN IN THE FOLLOWING FIGURES.

Effect of Heat Transfer - Gas to Structures:

$$\Pi_{gs} = \frac{h_{gs}\left[T_{go} - T_{so}\right]}{W_{go}H_{go}} A_s \qquad 1$$

$$= \omega_{gs}\tau_o \qquad 2$$

where

$$\omega_{gs} = \frac{h_{gs}\left[T_{go} - T_{so}\right]}{\rho_{go}H_{go}} \frac{1}{L_s} \qquad 3$$

and

$$\tau_o = \frac{V_{cv}}{Q_{go}} \qquad 4$$

$$\frac{A_s}{V_{cv}} = \frac{1}{L_s} \qquad 5$$

Effect of Water Liquid:

Assuming: $q_{gl} > q_l; \qquad q_{dl} \cong 0$

Then

$$\Pi_{w-1} = \frac{6h_{gl}}{d_{wdo}}\left[\frac{T_{go} - T_{vo}}{W_{go}H_{go}}\right]\frac{H_f}{H_{fg}}\left[\alpha_w \alpha_{wl} \alpha_{wld}\right]_o V_{cv} \qquad 1$$

If heat transafer is dominated by convection, then

$$\Pi_{w-1} = K_g \frac{6}{d_{wdo}^2} Nu\left[\frac{T_{go} - T_{vo}}{W_{go}H_{go}}\right]\frac{H_f}{H_{fg}}\left[\alpha_w \alpha_{wl} \alpha_{wld}\right]_o V_{cv} \qquad 2$$

$$= \omega_w \tau_o = \omega_w \frac{V_{co}}{Q_{go}} \qquad 3$$

Where

$$\omega_w = a_{go} \frac{6}{d_{wdo}^2} Nu\left[\frac{T_{go} - T_{vo}}{T_{go}}\right]\frac{H_f}{H_{fg}}\left[\alpha_w \alpha_{wl} \alpha_{wld}\right]_o \qquad 4$$

$$\Pi_{w-2} = \frac{P_\infty}{\gamma_o - 1}\frac{1}{\rho_{wl} H_{fg}}\Pi_{w-1} \qquad 5$$

Effect of Zircalloy Oxidation:

Assuming

a) $\dot{m}'''_{zro_2}\Delta H V_d = \dot{m}''_{zro_2}\Delta H A_{dg}$

b) parabolic rate equation

Then

$$\Pi_{ch} = 12\frac{D}{d_{mdo}^2}e^{-\frac{E}{RT_{do}}}\frac{\rho_d \Delta H}{W_{go}H_{go}}[\alpha_d \alpha_{dm} \alpha_{dmd} \alpha_{zr}]_o V_{cv} \quad 1$$

$$= \omega_{ch}\tau_o \quad 2$$

where

$$\omega_{ch} = 12\frac{D}{d_{mdo}^2}e^{-\frac{E}{RT_{do}}}\frac{\rho_d \Delta H}{\rho_{go}H_{go}}[\alpha_d \alpha_{dm} \alpha_{dmd} \alpha_{zr}]_o \quad 3$$

$$\tau_o = \frac{V_{cv}}{Q_{go}} \quad 4$$

Effect of Heat Transfer - Debris to Gas:

$$\Pi_{dg} = \frac{h_{dg}\left[T_{do} - T_{go}\right]}{W_{go}H_{go}} \frac{6}{d_{mdo}} \left[\alpha_d \alpha_{dm} \alpha_{dmd}\right]_o V_{cv} \qquad 1$$

Assuming heat transfer is dominated by convection, then

$$\Pi_{dg} = 6 \frac{K_g}{d_{mdo}^2} Nu \frac{\left[T_{do} - T_{go}\right]}{W_{go}H_{go}} \left[\alpha_d \alpha_{dm} \alpha_{dmd}\right]_o V_{cv} \qquad 2$$

$$= \omega_{dg} \tau_o$$

where

$$\omega_{dg} = 6 \frac{a_{go}}{d_{wdo}^2} Nu \frac{\left[T_{do} - T_{go}\right]}{T_{go}} \left[\alpha_d \alpha_{dml} \alpha_{dmd}\right]_o \qquad 3$$

Relative Temperature - Oxidation vs Heat Transfer:

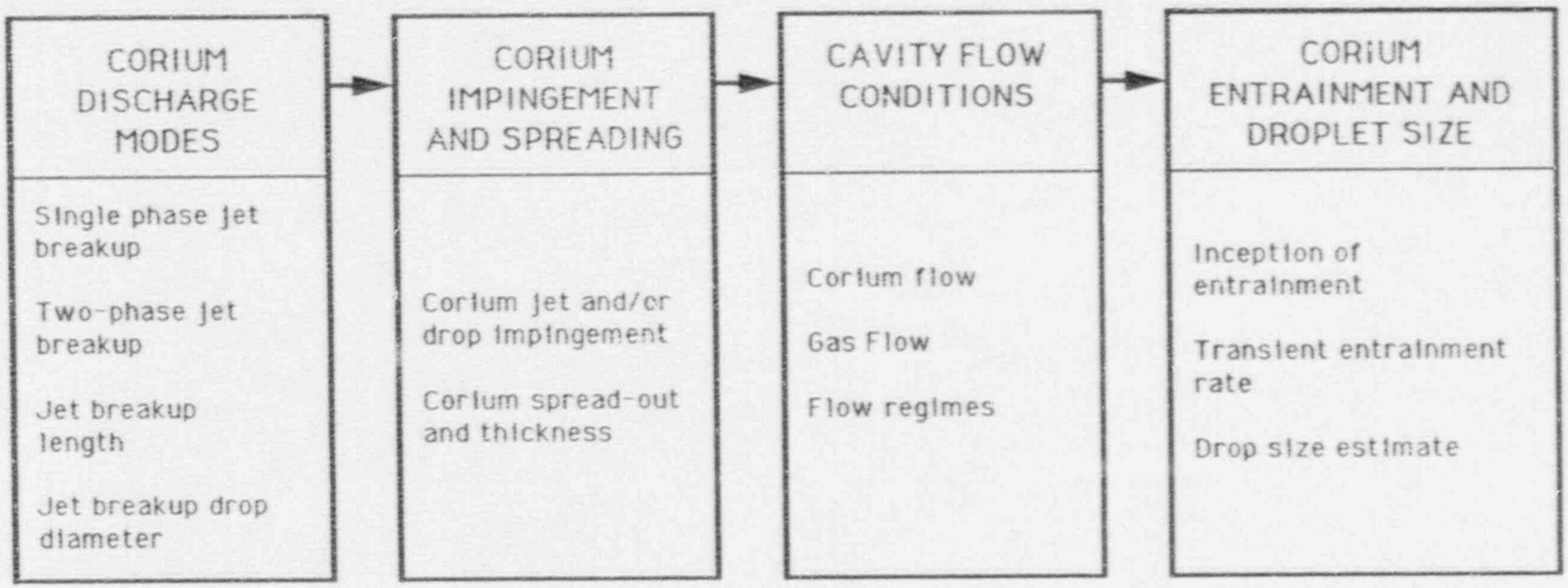
$$\frac{\Pi_{ch}}{\Pi_{dg}} = 2De^{-\frac{E}{RT_{do}}}\frac{1}{Nu}\frac{\rho_d \Delta H \alpha_{zr}}{K_g\left[T_{do} - T_{go}\right]} \quad 1$$

$$= 2\frac{D}{a_{go}}e^{-\frac{E}{RT_d}}\frac{1}{Nu}\frac{\rho_d \Delta H \alpha_{zr}}{c_{p,go}\rho_{go}\left[T_{do} - T_{go}\right]} \quad 2$$

BOTTOM-UP/PROCESS SCALING

OF

REACTOR CAVITY PHENOMENA



FLOW DIAGRAM AND TOPICS ADDRESSED IN BOTTOM-UP/PROCESS SCALING OF REACTOR CAVITY PHENOMENA

APPENDIX

SCALING STUDY OF CORIUM DISPERSION IN DCH

Prepared by

Mamoru Ishii*
Purdue University

August 31, 1990

* This work was performed under the Consultant Agreement with Brookhaven National Laboratory (Contract No. 3825) in support of the Nuclear Regulatory Commission.

3-31

Table 1. Sample calculations for various parameters in corium dispersion

Case Studied	Jet Disintegration: v_{fj} (m/s)	1ϕ L_B (m)	2ϕ L_B (m)	d (mm)	d_{max} (mm)	d_{st} (mm)	$\frac{\mu_f v_{fj}}{\sigma}$	We_{tr}	Impingement: We_{im} $\times 10^4$	Film Spreading: δ_i (cm)	δ_{min} (cm)	δ_{max} (cm)	δ_{cavi} (cm)	v_f (m/s)	Re_f $\times 10^5$
Corium-Steam Full Scale 1000 psi	39.0	7.9	2.00	4.10	12.8	1.45	0.24	192.	2.09	5.0	0.4	41.4	9.0	3.20	9.60
Corium-Steam 1/10 Scale 1000 psi	39.0	2.5	0.85	1.30	4.10	1.45	0.24	19.2	1.87	0.5	0.04	4.14	0.9	3.20	0.96
Water-Air Full Scale 1000 psi, 20C	116.5	1.2	0.41	0.07	0.23	1.68	1.28	4.36 $\times 10^4$	1.36	5.0	0.4	41.4	9.0	9.20	23.0
Water-Air 1/10 Scale 200 psi, 20C	50.0	0.6	0.20	0.08	0.26	1.6[illegible]	0.[illegible]	[illegible].04	0.28	0.5	0.04	4.14	0.9	4.00	1.00
Woods metal-Air 1/10 Scale 200 psi, 75C	17.9	1.6	0.56	1.92	6.01	1.11	0.09	17.2	1.13	0.5	0.04	4.14	0.9	1.44	1.00

Table 1. (continued)

Case Studied	Entrainment									
	v_g (m/s)	v_r (m/s)	ϵ (g/cm^2s)	t (s)	d (mm)	d_{max} (mm)	Weber d_{mean} (mm)	Crit. d_{min} (mm)	Re_g $\times 10^6$	We $\times 10^6$
Corium-Steam Full Scale 1000 psi	136.0	88.0	3.07	14.7	6.6C	20.6	1.10	0.190	10.2	0.684
Corium-Steam 1/10 Scale 1000 psi	136.0	88.0	0.433	10.4	2.09	6.53	1.10	0.190	0.10	0.068
Water-Air Full Scale 1000 psi, 20C	90.75	16.97	6.33	0.79	0.86	2.70	0.10	0.016	13.3	3.140
Water-Air 1/10 Scale 200 psi, 20C	18.15	16.90	0.026	19.0	2.60	8.16	3.70	1.620	0.27	0.013
	36.30	16.90	0.095	5.20	1.03	3.23	0.71	0.118	0.53	0.054
	54.45	16.90	0.201	2.49	0.60	1.80	0.29	0.049	0.80	0.113
	90.75	16.90	0.516	0.97	0.30	0.95	0.10	0.017	1.33	0.315
	127.1	16.90	0.962	0.52	0.19	0.61	0.05	0.008	1.87	0.617
Woods metal-Air 1/10 Scale 200 psi, 75C	19.67	52.50	0.019	--	No entrainment				0.29	0.005
	39.34	52.50	0.069	--	No entrainment				0.58	0.019
	59.01	52.50	0.146	27.4	3.23	10.1	1.36	0.227	0.87	0.044
	98.35	52.50	0.377	10.6	1.64	5.12	0.48	0.080	1.45	0.122
	137.7	52.50	0.702	5.70	1.05	3.27	0.24	0.041	2.03	0.239

APPENDIX

DEBRIS DISPERSAL FROM REACTOR CAVITY DURING LOW TEMPERATURE SIMULANT TESTS OF DIRECT CONTAINMENT HEATING*

Prepared by

*Salomon Levy***

S. Levy Incorporated

August 31, 1990

* This work was sponsored by Brookhaven National Laboratory under Purchase Order No. 402034 in support of the Nuclear Regulatory Commission Severe Accident Scaling Methodology (SASM).

** The author would like to recognize the extensive help received from Dr. J. Healzer who performed all the test data reduction and their plotting.

TABLE OF CONTENTS

3-35

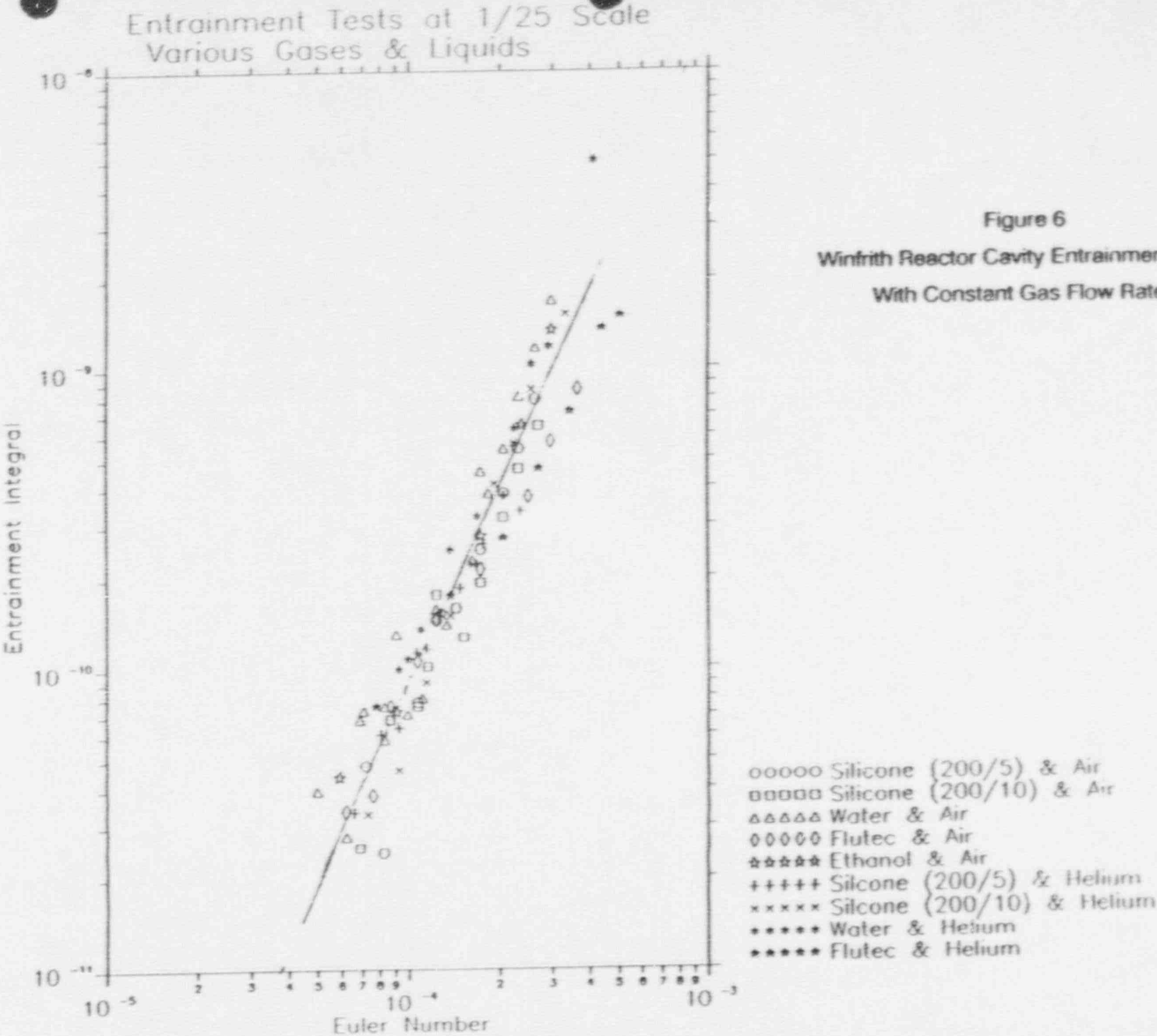
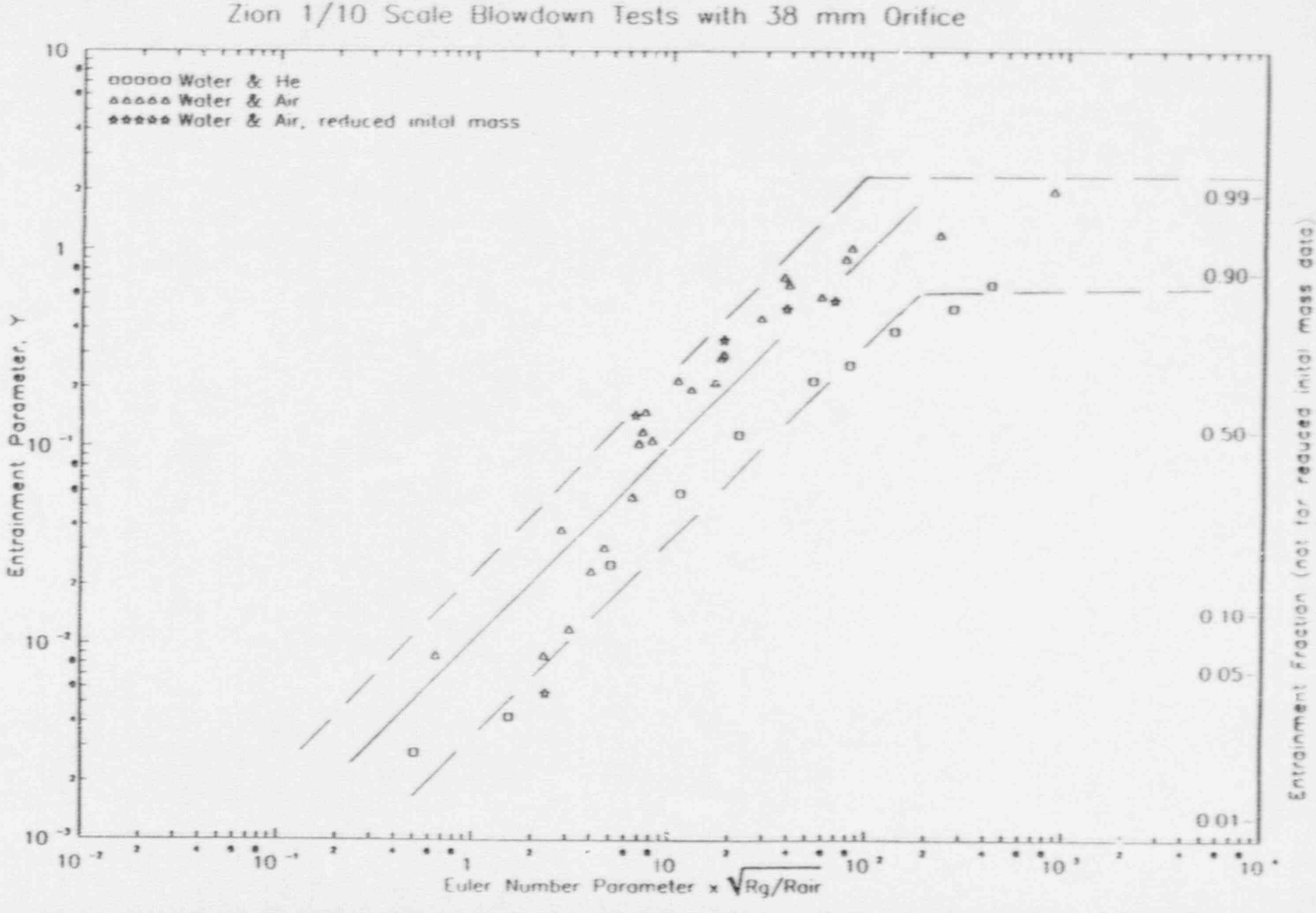


Figure 6

Winfrith Reactor Cavity Entrainment Tests

With Constant Gas Flow Rates

Figure 15



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3-37

4. CONTENT OF THE REPORT

CONTENTS

VOLUME 1
AN INTEGRATED STRUCTURE AND SCALING METHODOLOGY FOR SEVERE ACCIDENT TECHNICAL ISSUE RESOLUTION

VOLUME 1
AN INTEGRATED STRUCTURE AND SCALING METHODOLOGY FOR SEVERE ACCIDENT TECHNICAL ISSUE RESOLUTION
[Continued]

VOLUME 2
AN INTEGRATED STRUCTURE AND SCALING METHODOLOGY FOR SEVERE ACCIDENT TECHNICAL ISSUE RESOLUTION

5. CONCLUSIONS

CONCLUSIONS

IN THIS PRESENTATION WE HAVE OUTLINED RATHER BRIEFLY, THE RESULTS OF THE WORK PERFORMED TO DATE, BY THE TPG ON DEVELOPING A SEVERE ACCIDENT SCALING METHODOLOGY. IN PARTICULAR:

1) WE OUTLINED THE ISTIR METHODOLOGY FOR INTEGRATING EXPERIMENTS, ANALYSIS, AND UNCERTAINTY QUANTIFICATION TO ENSURE THEREBY, A COST-EFFECTIVE AND TIMELY RESOLUTION OF A TECHNICAL ISSUE.

   THE ISTIR METHODOLOGY IS SYSTEMATIC, COMPREHENSIVE, AUDITABLE, AND PRACTICAL AS NEEDED BY A REGULATORY AGENCY.

2) WE DISCUSSED SASM DEVELOPED BY THE TPG TO ENSURE THAT EXPERIMENTAL DATA, SPECIAL MODELS, AND/OR COMPUTER CODES USED TO RESOLVE A TECHNICAL ISSUE, HAVE THE CAPABILITY TO SCALE-UP PROCESSES TO CONDITIONS RELEVANT TO NUCLEAR POWER PLANT OPERATION.

CONCLUSIONS (CONT'D)

3) WE DISCUSSED A HIERARCHICAL APPROACH, THAT IS, A TWO-TIER SCALING METHODOLOGY TO PROVIDE FOR SUFFICIENCY AND EFFICIENCY. ONE APPROACH IS BASED ON TOP-DOWN (SYSTEM) SCALING THE OTHER ON THE BOTTOM-UP (PROCESS) SCALING.

4) WE REVIEWED THE RESULTS OBTAINED BY APPLYING **ISTIR** AND **SASM** TO THE **DCH** PROPLEM.

5) THE CHARACTERISTIC TIME RATIOS:

$$\Pi_P = \omega_P \tau_{CV}$$

INCORPORATE THE CHARACTERISTIC TEMPORAL AND SPATIAL SCALES OF THE SYSTEM (CONTROL VOLUME / AND OF A PARTICULAR RATE PROCESS.

CONSEQUENTLY, THEY COMBINE THE SYSTEM AND PROCESS VIEW POINTS.

CONCLUSIONS (CONT'D)

6. THE CHARACTERISTIC TIME RATIOS TAKE DIRECTLY INTO ACCOUNT THE EFFECTS OF:
   - A) INITIAL CONDITIONS
   - B) BOUNDARY CONDITIONS
   - C) PRESENCE OF OTHER CONSTITUENTS AND/OR PHASES.

7. THE SAME YARDSTICK IS USED TO EVALUATE (MEASURE) THE IMPORTANCE OF VARIOUS RATE PROCESSES.

YARDSTICK:

SYSTEM RESPONSE: τ_{CV}

AND INITIAL CONDITIONS

CONCLUSIONS (CONT'D)

8. THE CHARACTERISTIC TIME RATIOS PROVIDE A HIERARCHICAL STRUCTURE FOR:
   - A) RANKING VARIOUS PROCESSES, AND
   - B) PRIORITY DISCRIMINATION

9) THE DIMENSIONLESS GROUPS PROVIDE A TECHNICALLY JUSTIFIABLE RATIONALE FOR:
   - A) ESTABLISHING THE ORDER IN WHICH THE SIMILARITY BETWEEN PHENOMENA IN TEST FACILITY AND NPP SHOULD BE PRESERVED,
   - B) SPECIFYING FACILITY DESIGN AND TEST CONDITIONS (INITIAL AND BOUNDARY), AND
   - C) IDENTIFYING WHICH PHENOMENA AND/OR PROCESSES NEED TO BE EXAMINED IN MORE DETAIL (AT A LOWER HIERARCHICAL LEVEL) AND IN WHAT ORDER.

CONCLUSIONS (CONT'D)

10) THE CHARACTERISTIC TIME RATIOS PROVIDE A PHYSICALLY BASED FRAMEWORK FOR SENSITIVITY CALCULATIONS AND UNCERTAINTY QUANTIFICATION.

11) THE PROPOSED SCALING METHODOLOGY IS
- SYSTEMATIC
- COMPREHENSIVE
- AUDITABLE
- TRACEABLE
- WITHOUT ARM WAVING

(7)

USE OF SASM IN THE SEVERE ACCIDENT RESEARCH PROGRAM AND THE ROLE OF SASM IN SEVERE ACCIDENT ISSUE RESOLUTION

BRIAN W. SHERON, DIRECTOR
Division of Systems Research
Office of Nuclear Regulatory Research

Presented to the Advisory Committee on
Reactor Safeguards

December 7, 1990

- IN LATTER PART OF 1988, RES OFFICE DIRECTOR AND DSR DIVISION DIRECTOR WERE CONCERNED THAT SOUND SCALING RATIONALE DID NOT EXIST FOR ONGOING SEVERE ACCIDENT EXPERIMENTS

- DIVISION DIRECTOR ASKED N. ZUBER TO LOOK INTO PROBLEM AND DETERMINE IF A GENERAL SCALING METHODOLOGY FOR SEVERE ACCIDENT EXPERIMENTS COULD BE DEVELOPED, AND IF SO, TO DEVELOP SUCH A METHODOLOGY

- OBJECT WAS TO MAKE METHODOLOGY AVAILABLE TO SEVERE ACCIDENT EXPERIMENTERS FOR GUIDANCE IN DEVELOPING SCALING RATIONALE FOR SPECIFIC EXPERIMENTS

- ZUBER FORMED HIS SEVERE ACCIDENT SCALING METHODOLOGY (SASM) TECHNICAL PROGRAM GROUP (TPG) CONSISTING OF 17 EXPERTS FROM VARIOUS FIELDS RELATED TO SCALING AND SEVERE ACCIDENTS

- EXPERIMENTS THAT PROMPTED DIVISION DIRECTOR'S CONCERN WERE SURTSEY DCH EXPERIMENTS AT SNL. ZUBER TOLD HE COULD USE DCH AS AN EXAMPLE TO DEMONSTRATE METHODOLOGY

- CHARTER OF GROUP WAS TO DEVELOP METHODOLOGY WITH EXAMPLE APPLICATION; EACH EXPERIMENTER WAS STILL RESPONSIBLE FOR DEVELOPING SCALING BASIS FOR SPECIFIC EXPERIMENTS, AND AEB STAFF WAS STILL RESPONSIBLE FOR REVIEW AND APPROVAL OF TESTS AND TESTING BASIS

- SNL IS RESPONSIBLE FOR ALL FACETS OF SURTSEY TESTING, INCLUDING BASIS AND SCALING RATIONALE FOR TESTS, CONDUCT OF TESTS AND ASSOCIATED ES&H

- ALTHOUGH SASM TPG DEVELOPED EXAMPLE SCALING GROUPS FOR DCH, SNL CHOSE TO DEVELOP ITS OWN SCALING GROUPS TO SUPPORT PROPOSED SURTSEY TESTS

- HOWEVER, SNL PARTICIPATED EXTENSIVELY IN TPG, AND WAS INSTRUCTED TO UTILIZE TPG-DEVELOPED METHODOLOGY AS IT EVOLVED IN DERIVING SCALING FACTORS FOR SURTSEY.

- PLAN IS FOR STAFF TO REVIEW SNL SCALING REPORT, WITH INPUT FROM SELECTED OUTSIDE EXPERTS. STAFF APPROVAL WILL AUTHORIZE SNL TO COMMENCE DCH TESTING

- EXPECT TO COMMENCE TESTING IN MARCH, 1991

- SASM METHODOLOGY REPORT NOT YET COMPLETED. TPG WILL BE DISSOLVED WHEN METHODOLOGY REPORT COMPLETED. EXPECT COMPLETION BY END OF YEAR.

- ADEQUACY OF SCALING WILL BE REVIEWED AFTER FIRST TEST, AND ADJUSTMENTS IN TESTING MATRIX AND CONDITIONS WILL BE MADE AS APPROPRIATE.

- SEPARATE EFFECTS TESTS WILL ALSO BE RUN THAT WILL CONTRIBUTE TO OVERALL SCALING EVALUATION.

- USE OF SASM IN RESOLUTION OF DCH AS A SEVERE ACCIDENT ISSUE

  - DCH ISSUE IS COMPLEX AND MULTIFACETED. EXPERIMENTS ON HIGH PRESSURE MELT EJECTION ARE ONE FACET OF THE ISSUE

  - OVERALL ISSUE IS "WHAT IS THE RISK ASSOCIATED WITH THE DIRECT CONTAINMENT HEATING PHENOMENA, AND WHAT, IF ANY, PLANT MODIFICATIONS SHOULD BE MADE TO REDUCE THIS RISK?"

  - SASM ONLY PROVIDES THE BASIS FOR ASSURING THAT EXPERIMENTAL DATA IS MEANINGFUL(E.G., PROPER SCALE, APPROPRIATE INITIAL AND BOUNDARY CONDITIONS) AND CAN BE CONFIDENTLY APPLIED TO VALIDATE CODES FOR USE IN CALCULATING LARGE PLANT PERFORMANCE

- CURRENTLY, THE ONLY "FIX" FOR DCH IS INTENTIONAL DEPRESSURIZATION

- ALSO, CURRENTLY, NO OPERATING PWRS CALL FOR OPERATORS TO INTENTIONALLY DEPRESSURIZE THE PRIMARY SYSTEM WHEN NO AC POWER IS AVAILABLE

- THE QUESTION WE ARE TRYING TO ANSWER IS, "IS INTENTIONAL DEPRESSURIZATION A COST-BENEFICIAL AND PRACTICAL FIX FOR DCH (I.E., SHOULD WE REQUIRE INTENTIONAL DEPRESSURIZATION)?"

- CURRENTLY, STAFF APPROACH IS AS FOLLOWS:

  (1) ESTABLISH LIKELIHOOD OF ACCIDENTS THAT PROCEED TO CORE MELT AT HIGH PRESSURE (NUREG-1150 GIVES US GOOD INSIGHTS INTO THIS LIKELIHOOD)

  (2) ESTABLISH LIKELIHOOD THAT SYSTEM WILL BE DEPRESSURIZED PRIOR TO LOWER VESSEL HEAD FAILURE AT HIGH PRESSURE (I. E., WHAT IS THE LIKELIHOOD THE PRIMARY SYSTEM WILL DEPRESSURIZE DUE TO STUCK OPEN S/RV, PUMP SEAL FAILURE, INTENTIONAL OPERATOR ACTION, OR CREEP RUPTURE FAILURE OF PRIMARY PIPING)

  (3) ESTABLISH LIKELIHOOD THAT HIGH PRESSURE MELT EJECTION WILL LEAD TO CONTAINMENT PRESSURES IN EXCESS OF ULTIMATE PRESSURE CAPABILITY

(4) SHOW REDUCTION IN CONTAINMENT FAILURE PROBABILITY IF INTENTIONAL DEPRESSURIZATION IS REQUIRED AND ESTABLISH COST/BENEFIT

(5) DETERMINE GENERIC APPLICABILITY OF ANALYSES

ITEM (3) WILL BE DETERMINED THROUGH USE OF CODE ANALYSES, USING CODES VALIDATED AGAINST APPLICABLE EXPERIMENTS. SASM IS APPLIED TO ENSURE EXPERIMENTS ARE APPLICABLE.