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UNITED STATES
NUCLEAR REGULATORY COMMISSION

In the matter of:

THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS, AD HOC SUBCOMMITTEE MEETING ON NATURAL CIRCULATION HEAT REMOVAL

Place: Washington, D. C.

Date: March 26, 1980

Pages: 1 - 269

INTERNATIONAL VERBATIM REPORTERS, INC.
499 SOUTH CAPITOL STREET, S. W. SUITE 107
WASHINGTON, D. C. 20002
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8004210311

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NUCLEAR REGULATORY COMMISSION

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1717 H Street, N. W.
Washington, D. C.

Wednesday, March 26, 1980

The Advisory Committee on Reactor Safeguards, Ad Hoc Subcommittee Meeting on Natural Circulation Heat Removal, met, pursuant to notice, at 8:40 a.m., Mr. Max Carbon, Chairman of the Subcommittee presiding.

PRESENT:	Dr. Shrock
ACRS MEMBERS:	Dr. Zudans
Mr. Etherington	Dr. Catton
Dr. Plesset	Dr. Theofanous
Mr. Carbon	Dr. Lienhard
Mr. Bender	
Mr. Ebersole	
Mr. Bates	
SUBCOMMITTEE MEMBERS:	
Mr. Sullivan	Mr. Sheron
Mr. Zoltan	Mr. Baer
Mr. Graves	
Mr. Hodges	

P R O C E E D I N G S

8:40 a.m.

CHAIRMAN CARBON: The meeting will now come to order. This is a meeting of the Advisory Committee on reactor safe guard subcommittee on natural circulation and feed and bleed heat removal.

My name is Carbon. I'm the subcommitte chairman. The other ACRS members present are Dr. Plesset, Mr. Etherington, Mr. Ebersole. Mr. Bender will be joining us later in the day. We have Dr. Catton, Schrock, Theofanous, Zudans, and Lienhard with us today as consultants.

The purpose of this meeting is to review the present state of knowledge with regard to natural circulation and feed and bleed removal methods and plans to obtain additional information in the future.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and the Government Sunshine Act. Mr. Andrew Bates is the designated Federal employee for the meeting.

The rules for participation in today's meeting have been announced as a part of the notice of this meeting and previously published in the Federal Register on March 10, 1980. A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice.

As usual, it is requested that each speaker first himself and speak loudly and so on.

We received no written comments or requests for time to make oral statements from members of the public. We will proceed with the meeting, and I will call upon Mr. Wayne Hodges.

MR. HODGES: I am Wayne Hodges with the NRC staff. I am currently with the analysis branch and soon to be with the reactor systems branch.

I will start out this morning talking a little bit about what the NRC requirements are for natural circulation and then follow roughly the outline that had been given in the agenda. There may be some slight deviation.

The criteria that the NRC presently has for natural circulation are specified in Reg Guide 1.68, revision 2, which was August 1978. The same words appear also in Reg 1, which was issued in 1977. So, these words apply to any plant whose OL application was docketed in 1977 or later.

Basically, what these words say is that all the plants that get an operating license application have to perform a natural circulation test. They either have to do it themselves or justify referencing the prototype plant, which essentially says they have to run a test. So, new plants have to run natural circulation tests in water solid conditions except for the pressurizer.

Before 1977 they could reference a prototype plant, and so we have natural circulation tests on only a few plants. We also have --

CHAIRMAN CARBON: Excuse me.

MR. HODGES: Yes, sir.

CHAIRMAN CARBON: I have been told by reactor operating people -- plant operating people that you really can't depend on the results of a test at one plant being applicable at another even though it is the same design. Could you commen on that?

MR. HODGES: There will be differences, maybe, in the fuel if they've got an improved fuel design or something like that in the cases I have referenced, older tests.

For this particular type of test, though, which again, it's water solid. There's no boiling. It's a very simple case.

Unless there's a drastic difference in the systems I don't see any problem -- a big difference. The biggest problems come about, really, in measurement. The measurement uncertainties are larger probably than the differences you will see from plant to plant, with minor changes.

If it's two B&W plants with a lower loop steam generator, we may have, say, small differences in fuel design or some small differences on the secondardy side. You are probably going to see more differences in the measurement uncertainties.

DR. PLESSET: If you change from 15 by 15 fuel to 17 by 17, is there any noticeable difference?

MR. HODGES: Well, you could get some differences in the resistance in the core. And so --

DR. PLESSET: Would they run another test if they made that change in fuel?

MR. HODGES: Well, now they will. In -- in the past --

DR. PLESSET: Well, if you --

MR. HODGES: -- not necessarily.

DR. PLESSET: Okay.

DR. ZUDANS: It would probably result in establishing different steady state temperature.

MR. HODGES: A slightly different steady state temperature. But again, we're saying that probably the differences are going to be lost in the scatter of what you could measure because it is not easy to measure what your natural circulation flow is. And we will get into that in a little bit of detail.

DR. SCHROCK: Does the Reg Guide include standards on the measurement accuracy?

MR. HODGES: No. No, sir.

DR. SCHROCK: Okay.

MR. HODGES: We also have reactor safety -- or reactor systems branch technical position 5-1 and Reg Guide 1.139, which say that they have to demonstate the adequacy of mixing of borated water added to the -- reach cold shutdown concentrations, and also have to demonstrate the ability to cool the reactor coolant system within a reasonable time.

DR. CATTON: I understand that they have certain conditions that they can go over into natural circulation. Like a certain delta T has to exist between the steam generator and the core. When do they establish that? Or is that to be just calculated on?

MR. GRAVES: It is established to a certain -- you mean in the test?

DR. CATTON: I'm asking when do they establish it?

MR. GRAVES: When do they measure it? By established you --

DR. CATTON: Is it based on measurement?

MR. GRAVES: You have measurements of delta T plus the core.

DR. CATTON: During natural circulation?

MR. GRAVES: Yes.

DR. CATTON: And then those are built into the reg specs?

MR. GRAVES: Well, this goes --

CHAIRMAN CARBON: Wayne is probably going to cover this later in terms of the -- it's a matter of a heat balance as we -- power.

MR. HODGES: No, no. I think he's asking a different question, Chuck.

DR. CATTON: The operators are --

MR. HODGES: He said in his criteria. You're talking about the criteria to go to natural circulation.

DR. CATTON: Whether or not they can go into that --

MR. HODGES: Well, if you, for example, have an event where you lose off-site power, the system doesn't know that you've got criteria. It's going to go there. The operator has certain criteria that he has to try to establish to maintain these temperature differences within certain range. So, he will try to control levels of the steam generators and this sort of thing.

The natural circulation is going to occur.

DR. CATTON: I understand. Where does he get those temperatures he tries to maintain? Does that come his initial experiments? Does the temperature --

MR. HODGES: No, no, it's -- it's a very rough guidance. His temperatures are less than his operating temperatures.. He's operating delta T. And he's told, for example, his cold leg temperature should be steady or decreasing.

DR. CATTON: Okay.

MR. HODGES: All right. So, it's not pay you've got to have 27 degrees. It's that it's got to be less than your full power or your delta T at the time you are operating.

DR. CATTON: Okay.

MR. HODGES: A number of these slides you will have seen before in various forms probably.

Traditionally when we've discussed natural circulation and what -- what we've referred to in these requirements that are in the Reg Guides is for natural circulation in PWR's with a water solid system except in a pressurizer, and to try to calculate this involves a simple balance between the elevation head and the friction and the acceleration losses. So, it is not a sophisticated calculation. It's strictly a trade-off between the density differences and the friction losses. This is just shown schematically here, so --

CHAIRMAN CARBON: Mr. Ebersole.

MR. HODGES: Yes, sir.

MR. EBERSOLE: Is this information all based on the thesis that you retain and pressurize the heaters?

I know you lost the points. But many designs don't have duracarbon heaters or get hot earlier.

MR. HODGES: In the first half-hour to an hour it makes very little difference because you have just little heat loss from there. If you --

MR. EBERSOLE: I understand. It's just the long-term I'm talking about.

MR. HODGES: In the long term, if you lose that you start depressurizing. But these calculations are assuming that you are at pressure.

MR. EBERSOLE: Under the pump head.

MR. HODGES: Yes.

No, no.

MR. EBERSOLE: Under the -- under the upper pump head; right?

You are at pressure because you are sustaining pressure with the pumps, upper injection pumps? If you've lost the heaters?

DR. PLESSET: No.

MR. HODGES: No, no.

MR. EBERSOLE: No.

MR. HODGES: No.

DR. PLESSET: He has no pumps.

MR. HODGES: You don't actually have any pumps on.

MR. EBERSOLE: No pumps.

DR. PLESSET: No pumps.

MR. HODGES: Yeah, your heat loss from the system is sufficiently small that you will have only a small pressure decay anyhow. So, without that you would remain at almost at a steady state. Just a very gradual decrease. Okay.

MR. EBERSOLE: Very well. Thank you. Fine.

MR. HODGES: Some of these slides we'll hit rather quickly. Just illustrating the nomenclature that's used in the calculations refering to the hot leg density to cold leg density and an equivalent length for the driving head.

As I've said a little bit earlier, the natural circulation in the plant is relatively difficult to measure. There are several techniques that are used during the testing. I have shown here a curve from -- an opponent test where they use what they call the induced transient temperature circulating time approach.

What they do in this case is they open a steam dump valve on the secondary side so that they cool the cold leg temperature about 10 degrees. And then they wait and see how long it takes for this temperature front to pass to the hot leg temperature thermocouples, or RTD's.

They know how much water volume they've got between those two locations of the cold leg RTD and the hot leg RTD. And so they can back out a flow rate just based on a transient time. That's one approach.

And then there are two approachs that basically use a heat balance where they will calculate a decay heat and apply that to a delta T to get the flow, or they will try to get the heat output from the heat balance on the steam generators and use the core delta T to calculate the flow.

So, there are basically three different ways of doing the measurement of the natural circulation. In this approach here you've got the problem that introducing the temperature transient increases your natural circulation. So, the measurement techniques effects the results.

They can adjust this a little bit by doing tests at 0-power isothermal tests where they will do the same sort of thing and see what the effect is and try to factor that in. But the measurement technique does effect the measurement itself.

If you are trying to use the heat flux with a delta T to back out the flow, you've got rather large uncertainties if you're trying to calculate it, say, from an ANS curve, or if you're trying to measure it on the secondary side at those low power levels.

So, either way you do it there are large uncertainties.

DR. THEOFANOUS: What do you mean large or -- well, what is large and what is small? And what is adequate?

MR. HODGES: Okay. I'll show you some curves and show you how the tests compare with data and the differences result from both measurement uncertainties and the fact that the vendors in doing their calculations don't know the resistances in the loop very well, so they assume conservative values of the loops. So, there are several things that go in. But you can look at -- scatter some of the data points.

DR. CATTON : But the spread that was removed would be a good indication --

MR. HODGES: The spread of the what?

DR. CATTON: The spread that you get in calculating it three different ways.

MR. HODGES: Yes.

And you may be talking about -- maybe one and a half.

DR. THEOFANOUS: What do you mean one and a half?

MR. HODGES: The factual diff -- well --

DR. THEOFANOUS: More than one?

MR. GRAVES: There has been one test at Connecticut --

I believe Connecticut Yankee or Maine Yankee. I'm not sure about the -- where they compared this result with the result of heat balance. They happened to get just about the same answer.

CHAIRMAN CARBON: We can't hear you.

MR. GRAVES: There was one test that -- there is only one test that I know where people compared two methods. This particular method would be heat balance method. And that is, I believe, Connecticut Yankee. And I could verify that very shortly.

They have to be getting very close agreement between the two results. But they believe this was rather unusual.

MR. HODGES: No, I think on Iconee they did the same thing, Chuck, and they got about a 50 percent diff- erence.

MR. GRAVES: 50 percent.

MR. HODGES: Yes. It can be --

MR. GRAVES: So, we havetwo cases. You found one and I found one where one case the two methods--the heat balance from the energy input was compared to the transient time method when they got closer together. And Wayne has found another one where there was a different percentage.

But there is -- part of it depends on the problem that you do have a fairly significant heat loss for a system that's not known at the time of these tests.

MR. HODGES: Well, look at these data points up here on the temperature. These little plots here are for th: cold leg temperature and the hot leg temperature. Now, you're taking a temperature difference which is on the order of 25 degrees for the natural circulation--25, 30 degrees. And you're seeing differences here of a couple of degrees on each one.

Just from the uncertainty and the temperature difference when that scatters about you're going to get a fair amount of uncertainty. And then you've got uncertainty that you back out of the heat flux measurement or the calculation itself. So --

DR. PLESSET: What's this WK mean? WK scale?

MR. HODGES: Oh, that's a WR. It's on a wide range scale.

MR. EBERSOLE: Oh, what is WR then?

MR. HODGES: Wide range.

MR. GRAVES: Wide range.

MR. EBERSOLE: Have there ever been tests run in which progressively larger, but in any case, small amounts of noncondensables have been injected into the system?

MR. HODGES: No.

MR. EBERSOLE: To observe the effect on this type of curve.

MR. HODGES: Not to my knowledge.

MR. EBERSOLE: Why not?

MR. HODGES: I don't think you want to do that in a plant that is generating efficient heat.

MR. EBERSOLE: It's a fear that something will happen.

MR. HODGES: If -- you may call it that, yes.

MR. EBERSOLE: But you even have the pumps with which you normally scrub out these tests, and yet fear still predominates.

MR. GRAVES: Well, the tests to-date, such as Wayne has described, is really based on the idea of trying to prove such. If your plant had this scram, say, you lost off-site power, and you're scraming in auxiliary feed water --

MR. EBERSOLE: Yes.

MR. GRAVES: -- and you want to remain at hot stand-by which was the instrument position. Let's say at that point and WASH 1400 as well, this test is to demonstrate -- the purpose of these tests is to demonstrate that you could reach a stable condition, remove heat by natural circulation. Everyone of those tests has had a month -- this particular series of tests came out of the Reg Guide 1.68.

And so you will findthat they will measure, they will -- the standard description of the test is that they will try to be in the range of a few percent power, sometimes going up to four or five percent and compare this with the values that were predicted in the final safety analysis report to demonstrate the test has shown natural circulation rates --

MR. EBERSOLE: I understand.

MR. GRAVES: -- in excess of what was used in the safety analysis.

MR. EBERSOLE: I guess my problem is this, though. This test is carefully sterilized against having any --

MR. GRAVES: Yes.

MR. EBERSOLE: -- perturbing influences?

MR. GRAVES: That's right.

MR. EBERSOLE: Even though the pumps are present to eradicate problems should the problems arise. And this is what bothers me.

MR. GRAVES: Well, some of the tests have been -- will go from the actual trip of the pumps, and you will have data all the way down to approach the natural circulation in approaching a stable condition in natural circulation.

There have been other tests in which the system was allowed to go into natural circulation, and the reactor was fisioning. In other words, it wasn't scrammed. They were simulating decay in the fision power.

MR. EBERSOLE: How long --

MR. GRAVES: A series of study state type tests. The transients have been the transients following the trip of the coolant pump down to the establishment of natural circulation.

MR. HODGES: If a test like this can at all be run outside of core, and you can set up tests and do this, and there are some that are going to be done by research. It would seem prudent to do it there rather than in the core where you might get something with a reactivity insurgent transient or something like that. It would cause a problem.

MR. EBERSOLE: Even though you have the pumps to --

MR. HODGES: Even though you have the pumps, yes.

MR. EBERSOLE: You know, the pumps are normally used to scavenger out the heat --

MR. HODGES: Yes. But the problem may not come from -- from the other.

MR. EBERSOLE: How long do these tests -- how long is it require that they persist? I notice this cuts off in about an hour?

Do you do tests that call for a time span, of say, two days, three days?

MR. HODGES: Across a time span of a long time like that, it would take a long time for things to come at equilibrium so you can run the test.

So, the test may not last more than an hour itself, but the time involved in running the test is a couple of days. In fact, I --

MR. EBERSOLE: During which it is on natural convection?

MR. HODGES: No, no, I don't think so. No.

MR. EBERSOLE: I'm looking at, you know, the possibility of problems arising in the course of a long time?

MR. HODGES: No, this is -- during which it's got --

MR. EBERSOLE: Well, this is really short-term. An hour?

MR. HODGES: Short-term under the natural circulation conditions, yes.

DR. ZUDANS: You know to reach this point how much time does it take from the time the pumps are shutdown to reach the equilibrium stage so that you can perform the --

MR. GRAVES: That's minutes.

MR. HODGES: Minutes, yes.

DR. ZUDANS: Minutes?

MR. HODGES: Yes.

MR. GRAVES: See, this particular test is -- usually you've got to watch it when you see a test like this. This happens to be the transient type test. You have very long transient time -- minutes at these powers. At a one percent power generation your flow rate is about 3 percent of the flow design value. And that's a factor of 33 and the typical loop transient times at full power would be in the order of 10 or 15 seconds. So, you're talking about 30 times that.

DR. PLESSET: Do they start from stagnant conditions?

MR. GRAVES: No, this is --

MR. HODGES: No.

MR. GRAVES: -- a steady state. And then they jog the system to try to get a temperature --

MR. HODGES: If you've got some heat in there already, it's very difficult to start from stagnant conditions.

DR. PLESSET: That's true.

MR. GRAVES: If you exceed -- Wayne, you have another curve probably showing what happens after a trip.

MR. HODGES: Yes, I've got one set in here from ANO --

MR. GRAVES: That's from a point of time test we're talking about.

MR. HODGES: A loss of off-site power event.

CHARIMAN CARBON: I'm not sure I understood all you said. To start these tests they are operating, are they, at something like a steady state of 5 percent, and then trip out the pumps and --

MR. HODGES: Well, they probably start operating at 20 or 30 percent. It depends upon the plant and what's been recommending for them. But it will be operating initially at some power level, and then they will trip.

CHAIRMAN CARBON: Trip both the rods and --

MR. HODGES: And then they would be sitting there on decay heat.

MR. ZUDANS: And that is a short period between that midpoint and the point that you conduct all the tests?

MR. HODGES: Yes.

CHAIRMAN CARBON: Well, you are performing the test as soon as you trip; aren't you?

MR. HODGES: But it takes awhile to reach the natural circulation. You've got a minute or two to coast down and get everything stabilized. So, you're talking about a matter of minutes.

CHAIRMAN CARBON: It's part of the experiment in getting onto --

MR. HODGES: Yes.

DR. SCHROCK: The pre-existing flow in that kind of test certainly aids the onset of natural circulation, and there may well be some circumstances in accident scenarios where the things are really stagnant before the onset of natural circulation is necessary. Are you concerned about that?

MR. HODGES: We are concerned about that, and we have asked research to do some tests. We don't have the tests yet. We don't have any data under those cir --

DR. SCHROCK: What we've heard is that the onset is very slow in terms of time.

MR. HODGES: But you don't want to run a test like that in a reactor, you know.

DR. SCHROCK: Well, I'm not arguing it needs to be run in a reactor, but I'm curious about --

MR. HODGES: Some people do, I think.

DR. SCHROCK: -- whether information of the type that you are describing here is adequate to answer questions about adequacy of natural circulation as a mechanism for --

MR. HODGES: Under accident conditions, the answer is "no."

DR. SCHROCK: Okay.

MR. HODGES: What I am going through now is what has been historically done. There was some interest expressed in what the data base is on plants, and so I was just trying to show a little bit of that flavor. We will get in a little bit later us to what additional we requested from research and what we think we need. See, this is what just now exists.

MR. BAER: I'm Robert Bayer of the NRC staff, and Wayne ended up saying much of what I was going to say. But I just wanted to point out that the tests we are talking about, pretty much as Wayne said, is something to demonstrate a normal design capability, and it's for the transient where you have lost offsite power or lost the reactor coolant pump. And the pumps have an additional rotational momentum built into them in terms of a fly-wheel to give you a reasonably -- I don't know how to say it, but so the flow doesn't decrease too rapidly, so that during the first part of the transcient there is adequate flow rate in the core so you don't go -- depart from nuclear boiling during the first part of the transient. And that's about a minute or so of coast-down, and then you get into the natural circulation.

And I think that at least some of the tests that Wayne is talking about are tests, really just to demonstrate that capability. That if the pumps were --

MR. HODGES: That's right.

MR. BAER: -- stripped from full power that you would achieve during the transient flow rates high enough to preclude DMBR in the core or an acceptable DMBR ratio in the core, and then you would be able to, as Wayne said, to stay at hot standby or in fact slightly cool down the plant power in that condition.

It is not an accident -- the test he is describing are not to demonstrate capability following an accident like a small LOCA.

CHAIRMAN CARBON: Is this done during startup of a plant, or is it done -- I mean initial startup, or is it repeated at shutdown?

MR. HODGES: There are two types of tests that are normally run. Before the plant is ever started up, they will do idiomatic tests where they will just get a driving head by cooling down the colag with opening a dump valve and having the pump have heated the system up.

After they have operated for a short period of time so that they can get some decay heat, then they will run a natural circulation test. But now they have had to operate it for a period of time before they can get to that point.

MR. ETHERINGTON: Some natural circulation systems are self-starting from rest and some are not. It seems to me that one ought to be self-starting. Have you an answer on that? Should it be self-starting?

MR. HODGES: It should be, but the tests that have been run were from a pump coast-down condition. I don't think we have any data showing that it absolutely is. I see no reason why it should not be. The driving head is there.

MR. ETHERINGTON: The driving head can be there, yes. But it has to be there from the beginning. To quote an example --

MR. HODGES: You've got a heat sink in your steam generator, and you're generating heat in the core, so you've got the density difference, and it should be self-starting.

MR. ETHERINGTON: I believe that's right.

I'll give you an example of one that isn't self-starting if that would help.

MR. HODGES: Okay.

MR. ETHERINGTON: In the old days of natural draft furnaces, the furnace in the high level had flues at the low level and a stack.

MR. HODGES: Yes.

MR. ETHERINGTON: And you could have the furance hot, but you would have no draft. You light a little fire at the bottom of the chimney stack and heat the stack, and then you'd have a system that was operating.

MR. HODGES: Yes.

MR. ETHERINGTON: That's the kind of possibility for having a system that isn't self-starting. I don't believe that applies to any that we have looked at here.

MR. HODGES: On the Westinghouse and combustion plants the steam generators are sufficiently above the core that there should be no particular problem. On the B&W reactors it is a function of what the secondary water level is. If you get the water level too low you could have a problem. So, there are constraints on the water level on the secondary side for the B&W steam generator with the lower loop plants.

MR. ETHERINGTON: That wouldn't be continued once it's started, then, would it?

MR. HODGES: I'm sorry. I didn't understand your question.

MR. ETHERINGTON: That isn't the case in not being able to start. That would be a case of not having --

MR. HODGES: It would not even continue if the level was not --

MR. ETHERINGTON: It wouldn't continue if it started; right.

MR. HODGES: That's right. So, there are constraints on the levels on the secondary side.

CHARIMAN CARBON: Have there ever been tests run where they started from scratch rather than pump coast-down?

MR. BAER: There are some proposed for near term OL's, and I will be talking about those here just briefly.

CHAIRMAN CARBON: But none have been so far?

MR. BAER: Not that I'm aware of.

MR. GRAVES: None have been run as a test that has occurred in transient. There have been a few situations where --

CHAIRMAN CARBON: I'm sorry. I couldn't hear you Dr. Graves.

MR. GRAVES: I believe there have been a few reactor transients in the past where a steam generator where there was -- there could have been a restart robinson in the loss of cold pump sales.

CHAIRMAN CARBON: Could have been, but you don't know whether it --

MR. GRAVES: Could have been. I'll raise the point, but by the -- there have been a few situations where there could have been such a case.

MR. HODGES: Okay, Brian Sheron just reminded me also on my statement on the B&W plant, that if they have off-speed that statement is not true. That could be true if they did not have off-speed and we're going on regular feed flow but --

MR. GRAVES: If it's low enough you can't neat, you're still going to -- even if you try the steam generator, you are still going to have a heat loss in the system of about three megawatts.

Thermal heat loss from the system is about three megawatts.

MR. EBERSOLE: I believe one of the possible demands on natural convection might be -- that has to be considered is the case for severe secondary side depressurization coincident with the loss of primary coolant pumps in which case you get a primary loop cooling, which restores power to some level activity at 50 percent. And yet you're dependent on natural convection for rejection from the pin to the coolant. Is this one proven in the experimentation that you can use natural convection at this power level in PWR?

MR. HODGES: No, not from tests.

MR. EBERSOLE: What's it power level? Do you happen to recall how high it may go on the severe secondary side depressurization? Is it like 20 percent?

MR. HODGES: Local pins can go -- that I'm -- I'm not sure that the reactor power --

MR. EBERSOLE: Reactor power for local pins.

MR. HODGES: Yes. But the core average would not be anywhere near that.

MR. EBERSOLE: Oh, I know that.

MR. HODGES: Okay.

MR. EBERSOLE: I'm talking about LOCA heat transfer problems under natural convection.

MR. HODGES: Okay.

MR. EBERSOLE: The pump --

MR. HODGES: Yes. Okay. I don't recall the numbers. I think LOCA you could go 20 percent or maybe more.

MR. EBERSOLE: Yes.

MR. HODGES: I think it's higher even than 20 percent, but I don't have the numbers in my head.

MR. EBERSOLE: And that would have to be dissipated by natural convection since the pumps are down? After the coast-down. You would be racing with lower ratio.

MR. HODGES: That's right. And it would depend upon how -- the rate at which the power increase as to whether or not you could do it.

MR. EBERSOLE: Yes. Well, it is a scenario which we face.

MR. HODGES: If it goes extremely rapidly so that the momentum of the water won't keep up with it, then you're going to get burnout.

MR. EBERSOLE: Yes.

MR. HODGES: Or D&B at any rate.

MR. EBERSOLE: All right. Okay.

MR. HODGES: Okay. If it's a slower transient, then the natural circulation can very probably keep up with it.

MR. EBERSOLE: Do you think it might should be a design basis that we won't get burnout by whatever means necessary?

MR. HODGES: A certain amount of D&B is allowed period. The cleanup systems are designed to handle it.

MR. EBERSOLE: I'm talking about burnout, not D&B.

MR. HODGES: Well --

MR. BAER: You're talking, Dr. Ebersole, about a pretty severe transcient --

MR. HODGES: Yes.

MR. EBERSOLE: Yes, it would permit some damage.

MR. BAER: -- and our criteria doesn't preclude D&BR.

MR. HODGES: That's right.

MR. EBERSOLE: Some degree of damage; right. Thank you.

MR. HODGES: These are just some examples of what's been measured in a couple of different plants during the natural circulation tests. These are the abilities that they see on Oconee and Davis-Besse. So, you've got an example of a lower loop and a raised loop plant, again, at low power.

MR. ETHERINGTON: We have tests -- don't we also have some cases of inadvertent going to natural circulation on --

MR. HODGES: From -- yes, sir, I'm going to show one case of that in my slides here. But just as an example.

Some of these I think we can go through rather rapidly. This is just -- the example for Oconee showing what they reported being requi ed in their F-Zar, and what they calculate and then wha they actually measured for the test. Again, I'll comment that typically the vendors will use conservative values of the flow resistances in the piping because they don't have a good feel for exactly what they are under these low-flow conditions. And that's why you almost invariably the data considerable higher than the predictions.

DR. THEOFANOUS: Which is data and which is conditional?

MR. HODGES: This is the data point. These are conditions.

DR. THEOFANOUS: Now, the data point is not really very meaningful unless you give me a narrow band around it. Based on what you said before, you wouldn't know very well what the point was. Can you give me an idea of how it -- how much of an asserted value there are?

MR. HODGES: There may be, and this is just a guess, I haven't tried to go through and do a numerical evaluation.

But that error may be 30 to 50 percent. Okay. In that range.

DR. THEOFANOUS: That is a guess; right?

MR. HODGES: Yes, because of the uncertainties in the temperature and power.

MR. GRAVES: That's because we are referring to flow.

DR. THEOFANOUS: Right.

MR. GRAVES: Now, remember even though there was a scatter in those thermal couples, there was still a hefty difference between --

MR. HODGES: That's correct.

DR. THEOFANOUS: All right. So, that --

MR. GRAVES: Part of the uncertainty is this business of knowing the heat source --

DR. THEOFANOUS: Right.

MR. GRAVES: -- to back out the flow rates.

DR. THEOFANOUS: That's the point. So, it is possible that we are really after the wrong there here.

MR. GRAVES: Well, I think the delta T's, that the core registers the temperature is most significant.

DR. THEOFANOUS: More meaningful. So why --

MR. GRAVES: More meaningful.

DR. THEOFANOUS: -- are you going to something that we don't know very well.

DR. THEOFANOUS: Those are the things we are measuring. You don't hear a very high percentage on that. I think those are the things that should be the primary factors to be reported and to be conferred with, other things such as analysis.

The flow is only an intermittent thing and might give him an idea as far as how the results compare --

MR. HODGES: My previous slide was on delta T calculated and measured.

DR. THEOFANOUS: No, you -- don't take long. Is this the matter only of procedure.

DR. ZUDANS: Could you describe how certain -- or how accurate is this hallowed measurement here? How is it --

DR. HODGES: For this particular one I'm not certain.

DR. ZUDANS: No, in general, how is it done?

MR. HODGES: There are two general techniques that are used--one is calculating for an AN&S decay curve.

DR. ZUDANS: That's not a measurement. I'm --

MR. HODGES: That's not a measurement. And the other one is doing the heat balance on the secondary side.

DR. ZUDANS: But that could either --

MR. HODGES: But you need the feed water flow rate.

DR. ZUDANS: Is that known accurately?

MR. HODGES: That's measured. And you need the delta T. But the problem is that the instrumentation on the secondary side also is set up for, you know, full power operation. And so you're measuring in the range of a few percent power, and so you get large uncertainties.

DR. ZUDANS: So there is not only a question where that point sits in the chart; also a question of how accurate that scale is relative to these points.

MR. HODGES: Yes.

DR. ZUDANS: Now, you can measure temperatures accurately.

MR. HODGES: You can measure them accurately, but even they bounce around.

DR. ZUDANS: That's right. So, the power is deduced from measurements that are not certain.

MR. HODGES: That's right.

DR. ZUDANS: Using A&S curve because that's --

MR. HODGES: That's correct.

DR. ZUDANS: Because -- type of curve isn't applied to this particular plant, not necessarily.

MR. HODGES: Yes. There have been state

DR. SCHROCK: -- heat if you do it. But I think what you're saying is that you use the -- only in a standard

3 decay heat curve following it. And in the radiation you have an answer which is not very reliable.

MR. HODGES: That is correct.

DR. SCHROCK: But you don't have to do that.

MR. HODGES: You don't have to do it. You can calculate it correctly, maybe. And --

DR. ZUDANS: If you know the feedwater flow.

MR. HODGES: If you can know the feedwater flow and the temperature dif^erence on the secondary side.

DR. CATTON: Well, I can see how it can get temperature differences. With our instrument accuracy, how can you get heat with flow like this low range of flow with any accuracy less than say plus or minus --

MR. HODGES: The percent.

DR. CATTON: -- 100 percent?

MR. HODGES: 10 percent.

DR. CATTON: Your level responses are rather vague at one percent.

MR. HODGES: It's pretty low. That's right. It's very uncertain.

DR. ZUDANS: And what is the significance of knowing all of this other than delta T like --

MR. HODGES: That's the major thing. You're demon -- it's a demonstration more than anything else.

DR. THEOFANOUS: There is no demonstration. If something doesn't demonstrate something you cannot call it a demonstration.

MR. HODGES: Oh, it is a demonstration. It is a demonstration that natural circulation exists under these conditions, and that therefore, the temperature difference that you're measuring in the core does not, you know, go sky high.

That's what it is.

DR. THEOFRANOUS: What you are trying to tell me is that they are other things that are more direct demonstrations instead of what you are trying to put up there as a demonstration.

Everytime that you put up numbers of your

MR. HODGES: No, no. I'm talking about the test itself. The test itself is a demonstration --

DR. THEOFRANOUS: Okay. Okay.

MR. HODGES: -- that the temperature differences don't go sky high.

DR. THEOFRANOUS: That is a demonstration. But not -- not that figure?

MR. HODGES: This is back out from that. That's right. No, I'm not claiming great accuracy for this figure. Okay. I think so.

MR. EBERSOLE: Is the required pool rate as shown here really kind of a homogeneous mix-mean, average flow to get the heat out of the core only when it's being generated?

MR. HODGES: That's water solid.

MR. EBERSOLE: That's all it is.

MR. HODGES: Yes.

MR. EBERSOLE: It doesn't take --

MR. HODGES: No boiling.

MR. EBERSOLE: -- advantage of the local picture in the core at all?

MR. HODGES: There's no boiling in there.

MR. EBERSOLE: No boiling. Right.

There will be some hotter channels than others, and some variability in the velocity of those; but that's it?

MR. HODGES: It's greater than that.

CHAIRMAN CARBON: Go ahead.

MR. ETHERINGTON: The off-speed water curve is higher because the water is colder; is it?

MR. HODGES: I'm sorry. There were several people talking. I didn't get the question.

MR. ETHERINGTON: The upper curve is because the water is colder; is that the reason? The aux water?

MR. HODGES: Oh, in this case the off-speed comes in at a higher level.

MR. ETHERINGTON: Pardon?

MR. HODGES: It physically comes under the higher level in a steam generator.

MR. ETHERINGTON: Oh.

MR. HODGES: So, since you've got more heat more surface would water on it.

MR. EBERSOLE: That's only one case. But we -- some of them -- all of them don't come in high.

MR. HODGES: This is the B&W case.

And this is just a similar curve for Davis-Bessett, again, at a higher power showing the flow above predicted. And I don't think we need to dwell much on that one anymore.

If you go through just a simple, say, energy ballot looking at the driving head and the friction losses you can arrive at a recipe like this, which is what Westinghouse uses in calculating their natural circulation, again, under water solid conditions. This is essentially derived in the book by Vinella on nuclear engineering that you come back and see how they get their. It just says that the flow is proportion to the third route of the heat generation and the elevation head when it works out.

Some calculations that Westinghouse has made and prepared with data of their plants, similar to the ones I just showed you for B&W, where they get a compulation and a measurement up here.

We've got the same kind of uncertainty, so the same questions we had on the other slides apply here as well.

DR. THEFANOUS: What kinds of tests are those? Are those -- can you please tell me what --

MR. HODGES: These are water-solid, natural circulation tests.

DR. THEFANOUS: And where are the other two?

MR. HODGES: These are in several Westinghouse Reactors.

DR. THEOFANOUS: Several differences.

MR. HODGES: Several differences and three loops and four loop plants that are shown on that curve. So, you've got several Westinghouse reactors.

DR. THEOFANOUS: One thing that surprises me is that you've done that experimental data. Now, the transcient I've seen never indicate to me one of two things--one is that the people who used the data were very careful to somehow eliminate error in some strange way. Of the other -- the transcient I see here do not indicate to me that whatever it is that you're measuring, the measurement procedes in a normal role. The experiment is very ready because I see very nice behavior.

MR. HODGES: There is at least a consistency.

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DR. THEOFANOUS: Yes.

DR. HODGES: Whether it's accurate or not, there's -- it's consistent.

DR. THEOFANOUS: Well, it's a matter of systematic errors. The point is that we have -- you could give a systematic arrow that could make a curve sit up and down, but there is -- other than it is an inherent measurement thereof, which is because of your lack of notes of some details in the system which are amplified and give you erratic behavior.

I construe to your previous comment to try to say that by -- almost by principal the measurement is very inaccurate.

MR. HODGES: That's right.

DR. THEOFANOUS: What I see over here doesn't show that and you -- can you help me to understand how that --

MR. HODGES: All right.

DR. THEOFANOUS: -- You just gave me.

MR. HODGES: This is one plant. This is a four-loop plant; all right? They use the same method that all three points on this test. So --

DR. THEOFANOUS: Well I'm comparing the heat runs.

MR. HODGES: Here you go in --

DR. THEOFANOUS: Between the reactors and all also even within one. It determines whether you are well-behaved.

DR. EBERSOLE: It would be much more conviencing if there wome error bounds on those data.

DR. THEOFANOUS: That's right.

DR. EBERSOLE: But there is nothing that you can do?

DR. ZUDANS: But in any case he is very well-behaved.

There is one thing you are overlooking?

DR. EBERSOLE: What?

DR. ZUDANS: Both scales are made from the same area of source. So, the curve that you applied before sounds okay.

The power is derived from people, and the flow is impaired from heat removal.

MR. THEOFANOUS: But, again, this is --

DR. ZUDANS: It is not a direct measurement of either of the scales?

MR. HODGES: No, no. Zero -- we are talking about two things. One is systemic error and there other is erractic error.

DR. ZUDANS: This is systemic error?

DR. ZUDANS: That's what I'm driving at. If there is some kind of error it must be systematic. What Wayne was trying to say before if you are measuring a flow that is one percent of your instrument scale, then you're not talking about systematic error.

You're simply talking about your ability to measure accurately and basically a random error. There is a basic difference between those two things. What I'm driving at is this behavior indicates to me that either there's a systematic only error and not the random error, or that there isn't any error at all.

DR. LIENHARD: May I say in different words? You've got two plants turning out perfect straight lines, and two other plants turning up curves that show absolutely consistent bends in them.

MR. HODGES: These are calculations.

MR. ETHERINGTON: There's another factor that may enter here. At the low rates of flow, we're getting pretty close to the Randall's critical number in the long tube so if we had a transition for turbulent viscous flow then the formula, of course, wouldn't apply.

MR. HODGES: That's correct.

MR. ETHERINGTON: And I think you're getting -- I think it is rather close in the long tube. But it does remain turbulent.

MR. HODGES: It's still in the turbulent range.

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Those pipes are big enough. It takes very little flow. If those pipes are large enough it takes very little flow before you're in the turbulent range.

DR. CATTON: What's the critical Randall number?

MR. ETHERINGTON: What do you call low?

MR. HODGES: Well, in the hot leg and the cold leg pipes under normal operation you --

MR. ETHERINGTON: I'm talking about the tubes. Not the pipes.

MR. HODGES: Okay. In the tubes. All right.

MR. ETHERINGTON: In the tubes. In the pipes it's really turbulent always.

MR. HODGES: Right. That's right. Okay. In the core it may well be, but maybe most of your pressure drop is --

MR. ETHERINGTON: I'm agreeing with you it is turbulent, but it's running kind of close.

MR. HODGES: It's probably running close.

MR. ETHERINGTON: It might get into the viscous range.

MR. HODGES: Well, let's see. You would have a quarter of a foot per second velocity, somewhere in that range.

MR. ETHERINGTON: Pretty close to --

MR. HODGES: In that range there. So that's getting

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in that range, right.

MR. ETHERINGTON: That size viscosity.

DR. THEOFANOUS: Anyway, Wayne, let me just say a little bit more bluntly what I'm driving at. If I give you a thermometer, and you've got the Delta-T increments of ten degrees. And I ask you to do an experiment in which you only can -- you are already asked to measure differences of one-tenth of a degree.

MR. HODGES: Right.

DR. THEOFANOUS: And you carry out the experiment in full cognizance of your instrument you have is not a very good one for that particular experiment. And if I see you getting a curve that looks very nice and, and you were talking with thermometer apparatus but with other different apparatuses, then I guess what I'm going to do is I'm going to be very suspicious, and I'm going to go back and look very carefully what you've done.

And what I suggest to you these kinds of data do not agree with your previous statement concerning the ENO's and therefore --

MR. HODGES: I think a lot of them are systematic. I think you will get big differences between -- or differences in this number depending upon the technique that you use, whether you use transient time method or whether you use the energy balance method.

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CHAIRMAN CARBON: Well, I think the point has been made --

MR. HODGES: Yeah. No, I understand what you're saying, Theo. I understand that fully, and why there is not more scatter there, I can't explain.

DR. THEOFANOUS: What I'd like to know is what are you going to do about it? I'm not so much interested in whether you agree with me or not. Is there something you can do about to learn more from the data? Are you going to look at them more carefully, or should we look at them more carefully? That's what I want to know.

DR. CATTON: I think future plants have a bit more flow measurements, don't they? I didn't know that they measured the mass flow in the auxiliary feed water system.

MR. HODGES: No, we're not talking about it. We're talking about on a regular feed water flow. But some of them can't.

DR. CATTON: Well, you had -- from the previous flow, you had an auxiliary feed water curve --

MR. HODGES: That was a theoretical curve.

MR. GRAVES: Some of these powers here here of these tests were raised on fission power where they didn't confer it --

MR. HODGES: That's right.

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DR. CATTON: Oh, okay. If this is from fission power, then a lot of -- we'd have a lot more confidence --

MR. HODGES: Not at that low level. In the next curve what I've shown is the data that's been plotted up from the charts on the ANO 1 for a loss of off-site power event.

This was not a planned event. And this just showed the hot leg and the cold leg temperatures and show that you've got natural circulation, and a fairly short period of time they restarted the pumps, and the event was over. But the Delta-T's were smaller than what you get during operation, and so it's a demonstration that they had natural circulation.

The rest of thecurves that I've included with it just are there to give you a feeling of what some of the other parameters were. I don't think we ought to dwell on them a lot. There are a lot of curves there, and you could talk about them a long time.

It's just strictly a demonstration that they do have natural circulation for those few minutes when it was needed. The bottom set of curves on this one shows that he stayed well below saturation on the hot leg, and again you've got the core Delta-T.

This just showed that the steam generators and the system pressure for the two loops were reasonably

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consistent. I don't want to spend a lot of time on these particular curves.

And again the steam generator temperatures and the saturation lines -- in fact, you can probably skip over the one on the KE and go to the next curve. There are several events on this particular curve, and they are tabulated in the next table also on the next slide. This just gives an indication of the natural circulation flow rate versus the KE power for both the tests and events that have been observed in the B&W plants.

MR. ETHERINGTON: What is the criterion for minimum acceptable?

MR. HODGES: That's what has been shown in this -- that final section analysis report to remove the heat.

CHAIRMAN CARBON: Once again, what does this show?

MR. HODGES: All this shows that if both the tasks that they run on natural circulation and the events where they've inadvertently gone to natural circulation, that they had more cooling than it showed that they required.

DR. THEOFANOUS: Which are the tests and which are the events?

DR. HODGES: The events are generally a little bit

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higher power on this.

DR. THEOFANOUS: Is it -- well, I see some W's and some X's there. Is there any difference there between the points or are they all X's?

MR. HODGES: Those are all X's. It's a poor copy.

DR. THEOFANOUS: And some of those points, then, are tests and some of them are events?

MR. HODGES: Some are tests and some are events.

DR. ZUDANS: And at the core, the KE is computed from -- by inference from the feed water --

MR. HODGES: Right.

DR. ZUDANS: And the natural circulation flow rate is derived from what?

MR. HODGES: The natural circulation flow rate would be like from -- just --

DR. ZUDANS: Well, I was on the right. There are two scales. How are these points found? This one you were saying --

MR. HODGES: Okay. Some of the -- on the tests some are obtained from this transient time. Some are obtained from using the secondary heat. So there are some of both on the low power. On the higher power, they're all basically on the secondary heat.

DR. ZUDANS: For the given event, the KE powers

17 is calculated from feed water information.

MR. HODGES: Yes.

DR. ZUDANS: And the amount of heat is reduced from that, and the flow rate -- the natural circulation is computed on the basis of the heat --

MR. HODGES: I think it's reasonable to say that you've got the secondary heat on both curves.

DR. ZUDANS: In that case, it should be a perfect curve. And the points should be matching exactly.

MR. BAYER: Well, you've got the core Delta-T measure.

DR. ZUDANS: You've got the core Delta-T measure.

MR. ZUDANS: There's always something in that.

MR. HODGES: Right.

DR. ZUDANS: To get flow rate.

DR. ZUDANS: Well, actually the both -- the KE and the flow rate are based on checking the information.

DR. CARBON: Wayne, before you leave that last curve, does that represent all of the B&W data that it's my understanding from what this says that if you take all the B&W test data, this is it?

MR. HODGES: That's close to it. The curve says all. There are some stuff on Three Mile Island that is not on here. And there is some additional tests that they've David -Besse and I don't have, but it's most of

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it.

MR. BAYER: Well, Wayne, could I ask my own? Is that sort of like one point per test?

MR. HODGES: Yes.

MR. BAYER: In other words, each of that and each test one could have a series of points. I guess they selected one.

CHAIRMAN CARBON: But in terms of total tests and total events on B&W plants for 15 years this is pretty much it?

MR. HODGES: Yes. At least I felt like Jonas. This table summarizes the points that you see on the other -- on the curve previously. The two tests for Oconee 1 that were both natural circulation tests. What you see shown for Oconee II. This was a lot of off-site power event. And in this particular case, they didn't have any emergency feed water for the first seven minutes.

The ANO 1 was a loss of off-site power event. The Crystal River 3 data point was a loss of all high power tests. The Davis-Besse, one point here was a loss of off-site power event, and the second one was a loss of off-site power tests.

MR. ETHERINGTON: Would you just go quickly down and say it's a test to examine --

MR. HODGES: Okay. The first two are natural

19 circulation test. The one for Oconee 2 was a loss of off-site power event. The one for ANO-1 was a loss of off-site power event. Crystal River 3 was a loss of off site power test.

And the first one I show here for Davis-Besse was a loss of offsite power event. And the second one was a loss of off-site power test.

DR. ZUDANS: In any one of these cases had any-one calculated actual behavior on the basis of prior off-site operation?

MR. HODGES: I don't know.

DR. ZUDANS: Has that been ever done to see how well these types of measurements or calcuations check with it?

MR. HODGES: It may have again. I don't know.

DR. SCHROCK: That would be pretty important to do because the power depends mainly on what the reactors have been doing in the last week or something like that. And this type of testing. I'm not sure we have done the evaluation with the prior power history.

MR. HODGES: If you calculate it -- if you measure it on the secondary, then it doesn't matter.

DR. SCHROCK: Well, I know it's very common to simply take the infinite irradiation to FE curves and take a point off of it which is totally inadequate for this

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application, I think, is what Dr. Zudans has pointed to.

MR. HODGES: Yes.

MR. EBERSOLE: ANO 1 data up there is essentially useless because it's got that notation on it that the RC pumps are not fully stopped. I don't know how you partially stop the motors, and therefore, I don't know what the flow was so, in essence, I find that you might as well obliterate that line.

MR. HODGES: Well, okay. It said the same thing on the curve also that it was well above the line. This was just --

MR. EBERSOLE: How could there be? Did they bump them or what?

MR. HODGES: No, no. This was an event. This was not a test.

MR. EBERSOLE: Yeah. But how did they get partial operation of RC pumps? Some of them were working and others weren't?

MR. HODGES: No, the pumps -- they had a loss of off-site power, but the pumps tripped. But seven minutes later they got power back and restarted them.

MR. EBERSOLE: So then they came back on.

MR. HODGES: Yeah. Or some -- for some short period of time it was -- it was not a long time period, but they got power back.

MR. EBERSOLE: A.. right, thank you.

DR. CATTON: Wayne?

MR. HODGES: Yes, sir.

DR. CATTON: These flow valocities, how much heat loss is there between the vessel and the generator? What percentage roughly of the --

DR. ZUDANS: Zero in this calculation.

DR. CATTON: Well, I understand it's true in calculations. But --

MR. EBERSOLE: I think it's not much.

DR. CATTON: Not much?

MR. HODGES: No, there would not be much.

DR. ZUDANS: It doesn't look that way from Three Mile Island if you read the tables as to megawatts because of weather changes.

MR. EBERSOLE: Oh, yes.

MR. HODGES: Yes.

MR. EBERSOLE: Recently, yes.

DR. ZUDANS: Recently.

MR. EBERSOLE: True.

MR. GRAVE: A typical loss frame for the Westinghouse plant is about six-tenths of a megawatt. That's from all parts of the primary system. A large part of that existing generators. That's pure loss for the installation.

DR. CATTON: Five or six percent would be outside for error.

MR. HODGES: Right.

DR. CATTON: Okay. Thank you.

MR. GRAVES: There are other sources, though, and it depends on the -- you have charging letdown, that can have a significant effect, for example. So, that's -- control rod cooling, pump seal flows is a significant part, too. I was just speaking of your loss for the air.

DR. CATTON: How much does that add up to?

MR. GRAVES: All of them add up to about three-and-a-half megawatts. That's control rod cooling, heat loss, charging letdown.

MR. EBERSOLE: That's a mistake.

DR. CATTON: That could be 25 percent then on some of these runs.

MR. GRAVES: Well, I'm not sure what was on during the runs, but I'm saying that the recharging letdown I think is to reduce the pump seal flow.

DR. CATTON: Okay.

MR. HODGES: The next few slides you've seen before. Brian Sheron, I think, presented them to the subcommitte; was it, about a month ago in talking about some of this. But for some continuity and feeding into the requirements for the two-phase natural circulation I've included them in here.

Again, I'm using just B&W as an example for some calculations that have been made on natural circulation where two-phase conditions exist, and we'll make some points about what is required.

On the statement here on re-flux boiling I think Brian wants to explain what is meant by that a little bit, so I'll let him explain that.

MR. SHERON: I'm Brian Sheron from the NRC staff. One of the questions that was forwarded to us was a clarification of terminology. And this new graph was originally put together, I believe, it was not less month but actually six months ago --

MR. HODGES: Okay.

MR. SHERON: -- it was in October when I made the presentation. And at that time I think a lot of people were referring to just any sort of two-phase natural circulation as a re-flux boiling mode. I think we've kind of sharpened our definitions, at least, myself, I refer to re-flux boiling as when the steam source is rising in a tube and condenses and falls back. Whereas, a normal two-phase natural circulation is one where the continuous circulation path.

In a B&W plant which has a rather high candy cane hot leg, one really doesn't get a re-flux boiling mode since there's no condensing surface on the uphill side. So, I just wanted to, I guess, correct that view graph that should just say, rather than re-flux boiling, or re-flux natural circulation to just say it's a two-phase natural circulation.

MR. EBERSOLE: That last sentence means wasn't really calculated not to occur; does it? Instead of not calculated to --

MR. SHERON: That's also a mistake. It was calculated --

MR. HODGES: Okay.

MR. SHERON: -- to occur.

MR. HODGES: The main point I'm trying to make with this slide and the next couple of slides is that we do have from the vendors some relatively sophisticated calculations with two-phase natural circulation. I'll show you an overview of what has been calculated, for example, with socket repressurization for the raised loops and no socket repressurization for the lower loops. And we don't have much of a data base.

But I'll show you where we're starting from on the questions at this point. Really, that's all it was intended to do.

Again, for just analysis, for very small breaks the steam generator can remove the K-heat if your accumulators don't come on. If you don't turn on the accumulators, and you don't have any significant core damage, you're not going to get a lot of gases, so the accumulation of non-condensable is not a particular problem.

MR. EBERSOLE: Are there pieces, though, where you don't really have a break except of a temporary character such as a stuck relief valve which follows, say, a by-pass value locked open on the secondary side in which case you get a substantial lowering of pressure and temperature for a period and then a repressurization, which channel are they accumulated?

MR. HODGES: If you get down to accumulative pressure?

MR. EBERSOLE: Yes, that's what I'm saying. Do you have cases where that showed up?

MR. SHERON: No.

MR. HODGES: Okay.

MR. EBERSOLE: It would depend on the severity -- the period of time in which you have a stuck relief starting about this stage.

MR. SHERON: There is no break that has been identified as an associated and isolatable break that would depressurize the system not only to the accumulator set point, but I believe below the steam generator secondary side pressure.

MR. EBERSOLE: However, they will challange the UHI tank; won't they?

MR. SHERON: A UHI tank I understand injects --

MR. HODGES: About 1250.

MR. SHERON: -- 1250 and the gas would not be calculated to come out until about 600 pounds; is it?

MR. HODGES: Probably.

MR. SHERON: Which again is well below the steam generator secondary pressure.

MR. EBERSOLE: Even if the valves stay open?

MR. SHERON: Correct.

So, the steam generators would not be heat removable source at the point of the UHI plant when the tanks start to inject.

MR. EBERSOLE: That's still above the pressure of the RHR system, though; isn't it?

MR. SHERON: Yes.

MR. EBERSOLE: They're 400 pounds, I believe; aren't they?

MR. SHERON: I think some are actuall two or three.

MR. EBERSOLE: Two, three, four hundred. Okay.

MR. GRAVES: It varies from plant to plant.

MR. HODGES: Yes.

And again, we've seen calculations with intermittent natural circulations with steam bubbles forming in the core of the hot legs, various conditions of repressurization in the analysis. At this point these calculations have no experimental basis, so we're just having to take the calculations for what they are.

We've seen calculations with time delays in the transitioning from natural circulation to pool boiling where you have to allow time for the steam generator level to drop before you can start what has been probably inappropriately referred to as re-flux boiling. It's questions about would the repressurization increase the break flow and lead to a core uncovery. There are still lots of questions from these analyses. We're not trying -- I can't give you the answers at this point. I think maybe that you are looking for answers. We don't have them yet.

MR. ETHERINGTON: This word "re-flux", I think we ought to define, I think, the -- different people seem to mean different things by it. A chemical engineer means one thing, and I think we sometimes mean another. Would you define re-flux --

MR. HODGES: Well, that's what Brian just tried to do a few minutes ago, I believe.

MR. ETHERINGTON: Pardon?

MR. HODGES: That's what Brian just tried to do a few minutes ago.

MR. ETHERINGTON: Oh, I'm sorry. I was thinking something else at the time.

MR. SHERON: That's the up-flowing steam condenses and flows back within the same channel.

MR. ETHERINGTON: That's down the same -- all right, that is real re-fluxing I guess.

MR. HODGES: All right. But that's not the way it was used initially right after Three Mile Island.

MR. ETHERINGTON: I apologize for my --

MR. HODGES: Okay.

MR. EBERSOLE: We make a statement in aspect to break switch below the water line, say, at the low point in the system. Repressurization determined by balance between steam generator and core is steam relieved by pressure.

MR. HODGES: Okay.

MR. EBERSOLE: What if you're not relieving steam by the break but you're just leaking water? Do you not get repressurization then without any benefit of the particular amount of enery that you release at the break?

MR. HODGES: Your energy release is just --

MR. EBERSOLE: It's just the water going out.

MR. HODGES: It's just the water going out, so it's considerably less.

MR. EBERSOLE: And so you have a net loss. You can get severe --

MR. HODGES: Yes. That --

MR. SHERON: Also, a break at the low point as it drains down to the steam generator will expose the condensing surface, so what the break doesn't remove the steam generator will.

ME. EBERSOLE: Yes, as a compensatory --

MR. HODGES: Yes.

MR. SHERON: Yes.

MR. EBERSOLE: If you get reflow?

MR. SHERON: Pardon?

MR. EBERSOLE: If you get reflow?

MR. SHERON: No, the only thing -- you're condensing to the steam then.

MR. HODGES: And this is just an example of the curves that have been shown from the calculations. This is the hot mixture level and the broken loop pressure time for a raised loop plant with a small break showing intermittent natural circulation. And the following curve, the same kind of analysis and you can overlay them and show that actually you would have natural circulation for a longer period of time. But there's still an intermittent nature to the calculation.

These types of curves are the basis for a letter that we sent to research in December where we asked for a log test. And we wanted tests where the system was controlled by the pressurizer pressure. We wanted a test where the system was controlled by the vessel pressure. We wanted a test where you had two-phase natural circulation with pool boiling in the core and steam condensation in the steam generator. We wanted tests where you had the system was recovering from a situation where it was controlled by the vessel pressure -- or for the two-phase natural circulation and was going to -- with the vessel pressure controlling. So, we have asked for a wide range of tests in LOFT and also some tests scheduled in semi-scale. Hopefully, these will give us the answers. We don't have them yet.

MR. BENDER: The answers to what?

MR. HODGES: The answers to whether you can get to natural circulation under these two-phase conditions, or whether these kind of analyses are reasonable to show that you can flip-flop back and forth between different modes. All we have at this point is analysis. We've got no verification that these modes can actually exist like this.

MR. SHERON: Mr. Bender, the tests that will originally be runned by research, the facilities that they have now are LOFT and semi-scaled. Both of which have a verb retube type steam generator.

This phenomena here is unique to a B&W plant. Research, as I understand, presently has in their planning stage a reconfiguration of semi-scaled to put in the B&W type steam moisture, steam generator, and an inverted -- well, the candy cane. And that is in the future planning. And I guess once that facility becomes available at modification, then more natural circulation tests with a representation closer to a B&W plant would be run.

MR. BENDER: If natural circulation is not occurring; what is the concern? Stagnation?

MR. SHERON: If natural circulation does not occur?

MR. BENDER: Yes. In making this transition back and forth, what are you trying to establish for yourself?

There are only two things we need to know--one, whether the heat's being removed from the core, and the other is whether it's being captured somewhere.

MR. SHERON: Well, the ultimate concern is that if you don't have a heat sink, what you do is you turn the whole primary system -- I guess a good representation is a pressure cooker with the safety valve being the pressure release.

MR. BENDER: You'll be boiling water away?

MR. HODGES: Yes.

MR. SHERON: Yes. And if you let it go to long the water just goes down until you're below the core. Then is when you really calculate your problem.

MR. BENDER: So, you're really trying to establish whether you can survive awhile without the water in the core boiling away?

MR. SHERON: Yes. I think Wayne will be talking about this later; won't you, on the feed and bleed which is --

MR. HODGES: Well, Bob is going to talk about that.

MR. SHERON Okay. Where you are really taking some action when you lose a heat sink such as the steam generators.

DR. ZUDANS:

If natural circulation stops then you don't have heat going through the steam generators depending on the safety injection system of the plant you either have a backup system, feed and bleed type of operation. Or you might not have that. There are a number of plants which cannot inject safety injection at high pressures and at the same time the backup be purposedly open might not be enough -- or not enough to depressurize it. In that case you would have a serious problem with core coolant in the actual surface.

MR. BENDER: Well, how about the condensation mechanism?

MR. SHERON: Re-flux.

DR. ZUDANS: The condensation mechanism is an actual circulation. As long as that one is going on in a   that's what we call a two-phase flow natural circulation.

MR. HODGES: That's one mode of it.

MR. SHERON: That refers to secondardy side.

MR. BENDER: It's a heat sink. But it doesn't necessarily have to be more than the steam generator you had when you -- it was there all the time.

MR. HODGES: No, but you had -- it has to be there. You have to have the water -- the secondardy water level to take the heat out.

DR. ZUDANS: The case in Three Mile Island, for example, was --

MR. BENDER: That's also true if the loop is solid water. You have to have the heat loop system --

MR. HODGES: Yes.

MR. BENDER: So, I think that criterium doesn't -- is irrelevant to the point. It's just a matter of whether you can -- if you get into a situation where you're boiling sometimes, and sometimes you're circulating solid water, and sometimes you're circulating a mixture, whether the heat removal mechanisms are the same.

DR. ZUDANS: That's correct. But it doesn't really matter if you have solid water or through a two-phase flow type of circulation. We do call both of those natural circulation. Different modes of natural circulation. And as long as you have that heat removal there is no problem. If for any reason you lose that heat removal, there is no heat removal in the steam generators, that's when you start to have --

MR. BENDER: Well, that's what I'm trying to find out now. The question I'm trying to ask is presuming that you get into a boiling mode some how or the other --

DR. ZUDANS: Yes.

MR. BENDER: -- and so you get into a situation where you're delivering gas or steam from one side of the system to the other, is there any reason to believe that condensation won't do the same thing that the liquid circulation system --

DR. ZUDANS: Following the Three Mile Island accident last fall, we have very carefully reviewed this question through a typical description of how will it work and some compulations which one way or another tried to simulate it. And our conclusion was that we do not see any reason -- any obvious reason why natural circulation should not take place.

In the B&W plants you have to be careful, for example, that didn't keep the water level in the secondary side. But as long as there are proper instructions for that, and those are being properly executed, then it's obvious to us that each of the systems--the should go into this mode of operation.

However, there is one problem that some of this types of natural circulation have never been demonstrated experimentally in this type of a system. So, even though just physically thinking about the problem and looking at a certain type of compulations, both tell us this will take place. There's still fear that there is a need to experimentally demonstrate that and show that it's really happening the way that we are thinking of it.

I would like to ask two questions.

CHAIRMAN CARBON: Excuse me, just a second. Still on the same --

DR. PLESSET: If you don't have permanent gas in the system, this condensation mode as a heat sink is very effective. I mean it would be expected to be, but it can be very seriously degraded if you have non-condensable gas in the system. I think that's the question of how much degradation do you get from permanent gas in the loop.

MR. BENDER: That doesn't seem to come out in this discussion. It may be true. I don't --

DR. PLESSET: If you don't have permanent gas in the loop, it's a very effective mode of heat transfer.

DR. ZUDANS: That's correct and if you have a large amount of gas in the system it would completely stop the process. But a large amount of gas would have to be large enough that you have a bubble. For example, if you think about the bond tube steam generator, you must have a large enough bubble in the candy cane that it completely balances the density difference that exists in the system. If the bubble is that large, then it could completely stop it.

We did review in some detail of how large a gas bubble could form in the system and short of any major core damage, I believe we have not looked at that, but short of any major core damage, the amount of gas that could be in the system was not enough to interrupt the natural circulation. It is documented in the various inactive cores, especially B&W.

MR. ETHERINGTON: It seems to me that the bigger question is whether the bubble is formed in the top of the

U-tube in the other types of reactor will carry over or accumulate.

DR. ZUDANS: In the U-tube type of steam generator even if you have a bubble in the U-tubes, let's assume you have a bubble in each of the U-tubes, even that would not stop the process because of this re-fluxing. The U-tube of type of steam generator, the steam would still enter the riser part of the tubes. Some condensation --

MR. ROSZTOCZY: Some condensation will take place and slow back to the top of the core. Whether the water goes to the top of the core or comes to the bottom doesn't make too much difference as long as it's going back.

MR. ETHERINGTON: But it would take less gas to make all of the tubes ineffective than it would to fill a candy cane -- wouldn't it, or am I wrong on that?

MR. ROSZTOCZY: We don't really have the data on that, but that's not obvious. That's not obvious. It's my point of action simply because there are some experiments that I will be starting now, but it appears that not all the tubes work the same way, so some tubes probably would stay open. And that may be some gas flow through, and some other tubes might have also.

MR. ETHERINGTON: So it seems to be there are two approaches that we could say that the gas doesn't have to carry over, and they're still all right. Or you can say there is enough velocity to carry the gas over which I think was the Westinghouse position at one time.

MR. ROSZTOCZY: That's correct.

DR. PLESSET: Well, let me mention what Westinghouse told us yesterday. We asked them to put all the nitrogen in the UHI accumulators into the loop, and then they calculated how much heat they could remove, and they could remove the KD by this reflex model. But there's a limit to this. I mean if you have more than that, it continued to degrade the system, but that was an example that Mr. Ebersole was very much interested in. That if we put all that nitrogen in a system what would happen.

And they did make the calculation.

MR. ROSZTOCZY: That's correct. If they would fill up the entire steam generator -- the primary side of the steam generator with gas then obviously they couldn't do it.

At one time, they gave us some round numbers. I'm not sure exactly what it was, but it was something like they need maybe three feet of the tubes or so for condensation, and that can do the job for them to relocate the heat. So as long as you have at least that much of a surface for heat transfer, it can do the job.

If you have gas in the whole steam generator, it will not lay down.

MR. EBERSOLE: What is needed to be done to demonstrate to reflux condensation with borated coolant? Is there any lay down problem in the tubes at the phase-change point?

MR. ROSZTOZY: Well there are some of the things that we would like to see from the experiments, whether any problems show up in there. Normally what you would expect

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is that the coolant would be retained more in the reactor core than in the -- not in the boiling surface more than in the coolant system --

MR. EBERSOLE: I guess what I'm saying is what degree of confidence do we have in the reflux mechanism? I recognize that that's an adequate mechanism if it works but even though you block nitro-flow in the primary load. That is I'm talking about liquid flow. But the question is how well does it work? What can be done to prove it? How well up are we in the interim period?

MR. ROSZTOCZY: We tried hard to postulate possible waste or this, and right now we don't have any which would tell us that it might stop this way or that way. The only thing that's left then is to see experimentally and see when you actually run these tests. Then you learn something new from it.

If you don't learn anything new from it, that's an indication that they do take place.

MR. EBERSOLE: Well, the other side of the coin is the feed and bleed process through an effort here in the primary loop like the primary loop valves. That's the last ditch.

MR. ROSZTOCZY: That's correct, and that can be done only on some of the --

MR. EBERSOLE: That has proved out on some.

MR. ROSZTOCZY: But you cannot do that.

MR. EBERSOLE: So we're boxed in with a need to show reflux condensation now.

MR. ROSZTOCZY: For some plants right now we are boxed in and other possibilities to put some other sort of requirement of those plants, and as you know, some of those there is no decision.

CHAIRMAN CARBON: Dr. Zudans?

DR. ZUDANS: Finally. How did you get that natural connection point line on this curve?

MR. SHERON: C & W curve, right. But you look at it.

DR. ZUDANS: But how did they get to that? How did you --

MR. SHERON: That is the elevation of the -- I believe the bottom of the candy cane. When the liquid drops below that elevation, then there's no broken flow --

DR. ZUDANS: Liquid where? Liquid in the core?

MR. SHERON: No, this is the hot leg in the big U-tuble.

MR. PLESSET: This represents an interruption of the liquid.

MR. SHERON: Right. The level drops down to below that point -- the bottom curve. There's no flow path. Okay. And that's what you're doing. You're dropping

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it below that point and so the circulation stops.

MR. ZUDANS: Correct. The second question that I wanted to ask is I understand the need for the experiment because you can learn a lot about things we just discussed. Do you anticipate that you will be able to apply the overall behavior findings from such experiments to real plants other than specific things like the position of boiler room and what not? Is there a chance to be able to scale any natural circulation experiment to the plants?

MR. PLESSET: I think it's a little different from the scaling. I think they want to really get a better grasp on the phenomenon.

MR. ZUDANS: Now, that I understand. I agree with that.

MR. PLESSET: But I don't think it's conventional scaling procedure unless they --

MR. SHERON: There are some scale questions which like -- I think the biggest one comes to mind would be the actual flow regimes in the pipes.

DR. ZUDANS: But that you could not transfer to actual plant.

MR. SHERON: Whether one has separated flow or homogeneous flow through a small pipe versus a pipe this big or through 1.9 inches in diameter. Those are some of the questions that I believe research is addressing, is looking at. I know they've done some work on it. I think Novak-Zuber is taking a look at it on that question.

DR. ZUDANS: I'm not saying that you shouldn't do tests, but my main point is that you really have an on-going test right now that's full-scale, and it's doing all kinds of funny things in Three Mile Island, the natural circulation. How much is being done to completely understand that behavior as compared to small scale tests?

MR. PLESSET: Well, Three Mile Island -- the system is full of hydrogen now --

MR. SHERON: It's full of water now.

MR. PLESSET: And I don't see where that relates to what they're trying to do now.

MR. BENDER: Heat generation rates very low.

MR. PLESSET: What?

MR. BENDER: That heat generation rate is also very low.

MR. ROSZTOCZY: Dr. Zudan, are you talking about the Three Mile Island accident -- what happened in the --

MR. ZUDANS: The working that takes place now. There's all kinds of interesting phenomenon.

MR. ROSZTOCZY: You're talking about what is being cooled today?

MR. ZUDANS: Right.

MR. HODGES: Water solid. It's water solid.

MR. ROSZTOCZY: We have looked at carefully what happened at Three Mile Island on the first day when natural circulation did not take place in Three Mile Island. Undoubtedly we have a full understanding of why it didn't take place at that time and has to do wit a high degree of voiding of the system, and that the water level was maintained on the secondary side.

Appropriate steps have been made to correct those so that different procedures for them. What kind of concepts are in the present natural circulation mode are not formally understood, and that may be one item that we should take a look at in the future.

DR. CATTON: I think the question that Zeon is raising is that you have an excellent opportunity to study single phase, natural circulation under rather bizarre conditions. And if you could predict those that would give one a lot of confidence in your ability to handle another -- I think that's the point --

MR. HODGES: The biggest uncertainty is water resistances through the loop. And you don't know what the core looked like at this point. There were calculations made, and they predicted the natural circulation flows within about ten percent which is probably amazing that they did that. I don't know.

MR. ROSZTOCZY: The work that Wayne is referring to was done a few weeks after Three Mile Island before Three Mile Island went into the natural circulation mode for careful evaluating the various cooling modes.

I am not aware of any recent calculations for Three Mile Island. I think that a point is well-taken that we should go back and we should check and see what information is available from the present cooling mode and what use we can get from that. You are right. We ought to look at that. Our main address, however, the last half of the year or so --

That's the one that we can get some data, but I fully agree with you.

CHAIRMAN CARBON: Dr. Schrock, do you have a question?

DR. SCHROCK: Yes. Can I make a statement. I've been sitting here. During the time that the accident was occurring, there was contemplation on how to get into natural circulation and how to leave the steam generators in work condition.

There was a number of calculations done. They predicted the solid phase in circulation -- single phase. And for circulation very well. And when they transferred to natural circulation, you remember that one of the loops stagnated for some reason.

The codes actually predicted that to occur. And once they knew they had an inbalance in the steam generators the codes were able to predict that they would stagnate one of the loops.

MR. SULLIVAN: And get into this other mode?

DR. SCHROCK: And get into this --

DR. CATTON: If that's the case, gee, I don't know what more you need to do other than measure flow loop resistance.

MR. GRAVES: There have been studies of this problem. Mr. Zudans is raising a point about this particular burping problem because you have part of the loop legs are in water or underwater -- they were cold. And as the idle steam generators cooling down as well, and on a period of sometimes a week, if you -- you'll have a sudden in-flow -- will flow through that idle. I don't believe that is what you're speaking of.

MR. SULLIVAN: The main concerns that I have about those is that the core blockage that wasn't effective -- it was looked at. There was also some speculation that some of the core was actually in the top of the steam generator -- speculation.

And then the effects of the loop sitting in water and how much heat loss there was from the loop to -- were in the containment building. All of these are unknown. The scatter in that data and what was assumed in the code is the only concern that I would have about calculating those.

But from those unknowns you don't know if you have tuned the code, so to speak, to the experiment. And a number of experiments were run in semi-scale about that same time. The codes did a decent job of that also.

But again, the unknown condition, the unknowns in the flow rates that they were giving us is numbers to compare to -- were the big questions.

CHAIRMAN CARBON: Fine. Thank you. I think we better move on.

DR. SCHROCK: I just had a comment concerning the case which Zoltan was addressing of the gas-bound U-tube with reflex condensation in the lower part of the inlet side o f the tubes. Under those circumstances, it seems to me you have a highly unstable situation because the vapor leaving he core now has to divide into several paths going out the hot legs through horizontal legs and then into a plenum in a steam generator, somehow distribute into a large number of tubes in the various steam generators.

The potential there for a lot of chugging sort of motion is pretty great, and I think the impact that this may have, then, on the core heat transfer is something that does need to be evaluated further and carefully.

In other words, I think the Westinghouse characterization of reflex condensation coping with this has a heat sink looking at the problem as though all of the steam arrives at the inlet to the tube bundles more or less uniformly. A few feet of tubing under those circumstances clearly is adequate, but I think it's very questionable that the steam will arise continuously in that way at all of the heat sink surfaces.

So I do feel that there is need for some more detailed consideration of what the countercurrent flow modes are in all of the segments of the loop operating in this reflex mode. That's just a comment. I don't disagree with what you said, Zoltan. I just think that the processes may be a little more complicated.

And while I don't have serious reservations that it won't work, I don't feel that we're in a position to say confidently that it is going to be an adequate heat sink situation.

MR. PLESSET: There are so many tubes, Virgil, that I think it would -- there will be some fluctuations in some of the tubes, but it will be different tubes perhaps at different times.

DR. SCHROCK: Different times -- different loops.

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DR. PLESSET: So it should be partly smooth on a gross basis, but there is a point.

DR. HODGES: Well, Harold can correct me if I'm wrong on this, but I think this is one of the modes that is proposed to be looked at in the flex-C set in about a year. Is that right, Harold? And they've got a fair amount of instrumentation in the steam generators that they will be using to measure that with.

MR. SULLIVAN: Here's a rather extensive experimental program that we're going to discuss this afternoon.

CHAIRMAN CARBON: Fine.

MR. ETHERINGTON: I think in all of this, I would like to have the criteria stated as to how much gas we're looking at. If we're looking at a very large amount of gas, then you could consider perhaps a 50/50 mixture of steam and gas in the T-routes. Then you drop the partial pressure of the steam half, you drop the saturation temperature. You may even have no temperature margins between the new saturation temperature and the water unless you also drop the water on the secondary side.

Now, if we're talking about a small amount of gas then we wouldn't have a problem of that kind. Do we have a criterion? Are we shooting for a Three Mile Island

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type of gas volume or something?

MR. HODGES: In the test?

MR. ETHERINGTON: Yes.

MR. SULLIVAN: What we're doing is looking at a significant amount of core damage that could occur so you get the gas fromthat. And also --

MR. ETHERINGTON: And how much is significant, Harold?

MR. SULLIVAN: It's not like 50 percent. It's more like ten percent of the --

MR. ETHERINGTON: Two percent. Well, there's nothing like Three Mile Island then?

MR. SULLIVAN: No. Even in Three Mile Island it was not 50 percent of the void in the system.

MR. PLESSET: Well, let me ask this question in another way. What percentage of a steam generator tube volume would you be voiding with permanent gas? What's the maximum?

MR. SULLIVAN: It all depends on how these calculations come out, and it's a pressure-sensitive number also how much --

MR. PLESSET: Yes.

MR. SULLIVAN: So we're looking at the expansion of the gas, the amount of hydrogen we can generate in a system, and we haven't decided how far we would like to carry the experiments through -- you could carry them till you covered the whole tube.

MR. PLESSET: Sure. Then you know what would happen then.

MR. SULLIVAN: Yes.

MR. BENDER: I find myself a little confused by the shifting around of the various arguments about what's going on. And I'd really like to get a little clarification. If I interpret what's been said so far, if there's no inert gas in the system, the question about heat removal -- whether it's by natural circulation or reflux condensation seem to be non-existent.

Is anybody concerned about that aspect --

MR. HODGES: They are minor.

MR. BENDER: Somebody has raised the question about whether there would be an accumulation of boron solids in the system in such a way that that might interfere with the heat transfer mechanisms in the core or in the condensor. Is that an issue that needs to be resolved?

MR. HODGES: I don't know if it's being actually looked at. I know that Three Mile Island when they started taking water samples in the loop, they got low boiling concentrations which is an indication there that they were getting a build-up of boiling in the core.

MR. BENDER: Well, I'm just asking whether it's

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something that needs to be resolved? Is that an issue? If it is, I think we need to be sure that it's addressed.

DR. PLESSET: It seems to me that what's boiling off the core or going into the steam generator would be lower in boron all the time.

MR. HODGES: Yeah.

DR. PLESSET: It would be almost impossible to have it otherwise.

MR. EBERSOLE: Doesn't that presuppose, though, a control level in the primary with a pre-steam parting surface above the core someplace when, as a matter of fact, the present PWR's don't have any way of knowing where the primary coolant is. And the steam to water interphase might well be in the tubes where the finished change occurs. We don't have any level indication in current PWR.

MR. HODGES: No, that's right.

MR. EBERSOLE: And it seems that one has to discriminate as to whether we've got an idealized situation in boiling with an adequate cover of water above the core in a parting surface. Yes, you would always have the concentration in the core that on the other hand perhaps that parting surface is in the tube itself. It still may be all right if it's really reflux instead of partial carry-over because it would tend to be -- the reflux process

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would stabilize it.

MR. BENDER: Well, that question needs to be sorted out. I'm just trying to define the question because I'm getting mixed up. The third question that seems to be plaguing all of us is the matter of the sources of inert gas and how you decide how much of it has to be addressed.

And I'm not right now very clear on either what the sources are; when they occur; or how you decide on the volume of it. Now, Mr. Etherington has addressed it ina slightly different way. He just said, well, look, what are you trying to assume at the condensing side of the system.

But I'd like to know how you're going to determine what the sources of inert gas so you can make that determination.

MR. SHERON: Last October, I believe I gave a presentation, and I don't have my slides with me.

MR. BENDER: I may have the slides you need.

MR. SHERON: Okay. But we did identify what we considered to be the dominant sources of non-condensable gases in the primary system. How much gas we would expect to get from each source if it all came out of solution and how much volume it would occupy; the accident pressures that we would expect should it accumulate in the wrong place like at the top of the candy cane.

17 I'm trying to remember. There were about seven or eight sources.

MR. EBERSOLE: Ten. Fits in the B&W plant less the UHI -- it's page 470 of NU REG 0565 --

MR. BENDER: I don't want an answer here, but I think we need a quantification of those things -- we need to know what the basis is for assuming they come out and how fast they ought to come out and what -- what ways there are to purge them.

MR. SHERON: This was a calculation I did up. This is the amount of non-condensable gas volume in the primary system in terms of cubic feet versus the system pressure, I believe. And let's see, total non-condensable gas volume -- I've separated out what comes from the -- if one assumes that water in the boiling water storage tank was saturated with air, I assumed a tenth of a percent surf water reaction, and also the dissolved hydrogen in the primary system coming out. And then there was also the contribution of the dissolved nitrogen in the core flood tank should they inject.

MR. BENDER: And what does all that tell me?

MR. SHERON: Okay. That tells you and you'll note this is for a B&W plant -- and the volume of hot leg U-bends -- in other words, the top -- is approximately 170 cubic feet.

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So what this says is that if all the gas that could possibly either come out of solution or be injected into the system and come out a solution for some reason -- for some reason all accumulated at the top of the candy cane, then this says when one would perhaps calculate, it would block natural circulation. Namely, fill up that volume.

MR. BENDER: Assuming a limited amount of exposed surface available for condensation?

MR. SHERON: This is just as a function of system pressure. This just says --

MR. BENDER: Then it doesn't address the question. I guess it's hard for me to follow the thinking. But the question that seems to be necessary to address is the matter if there's boiling on one side of the system, can there be condensation on the other side of the system. And will that maintain some kind of condition where you have a stable inventory of water?

MR. SHERON: There are two ways that non-condensables affect the primary system of behavior. One is it can degrade the transfer, and two is that it can essentially block the flow path.

DR. CATTON: This is block the flow path.

MR. SHERON: This is block the flow path. The vendors have done analyses where they have degraded heat transfer to the tune of, I think, reduce the heat transfer coefficients in the steam generator by something like 20/30 percent.

And they have showed that the only thing that would be expected would be a slight pressurization on the primary side, say, 10 PSI higher than would normally be expected with the system pressure comes down, and it can equilibrate slightly above the secondary side pressure.

DR. CATTON: Boron gas has a lot stronger effect than that on condensation normally.

MR. BAER: Remember you have steam generators that are 30 times or 50 times oversized.

DR. CATTON: Now, wait a minute. He said they decreased the heat transfer --

MR. SHERON: Coefficient.

DR. CATTON; Coefficient.

MR. SHERON: But the area is huge. I mean these -- I mean you're removing, perhaps, two to three percent KE. And the heat transfer area is oversized at 100 percent.

DR. CATTON: When do they do the HA, the product?

MR. SHERON: H was decreased by 20 percent.

DR. CATTON: What do they do? Increase the area?

DR. SHERON: No. The area is there. The area is affected.

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DR. THEOFANOUS: Well, he's telling you that this is --

DR. SHERON: Well, I'm saying that the Product HA, regardless of reducing H -- varies the two -- reducing it 20 percent --

DR. CATTON: I understand you've cut the heat transfer coefficient in half and you double the area of the same --

MR. SHERON: It isn't double the area. The area stays the same. The area available for heat transfer is the same. The point is that regardless of whether the product of HA or one-half HA is used, the delta-T necessary to remove the Q has only gone up maybe a couple degrees.

DR. ZUDANS: If you have the A.

MR. SHERON: And at those pressures, a ten degree increase in temperature, let's say, necessary -- not even ten degrees. But say two or three degrees increase in primary site temperature necessary to remove the KE because of the degraded H will increase the primary site pressure only by perhaps 20, 50 PSI at the most.

DR. CATTON: The picture you're giving is incomplete. What was the heat transfer coefficient before? What was it based on? And what does inert gas to do it? If the inert gas halves it, then that's not 20 percent. That's 50 percent. See?

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And inert gas can decrease the condensation heat transfer coefficient significantly. It's not 20 percent. It's a hell of a lot more --

MR. GRAVES: I know. What Bryan is trying to show us is sort of following. Let's go back to the solid work as just a start. And if you are the point if you remove the KE, and you're going to have a hot leg going up --

DR. CATTON: I understand that.

MR. GRAVES: It's aux feet design. You reach a cold leg temperature in very short distance. All the rest of the distance, there is essentially no heat raise. You drop to the cold leg temperature very rapidly. That's one reason why they get really high circulation rates. That's why they put the other reading up there.

So in terms of a temperature profile and a primary size, you go through these steam generators come in in the hot leg and drop very rapidly down to the cold leg temperature and remain there.

Now, that heat transfer is there. This time it's being used.

DR. CATTON: So what you're saying is that you can stand a great deal of degradation of the heat transfer coefficient because you have the surface area?

DR. GRAVES: That's right.

DR. CATTON: That's understandable. But now --

then the next question is how much can you degrade it before you do indeed get into the core --

MR. GRAVES: That's a good point, too, because the fact that the non-condensable is an H is a very drastic. It can be very drastic --

DR. CATTON: I think that just an arbitrary decrease of 20 percent doesn't tell me anything.

MR. SHERON: Well, I think they're trying to show the effect of -- and that is what does the degrading the heat transfer do? And when you degrade the heat transfer, it means that you need a larger driving potential to get the heat out.

DR. CATTON: I understand that.

DR. SHERON: That just causes the primary system on a small break when you're in this mode -- when it decreases, and it levels out slightly above the secondary site pressure -- okay -- that -- that pressure that it levels out at will be slightly higher. And that's all it means.

That it will level out at a higher pressure necessary to drive -- to establish this driving temperature differential to remove the decay heat.

DR. SCHROCK: Bryan, I would just say that Ivan is right in his first comment in that the exercise is a worthy one, but the assumptions should have been an order of magnitude of the temperature in the heat transfer coefficient. And then the case may be argued making a case for the 20 percent reduction in the coefficient --

MR. SHERON: Well, but the reduction was based on the normal, I guess, textbook principles.

MR. ETHERINGTON: Yeah. But on what gas fraction?

MR. SHERON: On -- based on the gas fraction.

MR. ETHERINGTON: But what was the gas fraction?

MR. SHERON: I don't have the numbers. They were based on -- I believe the gas that would be normally expected to -- if it was all came out of solution --

MR. ETHERINGTON: Yeah. But if we're talking textbooks, we must talk gas fraction rather than total.

MR. SHERON: Well, they took the gas that would be expected to come out of solution -- it all came out of solution for that size break. And they used it, and they distributed it in the steam generator.

DR. CATTON: There was more to it than that. If I recall -- and I can't -- I don't want -- I don't recall which vendor. But they used the wrong correlation in the wrong place and came to these conclusions. They had flow through tubes -- flow through condensing tube. And they used these relationships. And those relationships are just flat wrong. They don't apply in any way to it at all, and yet they were used.

They said don't argue that the 20 percent was based on textbook case of anything. It wasn't. It may have been, but it's the wrong textbook.

DF. SHERON: In our reports we requested that they confirm the condensation of the plant from models they used, and of course in non-condensables.

DR. CATTON: I get a very funny feeling when people are using wrong geometry, wrong correlations and arguing, but gee, they seem to do all right. That says the don't understand the physics at all. So any conclusions they reach it better be very narrow.

MR. BAER: Well, the problem with that is that there is an experimental data on condensation with non-condensables, and it's limited to very select geometry. Flat lights, vertical flat lights, vertical tubes that are outside, horizontal tubes on the outside --

DR. CATTON: But this particular case is more simple.

MR. BAER: And of course, flow through the inside of the tubes, and that's what you're referring to.

DR. CATTON: Yeah. And B&W you've got the tube that's deadheaded down where the condensation process is occurring. That's what the step -- that thing will practically shut itself off if you get enough gas in it.

If you continue to collect it where the

condensation process is occurring. Not as bad for the U-tube because it can escape up in the tube.

MR. BAER: Well, we have recommended then the tests on this particular geometry. There are no tests.

DR. CATTON: Okay.

CHAIRMAN CARBON: We've got to -- where do you think you stand, Wayne, in terms of our time schedule here?

MR. HODGES: Okay. We've taken a lot longer than I had planned. We can skip over the next few slides very, very easily. They were just there to show that there had been some two-phase work done a long time ago, but it's not very applicable so we can skip on over that and go into the --

CHAIRMAN CARBON: Let me still ask you, though, on this agenda -- which A, 1, 2, 3, 4 -- where do you stand?

MR. HODGES: I'll have to get out my agenda.

CHAIRMAN CARBON: Are you covering all of item A?

MR. HODGES: I'm covering all of item A and I'm just about down to the item 3 -- if we skip the next few slides, I'm down to item 3.

CHAIRMAN CARBON: Does that say we're halfway through or --

MR. HODGES: I hope it says we're a lot more than halfway through. We've over half my slides.

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CHAIRMAN CARBON: Okay. Maybe we better take a break at this point, and --

MR. HODGES: Okay.

(Whereupon, a short recess was taken.)

CHAIRMAN CARBON: Before you begin, Mr. Hodges, let me call on Mr. Bender.

MR. BENDER: I wanted to just get back to the definition of the issues a little bit. It seems to me that we have two kinds of problems to address. One has to do with the question of what to do about maintaining the natural circulation condition under the circumstances which normally occur in a plant operation.

Namely, when the plant shuts down because of loss of off-site power or some such thing as that, and whether we can show that we can maintain the cooling under those conditions.

And I think everybody recognizes that as an important factor that where we have to maintain natural circulation. There's a second phenomenon that we have talked about that has to do with the conditions that might arise when we get non-condensables in the system.

Now, that generally will be associated with times when boiling may have also started. And when we may be shifting back and forth from one phenomenon to another.

That needs to be sorted out separately. Now, the one thing that seems to be hanging up is the question of non-condensables and how they move around the system and where they come from.

And I'd like to separate that into two pieces. The non-condensables that exist prior to any metal water reactions because we're really trying to show that we can prevent the metal water reactions from occurring.

And then perhaps somebody wants to know what happens if the metal water reaction occurs. And it seems to me when you guys present your story that we should hear it presented in that kind of a formulation where the various steps that go on in the process are affected by the system condition. And I want to stop there. Thank you.

MR. HODGES: Okay. I'll have to apologize for presenting it in a confusing manner to you. I was not trying to present this is the whole story, and this is how we're approaching it; but more in the sense that there are concerns there. We don't have the answers yet. We've gone to research, and so I was just trying to run through some of that very hurriedly and maybe that's the source of the confusion.

This was not a presentation per se on the various modes and how much gas you get. There have been other

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presentations to the committee that talk about how much gas you get and under -- from the nitrogen in the accumulator and from coming out of solution, whatever.

DR. THEOFANOUS: When it's only a matter of confusion -- I think what I -- I share the same concern with Mr. Bender. It's a matter of giving the impression that maybe we are in much worse shape than what really we are. It would be safe to say we have this question and that question and many unanswered questions. The problem is general context.

Although some of those questions might be very valid, they give somebody with the impression that they may be in much worse shape than reality. The guy was giving a pessimistic view of the real situation. That's where this putting it by levels would help us.

MR. HODGES: Okay. Okay. We often do that.

MR. ROSZTOCZY: Mr. Bender, the two contacts orders which you outlined -- one of those -- the one without any appreciable fusions has been reviewed, and that has been documented in the various NU REG reports. The B&W, Westinghouse and NU REG reports.

So that part we think is physically complete at the present time. The second part -- what happens if you go a step further and you start to have some appreciable core damage, just what has been only addressed in a rather

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simplified fashion up to now -- there isn't a tremendous amount of information on that. So that may be the one that needs a little bit more.

MR. EBERSOLE: Zoltan, an aspect of the first group -- did that take into consideration the UHI plants and lay to rest one way or another whether or not we must consider the presence of gases in the UHI system?

MR. ROSZTOCZY: I'm sorry. I didn't hear.

MR. EBERSOLE: Did that take into account the presence of the UHI-Westinghouse design and lay to rest whether or not we're going to have to deal with some portion of the UHI gases?

MR. ROSZTOCZY: No. That evaluation -- original evaluation when they do the statistical evaluation certainly did not include the UHI design. But the UHI design is presently under review as it was presented to you yesterday. And the safety evaluation which we have come out as a result of that review, that safety evaluation is going to address the same problem for the UHI.

MR. EBERSOLE: Yeah. Thank you.

MR. HODGES: Okay. In the interest of time, you can skip over about the next four slides that were in the package. They're just referring to a paper that was written by some people from Bettis on some natural circulation tests they did under two phase conditions. If you'll look at the first slide, it gives you the reference to the paper, and there's a few figures in there. You can look it up yourself. It's relatively interesting so that if you know all the resistances real well, you can do a fair job of predicting.

If you don't, you can't. And that's the bottom line from those slides. We'll go now to the natural circulation guidelines slide. And these are really guidelines for looking at the water solid situation. These are the normal situations for like loss of off-site power.

And what the operator is doing -- he's verifying reactor trip, make sure -- if he's lost off-site power he's starting the diesel generators. There find that he's got some core flow looking at his delta-T's.

So there's nothing fancy -- nothing, you know -- exotic that he's doing at this particular time.

MR. EBERSOLE: Pardon me. This is all idealized. Suppose where it says down here minimize reduction of direct cool by minimizing cool down. Suppose he's got a stuck bypass?

MR. HODGES: Okay.

MR. EBERSOLE: You see this is two sterilized. It's clean --

MR. HODGES: Well, that's like a steam line break. All right. And the same sort of thing happens. You get natural circulation. You're getting a cool down. Yeah. This is ideal. And the other slide will talk about contingencies and what to do if you don't satisfy these.

MR. EBERSOLE: All right. This is extrapolated then into more details.

MR. HODGES: Yeah.

MR. EBERSOLE: Life gets more complex.

MR. HODGES: Yeah. There's some other slides here. Again, this is just an indication of what instrumentation the operator has available to him for detecting natural circulation and assuring that he satisfied all the conditions for the prerequisite for natural circulation.

He's looking at the incore thermocouples. He's looking at the temperature drop across the core. He's read on his hot leg and his cold leg temperature. He's making sure that he's at pressure and has a water level and a pressurizer, a steam pressure, and the level of the water and the steam generators.

There's indication that he has heat removal. The Delta-T across the core is less than his full power Delta-T. There's a steady or decreased seen reactor coolant system temperature and that the steam pressure is relatively constant or increasing, and his incore thermo-

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couples are constant or decreasing. If those conditions are satisfied then he can be certain that he's getting cooling. He's got no particular problem.

This is some examples of prerequisites that have been spelled out by combustion engineering for their operators that the pressure has got to be greater than the saturation pressure for the hot leg temperature and the pressurizer temperature greater than the hot leg temperature. And the steam generator level in the normal operating range.

So these are the kind of conditions that are spelled out for the operator.

MR. ETHERINGTON: We're no longer using the 50 degrees subcooling and --

MR. HODGES: Well, these are some old guidelines. So the numbers may have changed slightly.

MR. HODGES: -- if it hasn't satified his conditions, these are some corrective actions you can take. Energize the pressurizer heaters, increase steam generator flow, maintain this level within range.

Basically he's controlling pressurizer pressure and level with make up and his heaters a:d for the pressurizer sprav. And he's maintaining the steam generator level with his feed water.

DR. ZUDANS: Is there any instruction that goes along to help operater to decide whether indication of pressurizer level is valid or questionable?

MR. HODGES: He's told to look at both his pressure and his level.

DR. ZUDANS: Okay.

MR. HODGES: And if his pressures are in the normal range, then he assumes that his level is okay.

And verification of the natural circulation, again is delegated across the core is less than the full power Delta-T within 10 minutes after tripping the pumps, and its out-leg temperature is constantly decreasing.

This number 3 power in the flow ratio of less than one. That's essentially the same thing as the Delta-T of being less than the full power ratio.

And if we can't verify it, natural circulation he goes back and tries to establish his water level and steam generators and his pressurizer pressure and level and make sure he can get it.

MR. ETHERINGTON: Does he have any instructions on the steam generator pressure?

MR. HODGES: I don't think so.

MR. ETHERINGTON: I didn't want to know what they were. I just --

MR. HODGES: No, I don't think so.

I don't recall any.

MR. BENDER: Now, these instructions apply to a liquid system.

MR. HODGES: Yes. Yes, sir.

MR. BENDER: To no other system?

MR. HODGES: Once you get into the two phase situation, it's different. He doesn't have the same kind of indications.

MR. BENDER: I just wanted to be sure it was on the record. I don't have any other reason for raising it.

MR. HODGES: I tried to say that at the outset, but it doesn't hurt to repeat it.

DR. ZUDANS: Is this -- how is this power to flow ratio defined at this stage?

MR. HODGES: Basically, this power flow ratio of full power would be one. So if it's Delta-T is less than that at full power, he's satisified this required here.

DR. ZUDANS: Just by the fact that Delta-T is less than full power, has nothing to do with flow.

MR. HODGES: That's really the only indication he's got.

DR. ZUDANS: But then it's a wrong name.

MR. HODGES: It's a wrong name.

DR. ZUDANS: It's a wrong name.

MR. HODGES: Well, he's got flow meters, but they're down at the low end of the range and he can't really measure very accurately with those.

This is basically what he's got. Is the Delta-T.

DR. CATTON: Is that --

MR. ETHERINGTON: I'm not quite clear. What is a numerator and what is denominator in these ratio there?

MR. HODGES: Okay. You've got to have some constant out front to take care of the units. Okay.

You define it as one at full power. The power in a delta-t -- a delta-t power and a flow. with a constant out front to take care of the units.

VOICE: Well, it's a delta-t ratio then?

DR. CATTON: It's just delta-t.

MR. HODGES: Just delta-t. Yes. That's really all it is.

MR. ETHERINGTON: Well, it's got to be a ratio to be less than one, hasn't it?

DR. ZUDANS: Except it's delta-t to delta-t ratio.

CHAIRMAN CARBON: In fact that when is the delta-t less than it was?

DR. ZUDANS: That's right. And the power to flow ratio could be.

MR. HODGES: You've got specific heat and you've got some other constants to take care of the units.

DR. ZUDANS: Okay. That's all right.

DR. THEOFANOUS: To simplify it, where do you say delta-t over delta-t?

MR. HODGES: Well, it's a delta-t -- we have a delta-t at full power is what it boils down to.

DR. ZUDANS: Which is the same as acting one in this case.

DR. LIENHARD: That's assuming a constant flow rate?

MR. HODGES: No, no. What that assumes is when you drop down on natural circulation that the ratio of the flow to the power is larger than the ratio of the flow to power at full power. So, you know --

DR. ZUDANS: Without knowing what the flow is.

MR. HODGES: That's all.

MR. ETHERINGTON: Even now, it's not clear the difference between one and two. One -- that condition has to be met after --

VOICE: There isn't any difference.

MR. HODGES: That's what I'm trying to say. They're essentially the same.

MR. ETHERINGTON: I see. Except that the 10 minutes doesn't mean anything then? It has to be less than that all the time?

MR. HODGES: Well, all the time is maybe -- I'm not sure it would be. It might be. I'd have to think about that a minute.

MR. ETHERINGTON: No, it wouldn't be for the first minute, of course.

MR. HODGES: I'd have to think about that a minute. You've got some lag in what the thermo couples are reading, you know, and so it may slightly larger for a few minutes. So all the time is maybe too strong a statement.

And again, just the conditions the operator had used to satisfy that he had gotten natural circulation. Same thing as you saw in the previous slide.

DR. ZUDANS: In this next slide that you just skipped so fast, I didn't even have a chance to turn my head.

MR. HODGES: Okay.

DR. ZUDANS: You still have the same item 2 there that's equivalent to item 3.

MR. HODGES: Well, the reason I skipped it so fast. It's basically the same item. Just now it just says the operator is looking for these. That's all.

DR. ZUDANS: Well, how can he look for something that he doesn't have information on? That's what bothers me.

DR. CATTON: You have to make calculations, right?

DR. ZUDANS: No.

MR. HODGES: No.

DR. THEOFANOUS: He's got it out of here, I --

MR. HODGES: All he's doing is reading his delta-t's.

DR. CATTON: Well, I understand if he were -- if he were to want to find power to flow ratio, he'd have to make a calculation.

VOICE: Yes, but he doesn't want that. That's in the blueprint.

MR. HODGES: That's all he's really doing, is looking for his delta-t. He makes sure he's got his pressurizer level and range and that his pressure's in range, that he's got a level in the steam generator. And he looks at his delta-t.

If those are all satisfactory, he's happy. He's

He's gotten that to circulation.

That's what all that means. If it boils down to simple terms, that's what it all means. These are the criteria that have been spelled out by combustion and in simpler forms, that's what it is.

MR. EBERSOLE: I see three blocks up there that say corrective action.

MR. HODGES: Yes.

MR. EBERSOLE: Implicit in each one of them is that corrective action would be found and respiration will be accomplished.

MR. HODGES: The corrective actions we went through on a previous slide. This was adjusting the steam generator levels, modifying the pressure.

MR. EBERSOLE: I notice in none of those -- there's no apparent attempt to treat the low pressure and get a RHR by depressurizing secondary.

MR. HODGES: No.

MR. EBERSOLE: And starting some to get on down.

In short, PWR's don't attempt to do what the BWR does routinely. To get the low pressures going --

MR. HODGES: The BWR, if you got an event and if you think you can get a loss of power, if you think you can get it back in a few minutes, he's going to stay

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at high pressure with his IC.

MR. EBERSOLE: Yes, this is all anticipate you're going to get back on it.

MR. HODGES: Yeah. And the BWR does the same thing.

MR. EBERSOLE: So this is all preconditioned on the idea of let's stay hot and pressurized so I can get back on the line.

MR. HODGES: Sure.

And the BWR does the same thing.

MR. EBERSOLE: It is not really an emergency level condition.

MR. HODGES: No.

MR. ROSZTOCZY: Dr. Ebersole, even if it's an energistic combination, they have presently the procedures are set up for the BWR in two different steps.

It's one step just to stablize the conditions following a small attack of feedine, and they had a feedine procedure for that.

What you are hearing here is about that procedure. They have a separate -- a completely separate other procedure, how to depressurize the track and how to go --

MR. HODGES: That's right.

MR. ROSZTOCZY: -- over there to

MR. EBERSOLE: All right. This is the more important area.

MR. ROSZTOCZY: And at the end of this procedure, stands, everything is stable, then go to another procedure.

MR. EBERSOLE: All right.

MR. HODGES: All right.

MR. EBERSOLE: Thank you.

MR. HODGES: Okay. Yes, I was not trying to cover the -- all the many different procedures. We were talking only about the natural circulation.

Okay?

And this is just a logic training he would go through to verify it, or if he doesn't have it, to make the corrections so that he does have it.

Just put in a flow box form what we had on a previous line.

This is basically the type of training that the operator would get in learning to detect natural circulation. This is from -- is work done on the simulator at Zion. They run through a bunch of events. They look for station black-out, tube rupture, feedline break, steamline break. And the operator gets to recognize it. And he sees what his indications are the delta-t.

And he learns to cope with it. Maintaining his water level and such.

And that's been the extent of the training that

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he's had on natural circulation, is going through these kinds of events.

MR. EBERSOLE: That's anticipated events?

MR. HODGES: Yes, sir. And they lead to natural circulation

MR. EBERSOLE: Right.

MR. HODGES: And so he's learned to --

MR. EBERSOLE: He's trained in anticipated recovery. I mean recovery from anticipating.

MR. HODGES: Yes. Yes. But --

Yes, sir?

DR. LIENHARD: I've been reading a lot of stuff in the popular press about the lack of preparation of operators. That they include high school drop-outs and so on and so forth.

What -- what level of capability are we really talking about when we talk about operators?

What do operators know before they start learning these things?

MR. HODGES: Well, okay, I'm maybe not the best one to talk about operator qualifications, but basically, he can be a high school graduate.

All right? And then he goes through a fairly -- several months training in reactor systems, a little bit of reactor theory.

He's had to sit down and memorize all sort so of systems, and then he goes into a simulator and he learns to manipulate the valves.

But it's over a period of several months.

MR. ROSZTOCZY: In terms of actual requirement it's only a high school graduate and then approximately 2 years training program.

In terms of actuality, where the operators come from turns out that most of them -- something like 60% or so comes from the Navy.

They already went through on their Navy experience, nuclear ships, nuclear submarine type of experience, after, when they then they enter into the program.

I am not an expert on this, but I did some review for Three Mile Island, the operators who were involved there. Almost all of them who were involved there, had Navy experience.

DR. LIENHARD: Are there intelligence requirements?

MR. ROSZTOCZY: Sir?

DR. LIENHARD: Are there basic intelligence requirements?

MR. ROSZTOCZY: The two years training, what they go through includes a number of exams and so on. So I assume that if somebody is not doing that would be some kind of screening process.

MR. HODGES: Yes.

MR. ROSZTOCZY: This is all for the past. In the future, there will be some changes in this -- there would be higher requirements.

DR. LIENHARD: My reason for asking was I just wondered whether or not, you know, on what level this stuff is learnable.

MR. HODGES: It's not too bad. Most -- for the simple things like this --

I went through a one-week simulator course, and I can almost do it. So, you know, you give somebody a couple of years in the plant working up as an auxillary operator and you give him 6 months or ever how much it takes to go through his training, plus, you know, several weeks on the simulator -- maybe 6 weeks. I don't know the actual amount of time on a simulator.

And if he's moderately bright, he can do it.

DR. LIENHARD: These procedures call for no diagnostic capabilities, really.

MR. HODGES: They ask him to diagnose what type of vent he has.

DR. LIENHARD: I see.

MR. HODGES: But he's memorized symptoms.

DR. LIENHARD: I see. Thank you. Kinda like an M.D.

[Laughter]

MR. BENDER: This simulator program doesn't address on/off activities that the feed water are assisting does it?

MR. HODGES: Does not address what?

MR. BENDER: On/off kinds of activities that the feed water supplies?

MR. HODGES: You mean, like failure to feed water supply?

MR. BENDER: Yes. Being off and on for periods of time. Like occurred at TMI. That was a situation where the feed water --

MR. HODGES: The simulator training, you know -- the plant behaves or the simulator behaves like they think the plant would behave under various events.

You look at different failures. It's not normally a combination of failures, although they can program those in there.

They look at typical kinds of transients.

MR. EBERSOLE: Well, simulator program is built on the thesis that the single failure criteria will always work.

MR. HODGES: Reasonably so, yes.

MR. EBERSOLE: And when it won't work, the program falls apart.

MR. SHERON: Right now, if they lose all feed water in the gazzle while they're in the midst of this, certain indications should appear to the operator which he is trained to recognize as symptoms of inadequate core cooling.

And he will be moved right to a procedure aimed at dealing with inadequate core cooling and ways in which -- what steps should be taken, what systems should be verified to be your on or off, or to take necessary actions.

MR. EBERSOLE: Those are the new programs. Not the old. That did not exist previously.

MR. SHERON: Yes, they did not exist previously.

MR. EBERSOLE: Right.

MR. SHERON: But the inadequate core cooling procedures, as I understand are -- the guidelines are established, and I believe the procedures are being developed if they're not already in place at some plants.

MR. BENDER: But they're not observable through the simulator training program at the moment if I understand what you're saying.

MR. HODGES: You know, it depends upon the capability of the different simulators. Some simulators can and some can't.

I've visited the one at Dresden for the BWR's.

It'll do some things. It won't simulate a small break. I've -- the Brownsferry simulator, it will do a fair job of simulating small breaks up to a point. I've done -- I had a week on the one for Sequoyah. It'll handle small breaks up to a point.

After a while, the modeling breaks down, and you know, you start getting garbage.

MR. BENDER: Well, I asked about the feed water supplies. Are the simulating --

MR. HODGES: Yes.

MR. BENDER: -- feed water changes?

MR. HODGES: Oh, yeah. You know, you're regulating the feed flow. You got the off-feed system simulated. All that's is simulated, and you could simulate easily enough cutting it on and off.

MR. ROSZTOCZY: I think the answer there is the same that it's different on the individual simulators. Some of the simulators have all of these strange things and accidents marked up, in a somewhat simplified way just like a computer, in the simulator system.

Some of them do not. Some of them have simply programmed curves into the simulator which came from some safety --

So a simulator, which let's say for a loss of cool off accident, has programmed curves rather than programming the physics in that won't be able to do it.

You have to generate another set of curve and then somehow program that into a simulator that others can do it.

Now, the others who can do, whether they give the correct VR's to you, that's very questionable. Cause at the time when they dealed with this, it was not one of the requirements. It was not checked for that, and those models have to be checked before somebody actually using it for training.

MR. BENDER: Well, this might be a side issue and I don't want to pursue it, but one of the things that keeps going through my mind is, what has the operator seen before that would help him recognize these transients besides a written procedures?

And if he's well enough trained, he may not need to see those things. But if he's not able to absorb it, because his analytical skill is not well enou h developed, then the only thing he can do is look at symptoms he's seen before.

MR. ROSZTOCZY: And we agree with you completely, and one of our recommendations was that simulators in the future should simulate to grievance in those same reports that I referenced earlier. Those reports have -- even in in connection with the small low cover they think they should simulate.

One of those is the small loss of coolant accident, together with the loss of feed water. One is with the wasn't working. And anyway working continuously or for a periodically, and the other one is assuming that you don't get what we are saying, even that much would be simulated in the future.

MR. HODGES: But even under the old training, he has seen on a simulator a fairly wide range of transients. And accidents. So he's -- the symptoms are what the analysts have told them they would be for those events that had not been experienced.

And that's what is programmed into the machine, and that's what he's looking for.

DR. CATTON: In this latter case, wasn't that one of the bulletins and orders to be solved by 1 July?

MR. ROSZTOCZY: All of those dates which originally appeared in some of our presentations and the reports, are being reconsidered as part of the TMI Action Plan. The Action principles put together recommendations from different task forces and from other areas prioritize them and arrange them in an order.

So the Action Plan comes up, we'll have probably a new set of dates. Some of them might be close to the one that was originally recommended. Some of them might be quite different.

CHAIRMAN CARBON: Dr. Zudans?

DR. ZUDANS: Yes. Did I understand from other presentations that they were sub-submitted, the date, something like actual real timing and consideration of certain simplified different deliberations?

MR. HODGES: Oh, yes.

DR. ZUDANS: That is now?

MR. HODGES: Yes.

MR. ROSZTOCZY: You still can do that.

DR. ZUDANS: That's really the question of expanding that capability to include more systems.

MR. HODGES: And basically what they do on those, they've got a simplied equations, and then they'll go through and from start up data on a plant and transients that observe. Then they'll start tuning the simulator to -- to match those.

DR. ZUDANS: That is probably the way to go at it.

CHAIRMAN CARBON: Move ahead then, Mr. Hodges.

MR. HODGES: Okay. I'm very near the end now. Basically one of your comments, or one of your questions was on the adequacy of the instrumentation for detecting natural circulation. And we've talked about what's there under the case where it's water solid, and that appears to be a reasonable amount of instrumentation for that application.

All he needs to do is verify his core delta-t, his less than full power delta-t, verified it as pressure and his pressurizer levels are in a normal range and that a steam generator level are in the normal range.

When you go to this accident situation, where you've got saturated liquid, he doesn't necessarily know where the level is in the core. He doesn't know whether he's got a break or not, so he can't rely strictly upon the heat balance from his steam generators.

You know, it's much more difficult to try to assess whether or not he's got natural circulation. If his cold leg is near saturation, he's got no delta-t across the core.

The only real indication then is -- are his in-core thermo cupples heating up to superheat. If he is, he knows he's got troubles.

But it's pretty weak at this point.

My final slide talks about some of the -- what's planned for the future.

Under the Action Plan, the K-heat is -- or the K-heat removal is one of the items --

We'll have to move it down as we go.

The objective there is to improve the reliability and capability of the nuclear power plant systems, to remove decay heat following transients and under post-accident conditions.

And then under the actions, we've got a couple of recommendations by the Lessons Learned Task Force, upgrade the heater supplies. Put it on an emergency power and establish new procedures and training for maintaining the reactor at stand-by conditions.

Also start looking at the generic study of the capabilities and reliabilities of the shut-down removal system under various conditions.

And finally to look at alternate concepts for heat removal. As an example, would you want to put an isolation condenser on a PWR?

There are many to be looked at and really the work is just getting started.

That's all I have for my presentation.

CHAIRMAN CARBON: Fine, thank you, Mr. Hodges.

[OFF THE RECORD]

CHAIRMAN CARBON: Anything that you could do to speed up --

MR. BAER: Well, I was going to start with an introduction that might slip five slides. I was going to talk about two things. The status of the review of the Sequoyah Low Power Test Program, and a little bit on bleed and feed.

The status on Sequoyah really hasn't changed very much since we've last talked to the full committee on this matter. We have done a preliminary -- we've written an SER, which is basically a status report, going over their test program, and pointed out that there are several things that must be submitted for staff review prior to the initiation of the test program.

And those were (1) a safety analysis for the test program they propose for each test.

And (2) was -- although they have -- although the TVA has provided us with a fairly detailed procedures on each test program, on each individual test, we had comments on those, but more importantly, we asked for a master document that was more or less a road map through the tests, the sequence, and clearly stated what procedures and what instructions applied during the conduct of the test and between tests.

Because the procedures were written to be used in conjunction with the normal plant procedures. So that we were, at least, a little bit confused and we want to make sure that we understood it better and that the applicant and the operators would understand it clearly.

Those were the two main conditions. Now, TVA hopes to submit that information this week. It may be on my desk today.

I talked to them yesterday and they thought today or tomorrow that it would be physically in our hands. Since we haven't had the information, we haven't, obviously, done any review.

If the sub-committee would like, I have a bunch of slides running through the program that TVA proposed, the criteria we used to evaluate it and a little more detail on the status in each aspect.

So at your discretion whether we do that or not.

CHAIRMAN CARBON: I think unless anyone's quite interested, we'll defer it.

MR. BAER: I guess I ought to point out one other thing. Is that all the tests proposed by TVA are single phased, all liquid natural circulation.

Some of them, several we think, are interesting demonstrations. Probably the key one is simulated loss of all AC power, both off-site and on-site. A simulation. They won't be tripping -- keeping water to reactor coolant pump seals and things like that, so there won't be any equipment damage.

These are, we t[illegible] [illegible]y useful in terms of training, but I don't think we or an[illegible]body else has made a point that it's going to answer the sort of questions that the sub-committee raised this morning.

DR. CATTON: There's some other parts to the question. We heard this morning, little we really knew about the state of affairs other than the delta-t. Are you going to make any changes in instrumentation of either North Anna II or Sequoya in order that, when you get the results, you know where you're at?

Like flow meters in the speed water system that read in the ranges you want? And so forth?

MR. BAER: There is some supplemental instrumentation, but not a whole lot.

DR. CATTON: Could you tell us what it is? We can't -- I'm wondering why bother, unless you do something that'll make it --

MR. BAER: The major purpose to my mind was additional training for the operators. Now there's a bunch of preliminary tests which -- I look at, anyhow, as a step toward these more significant tests, like loss of all AC power. Like doing some boron mixing and cool down experiments in natural circulation.

DR. CATTON: But are you going to instrument --

MR. BAER: Not to any --

DR. CATTON: -- any further things --

MR. BAER: They're going to be recording somewhat more data than they would in a normal plant, but they are not -- I don't believe -- adding much instrumentation.

We do have a TVA -- where did Lambert go? We had a TVA representative here earlier.

DR. CATTON: The answer that I'm getting is that, gee, we're really not going to do much.

CHAIRMAN CARBON: He said that specifically.

DR. CATTON: Yes. And I think that's a shame.

MR. BAER: Could I respond? In the areas that are being tested, I don't see any big question other than operator training and operator familiarity.

I'd be very surprised if the plant could not sustain natural circulation with an all liquid system.

DR. CATTON: I don't think that was in question at all. At least I didn't mean to question at all.

But you've got simulators all over the place, and one of the complaints that I hear from the people in the simulators, is, gee, we really don't have enough information. We kinda fake it all in order to get something together that reasonably well represents a plan.

You have an opportunity now to get good data, good initial conditions with just a minor effort. I don't see that it's going to be made.

So as far as I can tell, you're going to train the TVA operators, North Anna II operators very well.

And the rest are going to be where they were before.

MR. BAER: Well, Ithink plants getting operating licenses will be doing these tests for some time. They do, TVA plans to use some fine tuning of the simulator based on these results.

They hope to have the initial conditions down pretty pat, because they're doing simulating decay heat with fission heat, so they do need, I think, some better more accurate estimates of abilities to calibrate their instrumentation at these low power levels.

DR. CATTON: I don't understand why you can't put a different range flow meter on it. Just temporarily.

MR. BAER: On what? On the reactor coolant system?

DR. CATTON: Whatever. I heard earlier that one of the reasons that the data has so much scattering and you really don't know where you're at, is because you couldn't measure flow.

The reason you couldn't measure flow is you had a wide-range indicator and the needles bouncing on the fag.

MR. BAER: Well --

DR. CATTON: Why not put it on the flow meter?

MR. BAER: -- I don't know, but also I believe it was you, Dr. Catton, that said, why do you want to know flow? What you really want to know is the temperatures.

DR. CATTON: Yes, but that -- That answer is so ridiculous, I don't know what to say.

MR. BAER: No, but it's true. You really want to know the temperatures.

DR. ZUDANS: And the reason we concluded that was because we concluded from the presentation that we knew nothing about flow.

So that -- we said, why bother? Showing all those graphs. Flow-rate versus power-rate and all that is meaningless unless you know the flow-rate.

MR. BAER: Well, what Wayne showed was some curves that people try to compare, what limited experimental data they had versus the predictions they made.

The predictions were made on flow rate and so they took the data which was temperature and try to interpret that and infer a flow rate.

DR. ZUDANS: In a prediction, flow-rate was very well known. So the prediction is decent information.

In the actual experiement, the flow-rate was inferred from some very devious indications -- let's say questionable indications.

Showed charts like power verses flow-rate. The sent power verses flow rate. The experimental point could be anywhere in that draft. Anywhere you want to place it.

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DR. CATTON: Can the operators ask to look at a power to flow rate ratio? If the flow rate menas nothing, why do you continue to have it up there?

MR. BAER: Combustion likes to write their procedures that way. The operator's going to look to see that it delta-t -- delta-t is less than it was during normal flow.

Well, let me go back to the question of instrumentation. If we're talking about reactor coolant system flow rate, I think you're going to start talking about penetrating the reactor coolant system piping. And I'm sure -- as I said, I don't know if TVA's representative came back -- no.

Very certainly -- aren't going to volunteer to do that.

MR. EBERSOLE: They're not going to volunteer to do anything that they don't have to do.

DR. CATTON: That's the message that's coming through, isn't it?

MR. EBERSOLE: Well, of course.

MR. BAER: They volunteered a program and the committee -- I don't know how to say this tactfully, so I'll say it rather bluntly.

The committee wrote a very strong endorsing letter.

MR. EBERSOLE: Yes, I know. It was regarded as a benevolent sort of thing that they did. Actually they merely wanted to get the plant started.

DR. ZUDANS: There is nothing wrong with doing this.

MR. EBERSOLE: But that's perfectly all right.

MR. BENDER: Look, we're making an issue out of something that is a extrangeous to the matter we're discussing. It might be useful to have some instrumentation. I guess I would not be unsympathetic to Dr. Catton's point.

However, it's going to be more than just putting in wide-range types of equipment. I think they need different kinds of flow measures. Or equipment to measure what they have to measure at low flow.

And I don't think that can be done very easily. It's going to take more than just a casual request to do it.

And I suspect considering the incentives which TVA has, they would prefer not to do it. I'm not -- But I think the regulatory organization could make a point of finding a reactor where one of these days they could do that.

It doesn't have to be supported, but they could do it.

MR. BAER: I think if you get one early enough in the construction phase before it's all welded up.

But let me -- we --

DR. CATTON: I think you have to realize the need or it'll never be done.

MR. BENDER: But why put the bee on Sequoyah? It's a plant that's trying to get an operation, and they've offered some free information in the process.

CHAIRMAN CARBON: I think the point is well made. I hope it is. Let's go ahead.

MR. BAER: Okay. Should I -- is that enough on the proposed test program, and go on to --

DR. THEOFANOUS: I might ask a question of clarification.

MR. BAER: Sure.

DR. THEOFANOUS: Was this given through your first three or four slides. And I notice here that your criteria number one is meaningful technical data. I think that you should assure yourself that you do get meaningful technical data out of those experiments.

And item number two says no two phase testing reports. I'm a little bit puzzled. What does that mean as far as being meaningful?

MR. BAER: No, okay. I have some --

DR. THEOFANOUS: Are you planning a two page documentation --

MR. BAER: No, okay. These are -- the slides were made up for a somewhat difference purpose, and there are some words to go along with that.

And let me give -- explain this. This was supposed to be a very brief slide.

TVA, as I said, has not proposed any two-phase testing. And one of the concerns that I, and the people that have been reviewing the program, have is that from the training point of view, that we don't want this program to be misleading to the operator.

Because it's all single-phase flow, and I don't think there's going to be any problems getting natural circulation, we don't want the operators to feel or to believe at the end of the test program, that they know -- that they've experienced all the sort of things that could happen during an accident.

So we have asked TVA to confirm that they will be providing additional training to the operators, either classroom or preferably simulator -- if the simulator can mock it up -- to show, to train the operators as to the sort of conditions they would get following a small LOCA. The sort of things that we discussed earlier this morning, with boiling in the core and condensing in the steam generator, whether you call that natural circulation or not.

So that was the point there was --

CHAIRMAN CARBON: Did that answer it, Theo?

DR. THEOFANOUS: Yes, thank you.

CHAIRMAN CARBON: Go ahead.

MR. BAER: Okay. Let me jump ahead a little bit then to bleed and feed.

You really ought to be up here, Brian. Some of Brian's old slides.

This is sort of an introductory slide. To first of all to make sure we're all talking about the same things. Since the nomenclature on at least the natural circulation is, I think, confusing anyhow, and people use different nomenclature.

So by bleed and feed, I think we are all talking about the same thing. We're talking about adding a reactor -- or adding inventory to the reactor coolant system with a high pressure injection system, and discharging, hopefully steam, but possible two-phase liquid, through the power operator relief valve, or possibly the safety valve.

And at present, as the slide says, we don't have any firm NRC requirements for this mode of heat removal.

It's a complicated question as to what alternatives, if any -- what requirements, if any, should be imposed on existing plants and new plants.

In order to get into the situation where you need bleed and feed, you have to postulate more than a single equipment malfunction, or a single operator error. You have to lose all your feed water. And there are several alternatives that have been --

Well, I'm getting ahead of myself. I'm sorry.

MR. EBERSOLE: You don't have to lose all feed water. All you got to lose is natural convection.

MR. BAER: Or -- okay. If you get enough non-condensables, but the analyses -- short of having -- as Zoltan said, short of having significant core damage, and building up non-condensables --

For situations less severe than that, the analysis of the staff and of the industry shows that you will have adequate heat transfer.

MR. EBERSOLE: Does that include the UHI plants?

MR. BAER: WEll, I think he said that's still under evaluation.

But even there, you have to postulate more than a single failure.

MR. EBERSOLE: Oh, but that's not hard to do.

MR. BAER: No, it probably isn't, but we bump into a critería problem.

MR. EBERSOLE: Right.

MR. BAER: And even with feed and bleed, there are some uncertainties, and it's a combination of the 3 points Matt mentioned. The PORV's have to have sufficient relieving capacity, both for the transient condition and then the later studies state, it's tied into the pump shut-off head.

And the time of which the PORV's are open, goes back into the transient condition. How -- you have a race there. You're discharging -- you're producing heat and you're not getting rid of it.

And if you open the PORV's late, you've built up a -- you've raised the average energy in the system and now you have to rush that much harded to catch up with the bleed and feed.

MR. EBERSOLE: Isn't there a fourth condition? That is, you should know where the water level is in the primary --

Otherwise, you're going to be in a mixed flow condition. You're -- you really won't know what the mask flow and thermo flow rate is out of the PORV averages.

Don't you need primary level inventory information?

MR. BAER: You mean before you know whether you wanted to go to --

MR. EBERSOLE: As a fourth condition.

MR. BAER: I'm just not --

MR. EBERSOLE: What I'm saying without that --

MR. BAER: -- before knowing whether you wanted to initiate bleed and feed, you mean?

MR. EBERSOLE: To do a proper bleed and feed, you need to know the relieving capability RV's.

In order to know that, you've got to know where the water is. It's either going to be delivering water or steam or water and steam.

And those three conditions will define the relieving capability of the R.V. in three different ways.

MR. BAER: Well, but it's going to be relieving water intially, no matter what, because --

MR. EBERSOLE: Initially, right.

MR. BAER: -- if you're in a situation where you're using and you have a steam bottle on top of the vessel, it's pushing water up in the pressurizer.

MR. EBERSOLE: And it's going to lose inventory. And then it will come to some intermediate point at which it will be mixing water and steam.

MR. BAER: That's right. And then steam.

MR. EBERSOLE: It may persist there. Or it may descent until you have 100% steam. I don't know. But in order to do a proper job with your RV's, I think you have to -- you need a knowledge of the fairly precise point at which you have a water steam interface, if you're going to do a good job of it.

MR. BAER: You mean to go analyze it?

MR. EBERSOLE: Yes.

MR. BENDER: Could I ask a question about the middle point up there.

Are you planning to establish some kind of criteria for this mode of heat removal, or are you just telling us about it?

MR. BAER: WEll, I'm sorry. I started to jump into -- the next slide, and there are other alternatives that the staff is considering.

So let me go on to that slide and then we can come back to this point.

MR. BENDER: Another alternative says, the staff may not permit this kind of --

MR. BAER: Well, what I was thinking about is -- Let me jump down to the second portion of this next slide.

B & O Task Force recommended that we should consider the need for diverse decay heat removal path, independent of the steam generators.

And A and B, sort of tied to a bleed and feed system. And item C would be another alternative. It is high pressure with residual heat removal system.

It would be something, again, independent of steam generators. There's other people on the staff, frankly, that think you make the sux feed system super reliable and you solve the problem that way.

Now, that alternative isn't shown on the slide, because that wasn't what the task force recommended.

MR. EBERSOLE: Well, as a matter of fact --

MR. BAER: But there are those possible alternatives.

MR. EBERSOLE: Isn't it fair to say that the aux feed system is a hell of a lot more reliable than the natural circulation system?

And that to be improving that area, it would be diversion of effort?

MR. BAER: I'm not sure what you mean by natural circulation.

MR. EBERSOLE: Oh, I mean, I -- if I have an infinite amount of aux feed water flow, I still have the problem of cuppling the primary to the secondary system. Okay?

I don't have any problem acknowledging that I will always have secondary water. I do have a problem in acknowledging I will always have a cuppling mechanism from primary to secondary. Which is natural reconvection mechanism.

MR. BAER: Because of non-condensables?

MR. EBERSOLE: Whatever. Yes.

So I think to argue that you spent a lot of time or the bulk of your effort in improving aux feed water is really inappropriate without due consideration of the natural convection problem, to start --

MR. BAER: Well, I think, as said, Zoltan said it and Brian said it this morning, that other than the question of non-condensables --

MR. EBERSOLE: Yes.

MR. BAER: -- and only -- forgetting UHI for a moment, for the case of where the significant core damage, no one has yet found a mechanism, why, if you're boiling in the core and you have heat sink in the steam generators, you won't condense and get the liquid back.

MR. EBERSOLE: But Sequoyah, of course, is UHI.

MR. BAER: Well, Westinghouse -- and I'm sure this part of what Zoltan's people are reviewing, but Westinghouse recently submitted response to some questions on their guidelines for small break LOCAs for UHI plants. And I -- I don't think I could quote the numbers accurately, but they pointed out that there was a pretty narrow range of breaks -- at least it was their analysis-- where UHI would activate and you were in the break size where you're counting on the steam generators to remove the heat.

Now, typically, the UHI is designed for the larger breaks, intermediate size and up. And in those cases, you're discharging your energy through the breaks.

MR. EBERSOLE: Yes, I know that narrow window --

that narrow break side would happen to include the most probable kinds of breaks, which is PORV failure, temporary opening and subsequent reclosing.

And the other ways in which --

MR. BAER: I thought PORV was not...

DR. PLESSET: Westinghouse made a calculation, assuming that all the nitrogen in the UHI system went into the core and collected in the steam generators and I don't think the staff has reviewed it yet but their calculations show that they can handle any transfer that is needed.

MR. EBERSOLE: But they missed one part Bill.

DR. CATTON: That was the degradation of the heat transfer co-efficient due to the amount of surface area tubes and it was quite large.

DR. PLESSET: It still might be alright. I mean you can't say that it is not acceptable.

DR. CATTON: They have been asked to look at it and they have submitted a calculation.

MR. EBERSOLE: But, it has to invoke reflex condensation.

DR. PLESSET: Oh, yes, no question about it.

DR. CATTON: And what they did was they took all the gas they could find, put it in the tops of the tubes and said how much vertical height in the tube is left. Now the question is can that much break the tube and reflux efficiently. And to my mind that is a question.

MR. EBERSOLE: I see, that is secondary. Okay.

DR. CATTON: It's whether you've got enough area or not.

DR. PLESSET: The area is alright. I think there is still Catton's point about the effectiveness of the heat transfers in the remaining area and that is something that the staff can look at.

DR. CATTON: It's different than the VNW.

MR. BAER: Bryan Sheron has a point, just answer this question, if you could.

MR. SHERON: One of the things is that although the UHI accumulators come on at 1200 lbs., it is my understanding that the gas would not actually come out of those tanks until you are down around 600 lbs.

Down around 600 lbs. I believe the steam generator is a heat source to the primary system as opposed to a heat sink. In which case, you are not depending upon those steam generators to be removing decay heat.

MR. EBERSOLE: That's a very short term viewpoint.

DR. CATTON: Yes, but you are going to turn it around and you are going to want to...

DR. PLESSET: I think in the long term you do want to use it as a heat sink.

MR. SHERON: Yes, for a long term recovery.

DR. PLESSET: Right.

MR. EBERSOLE: To say that the steam generators are not a heat sink is to deny a problem because eventually they must be unless you are going to have bleed and feed.

M... CATTON: Forever.

MR. BENDER: I think we're just mixing up apples and oranges. There is the early part of the transient and the lighter part of the transient.

MR. BAER: Could I add one thing. Just before the break I stuck up my hand but we broke and I just want to amplify a point that Bryan made earlier.

And, that is that for the break sizes, I think we're talking about the reactor coolant system ends up at a temperature just slightly above the secondary system. This is without the non-condensable -- just several degrees, right, two or three degrees.

MR. SHERON: Yes

MR. BAER: And you do have a lot of excess area with that sort of calculation cause you have steam generators designed for full power although it's a different heat transfer mode as opposed to couple

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percent power. And, so you have extra area but even if the area is partially blocked or isn't really useful and even if the co-efficient of heat transfer, overall co-efficient drops and someone set an order of magnitude, then that 2 degree delta T goes up to 20 degrees or 3 degrees go up to 30 degrees and it still isn't, I don't see, is a huge problem as long as there is some heat transfer mechanism.

If it's as good as a good insulation then there is a problem but...

DR. CATTON: I think most of us would agree with that but we would like to be shown.

MR. BAER: I'd point to Zoltan except with the reorganization, I don't know who to point to.

MR. BENDER: Bob, can I get back to my original question. The A, B, and C up there at the bottom. Is A an alternative to B.

MR. BAER: A and B are really lumped together.

MR. BENDER: You have to have both of them.

MR. SHERON: Zoltan said it before and that is that there are a couple of ways you can go into bleed and feed mode. One is if you look at for example the B&W plants which have HPI pumps that have a shutoff head something well above the safety valve set point.

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You can remove decay heat by pumping water in at the safety valve set point and relieving it through a safety valve. You don't need a PORV. It's not a safe shutdown condition from the standpoint that you're at 2,500 lbs and you will stay there because the minute you drop or stop pumping, the valve will shut.

DR. PLESSET: You hope.

MR. SHERON: This is one mode of bleed feed and would probably be considered some sort of an interim mechanism until one could restore auxiliary feed water or heat sink. This is only capable on plants with high head HPI pumps.

There are some plants, all of the combustion plants have a low head pump around 1,300 lbs. shutoff head except for Maine Yankee I believe, which is very close. It is still below the safety valve set point and about 45 lbs. above the PORV set point.

For those plants, they calculate you have to open a PORV to depressurize the system down to let the HPI come on. The point there you're talking about increased PORV relieving capacity says that if you want to leave a plant that has a low head pump and not change the pumps, then you have to assure yourself that they can actually blow the plant down basically to get

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on those pumps and right now, as pointed out in Item 1, we don't know if that capability exists today.

MR. BENDER: But if it did, you wouldn't have to increase the head on the HPI pump, is that right.

MR. SHERON: Correct.

MR. BENDER: Okay, that is the point I was just trying to get clarified.

MR. ROSZTOCZY: All three of those are alternate possibilities. In one case, the emphasis on that that you have enough valves that any time you want to you can depressurize the system. Once you have accomplished that, you know you have the pumps and you can pump it.

The second approach is to provide high pressure pumps. Even if you cannot depressurize the system, you have the capability to put enough water in there.

And the third one is really coming from a different source, not as much from here but is on the list because if for any reason, you would have C then you will probably not need A and B. C is simply to take the RHR system, like we have today, to the operating pressure of something like 400 or 400 psi, upgrade that so you can use it even when you are working against the safety valves. If you have that system for any reason, maybe a different reason than what we are discussing, then you don't need A and B.

DR. PLESSET: But you are assuming that you have power, on site power.

MR. ROSZTOCZY: You assume that you have emergency power for that system, whatever it takes.

DR. PLESSET: Not in 1 and 2. You are assuming you have power.

MR. ROSZTOCZY: In each case, I have to use pumps and I have to open valves and so on so in each case, there is certain equipment that has to be on emergency power. How much is the demand of that equipment. Does A require more emergency power than B, I don't know. There are definite differences within the valuator but how much more you need.

MR. ETHERINGTON: A only requires DC power.

MR. ROSZTOCZY: A assumes that by opening the valves, you depressurize the system so you can use distress anti-existing high pressure pumps to do that and those are remember just pumps.

CHAIRMAN CARBON: Dr. Zudan.

DR. ZUDAN: We heard yesterday that two PORVs in the Westinghouse plant are not enough to remove decay heat. Do you contradict that?

MR. ROSZTOCZY: Did I contradict that just

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a minute ago?

DR. ZUDANS: No, no, Bryan.

MR. SHERON: Westinghouse plants have three safety valves.

DR. ZUDANS: But they said if they open those safety valves, the PORVs would not be enough to remove te heat so they won't open the safety valves.

MR. SHERON: Oh, PORVs, right. Westinghouse I believe has three PORVs. They calculated...

DR. ZUDANS: 1.4 inch diameter in only two of them.

MR. SHERON: I think you have two that he calculated couldn't and three could.

DR. ZUDANS: They said they needed safety cooling but the point is the safety cannot be closed when you want to close it. It just closes for the pressure problems.

MR. SHERON: Correct, well that's Item B. Like I said, that would be a riding on bleed and feed at a high pressure condition.

MR. BAER: In the Westinghouse high pressure pumps at least on Sequoia, their shutoff head is right at the safety valve. There is no flow there.

DR. ZUDAN: The point is really...they would be ready to seal capability of their own leak. So, you cannot use this method.

MR. BENDER: Under those circumstances, it might not be all that bad if the valves leaked a little bit.

MR. SHERON: I should point that you know the main point we made is that these are not a design requirement today and just by saying that these plants have the capability, if one has to say I will design my plant to have this capability then you've got to start identifying more criteria that it has to meet.

Namely, do the valves have to be capable of relieving a single phase of solid liquid flow. Right now, the safety valves are I understand just designed for a steam flow. They are not designed to relieve liquid.

We did some looking. If you look in the SAME code there are certain requirements that may be imposed on what the specified relieving capability should be for these valves. You may need to put more valves on so in other words, although the capability may be here, it doesn't mean that the system is specifically designed to operate in this mode. It just means that it can operate and if you want to make it a requirement, there may be other upgrades necessary.

MR. BENDER: I think for the other side of the coin then, would be criteria under which you would want to use the bleed and feed and that too ought to be thought about to solve the problem, in addition to considering whether you should have the capability.

MR. BAER: I was going to relate it to the boilers have an ADS system and I think if it becomes a firm requirement, you end up going in that direction with multiple valves, an automatic initiation but a timer that delays it and the requirement that pumps be available and running and it gets pretty complicated.

DR. PLESSET: Once in a lifetime.

MR. BENDER: Hopefully not more than that.

MR. EBERSOLE: Just stating that increasing PORV relieving capacity is not quite all that's involved, if your RVs at present are not designed to relieve in a safety context, their failure mode is probably closed, especially if you look at the block valve on the back side. If the piloted, they may require DC to function if you want to deliberately operate them.

All of the modes tend to close the valve and forbid its opening in the fail stage. If you are going to use it for this function, you have to reverse that rational and guarantee that you could open them.

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MR. BAER: That's right. And they still won't be single failure proof and you've got another psychological aspect that certainly for the next several years, given any small LOCA or anything that looks like it, I understand at Crystal River, every one in the control room ran over to make sure the block valves were closed and you are going to have that tendency too.

MR. EBERSOLE: It involves also environmental qualification because if you are going to do this, you are surely going to run your containment atmosphere and provide totally new environment for operating PORVs which is not presently in their design consideration.

MR. BAER: And the block valve.

MR. BENDER: And the block valve.

MR. ROSZTOCZY: If there is such a requirement, it would have to go through...there is nothing possible to solve it. The German pressurized reactors all operate on that principle.

CHAIRMAN CARBON: Excuse me, would you repeat that.

MR. ROSZTOCZY: The German pressurized water reactors all operate on the principle that is on A on this chart. They all have the capability to depressurize the system to whatever pressure they want

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to.

MR. EBERSOLE: Zoltan, as a matter of fact, didn't shipping ports start the PWRs out this way. Isn't shipping ports so qualified to operate...

MR. ROSZTOCZY: That's very possible. Last time I read on shipping ports was about 7 years ago.

MR. EBERSOLE: I believe it's true that somewhere along the line this capacity was dropped to do this. I don't know where.

CHAIRMAN CARBON: Dr. Schrock.

DR. SCHROCK: I have just a simple question. It's just my own ignorance that brings it up but I think it should be brought out for the record at least.

In order for the fluid to exit the system, it has to get to the PORV, to the relief valves, and then there is then the related question, is the constriction in the line connecting the primary lube to the pressurizer in any plant going to be the limitation or is it going to be clear that that is not a limitation.

MR. BAER: The surge line is usually I think a lot bigger.

DR. SCHROCK: I think it has got to be established, that is the point.

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MR. BAER: That would certainly, you know, I think ther^ are a lot of reasons why this plant hasn't jumped in to say, hey, this is a requirement of plants. It is a very complex problem.

CHAIRMAN CARBON: Go on, Bob.

DR. SCHROCK: Four inches is about the cumulative cross section we were talking about yesterday with the Westinghouse people that they need.

MR. BAER: Chuck Graves says 12 inches. I don't know, I thought it was bigger than four.

DR. SCHROCK: As I say, it just needs a simple answer.

MR. BAER: One of the questions along with the agenda, we were asked to demonstrate or asked to discuss was the problems if any with demonstrating of bleed and feed system in the reactor and this last slide addresses that.

I guess I wanted to make the first point that...

DR. THEOFANOUS: Excuse me, could I ask you why even do you want to demonstrate the bleed and feed in the reactor. I think that is the first question to be answered before even worrying about...

MR. BAER: Well, I want.

DR. THEOFANOUS: Do you feel that you need

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to sort of jumble the...it looks like you bring your uncertainties of the PORV flow, why couldn't you just run a...and use those results.

MR. BAER: Well, I think that is what I am going to end up saying.

We're answering a question that was presented to us...

DR. THEOFANOUS: But it looks like you are saying it in a negative way and it sounds like it is difficult to do maybe but why do you have to go to the negative instead of just saying I really don't lose anything if I do it outside.

MR. BAER: Well, that's what I was...

DR. THEOFANOUS: I think the way you are attacking the problem here is like it wouldn't be practical, this and that, but I think a better question to ask is do you really lose anything by doing it outside.

MR. BAER: Well, that's what I was trying to make as a first point is that if the PORV experimental data is available and this is being obtained and there is a requirement under short term lessons learned, that they do experimental work for all liquid and two phased discharge then people I talked to yesterday and I didn't

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have to much time to prepare for this since I only knew about it yesterday, the people I talked to thought that the bleed and feed approach could be calculated pretty well, pretty accurately if one had the experimental data, and that was my first point that if that turns out to be the case then the need for a reactor demonstration is certainly diminished. That was what I was trying to say.

DR. ZUDANS: Is there any problem anticipated in bringing that water or steam to the pressurizer to cool it...

MR. BAER: No, I think nature. Once you start boiling in the core and you start having a...you're going to form steam in the upper head of the vessel, I have no doubt that the water, first, you're going to push water into the vessel and if you discharge enough inventory, you are going to end up with water in the two phased mixture and then ultimately steam, if your inventory goes down that low.

DR. ZUDANS: Let's say the steam flow rate would be adequate to then move through those pipes that connect the pressurizer to the PORV.

DR. PLESSET: Yes.

MR. EBERSOLE: I mean that is the preffered method.

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MR. BAER: Yes, suddenly you are getting rid of the most energy with the least loss of inventory with the steam flow but in order to get there, physically you are going to end up discharging a lot of water first.

MR. EBERSOLE: Are you setting up experimental facilities to demonstrate the transition problems in going from the full water flow to the two phase flow to the full steam flow.?

MR. BAER: Well, the questions I asked some people yesterday is part of the calculation would have to include that transient and they thought that...

MR. EBERSOLE: What about the demonstration, the test?

MR. BAER: The thought that they had...the experimental data on the PORVs for the various phases of flow, liquid, two phase and then all steam , that with the existing codes one could calculate the transient. The codes would have to calculate what mixture was going in.

MR. EBERSOLE: I don't see that much experimentation is needed to verify that you can have a BWR on decay energy. We know that already.

MR. BAER: No, by the calculation I meant to see what the total...let me approach it a different way.

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On a small LOCA, you're really...it's a while before your high pressure injection pumps, at least if you only have one, are putting in enough fluid to make up your inventory. So, I think someone from B&W said it very well. It's a race -- you're discharging more inventory early on in the accident than you are making up and so you have to look at the total inventory and your total history so it seems to me part of the calculation has to look at that transient, see where the water level goes, how hot the fuel gets and then when you do catch up, when do you catch up and I was told yesterday that they thought the existing codes could do a reasonably good job of that and Harold, was standing up there and he knows far more about the codes than I do.

MR. SULLIVAN: I think that the program that Bob is referring to is the corporately funded program between the vendors and EPRI or the utilities and EPRI.

NRC has a task to monitor that program to make sure that the data is obtained to assess our codes and if required, to develop the model and we are currently in that. It is not as simple a procedure as testing a valve. There are several different designs in valves and both the PORVs and safeties are to be examined. Also the tail pipes to the quench tank make some effect

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upon those. A considerable review has done been done on the plants, the valves and those lines and a variety of tests are going to be performed both single phase liquid, single phase steam and two phase is where you know the conditions going to the valve and you calculate...or you measure the critical flow.

Currently under review is the instrumentation that you need in the test facilities to understand the critical flow that is coming through those valves. I think that the data will be able to provide a good assessment of our codes and either require us to develop some more complicated models or improve models or to say that the things that we have are okay.

MR. BAER: Okay, the remainder of the slide was an attempt to respond to the question of what are the difficulties, it mentioned the...collecting the overflow from the quench tank and said what are some other difficulties of trying to demonstrate this in a reactor and difficulties that I am aware of that have been brought to my attention or that I have thought about is boiling in the core...we'll be doing this with fission heat and you'll be boiling in the core if you were trying to do a pretty good simulation, for some extended period of time while you've simulated this, and this bothers at least Westinghouse both from a general fuel integrity point of view and I think perhaps a concern about getting some boron plated out on the fuel.

I know when we talked to Westinghouse and TVA about doing some two phased experiments that were a lot less severe than this in Sequoia this was a very major objection that they had to doing work...two phase work... experimental work in the low power test programs.

MR. EBERSOLE: Well, that same phenomenon will also be present in the reflex condensation process too so if we are going to overlook it in one place...

MR. BAER: Yes, it's not a brand new core under warranty then, I think. Frankly, I think Westinghouse has a problem. Or, its EPA's problem, I'm not sure which. I don't know if their lawyers were smart enough to have the warranty cover that condition.

Some other problems occur because decayed heat in such an experiment is simulated by fission heat and now, if one were to try and do this in a reactor, one faces the problem of controlling reactivity with voids in the coolant and in the area of the core and probably variable voids if one does appreciable blowdown.

And, there comes then the point where at least

I have to put back on my regulator hat and start looking at such an experiment considering the least single failures and for example, one that comes to my mind, you would be doing this with the steam generator feed water shutoff and the steam generators in equilibrium with the reactor core initially.

Well, if an operator suddenly made the mistake of putting on aux feed you now have a good potential for a reactivity insertion accident and I'm sure there is equipment malfunctions that would cause the same sort of thing. It's a pretty tricky experiment to do I think with fission heat because you are, even for the natural circulation test, that Sequoia or TVA is proposing for Sequoia, they hope to do these at a zero moderator coefficient just because of some of the concerns about reactivity feedback and they could certainly be much more severe if you were already at saturation conditions.

And, then, the point that I think is mentioned in the letter from the Subcommittee is the quench tank overflow is no simple problem. If you have to pipe it outside the containment and collect it somewhere then maybe there may be some possible hazards that one would want to consider and that is assuming that there is a containment penetration. If you put it into the sump

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with the idea of pumping it back into the system, I think you have the problem of potential dirty water into the reactor. So, all in wall, at least our initial thought is that it would be a very difficult thing to do in a full scale reactor experiment and that concludes my presentation.

CHAIRMAN CARBON: Are there any questions?

DR. ZUDAN: Just one. Is there good enough information on feed water pump characteristics in a low range of low range of flow ...on the pressure reading?

MR. BAER: I'm not sure offhand. I'm sure the original certified pump curves how low on flow rate they go, I'm not sure. Dave, you missed the exciting part. The TVA representative, please step back into the room, I'm not going to let you off the hook.

There are some questions about TVA's plans for additional instrumentation to perform the low power test program to get as much information as possible during the natural circulation mode in terms of accurately determining, or as accurately as possible, flow rates or I think the latest question in accurate heat balance which lets you at least infur flow rates and I remember the big stack of procedures and I've read through them and I know there is a whole list of instrumentation recorders to be hooked up but I don't recall...I didn't recall whether any of these were any special instrumentation or whether this was normal planned instrumentation. I don't know if you recall or not.

MR. LAMBERT: I'm David Lambert with the Tennessee Valley Authority and manager in the licensing section of pressurized water reactors section of our regulatory staff of TVA. So, I'm probably not the right person to address this but let me give you my impression.

First, there is an additional amount of instrumentation hookup for these set of tests to try and get a better handle on temperature and power so that we can infur flow. There is also additional work to be done in terms of base lining in actual circulation to understand the resistance of the system.

TVA is as I understand it technically still has some concerns about being able to identify the flow and temperatures as accurately as we would like to and we have done quite a bit of internal investigation and so has Westinghouse for us of looking at additional instrumentation, what might be available and as far as

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I know, as of a week ago, we still were not not coming up with any good ideas as to additional instrumentation as well as discussions with the NRC research in this area.

There will be some instrumentation put on the system for purposes of signature analysis "noise analysis" that might have some spin-offs in this area but I don't think we, TVA, or Oak Ridge or NRC research staff have any great expectations for this type of instrumentation to give us anything for natural circulation.

CHAIRMAN CARBON: Gentlemen, let's drop this at this point. I'd like very much to get in to Mr. Fabic's presentation and perhaps try and cover this before lunch and if we then want to come back to the TVA instrumentation question after lunch, we'll reopen the subject.

MR. BAER: I had planned to leave shortly. We will try to address that point. I plan to meet with the full committee I think April 10 tentatively to give them an update on the status of the low power test program and we hope to have had the TVA input for a sufficient length of time so we have done some review by then so we'll try to address that instrumentation

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at that time to the extent that we can.

MR. FABIC: Stan Fabic, I'm with the Reactor Safety Research Division.

CHAIRMAN CARBON: Stan, try and do it by 1:00 if you can.

MR. FABIC: Don't be frightened by the thickness of my handout, I will only cover less than half. But I thought it would be useful for you to have the remainder of the material so you can look at your leisure.

What I would like to cover is what kind of measurements do we need to verify...to get credibility and what are we getting so far. What kind of knowledge of a test facility condition do we have to have to verify calculations?

The code versus data comparisons is in the top of the package and I will not speak a lot about that and I'll tell you a few words about the code stops.

First, let me identify three kinds of natural circulation, everybody has a different name. Single phase natural circulation in loops with two-phase flow and on occasion when you have a recirculation or reflux condensation in a half life. A prerequisite for all of that is that the fluid temperature in the secondary side of the steam generator is lower than in the primary j'i-1

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side, otherwise we can't get -- so we have to have an experiment, we have to have the evidence in this case.

Now to predict and, therefore, verify the prediction of the predictive onset from natural circulation -- well, we find that if you're looking at temperature plots that oftentimes it is possible to tell from the change in gradient of the temperature whether we have or do not have onset of natural circulation.

You look here at the clock temperature time histories. Notice that you have good cooling here in this part, and then cooling deteriorates when the floor deteriorates until you get to saturation temperature -- as long as there is coverage by foam only.

So, this right here tells you that you got good, natural circulation. The flow is deteriorating.

Again, for single phase floor, floor measurement, the loops, full pieces -- this we can certainly do unless the floor is low enough that the fervent floor meters -- for the two-phase natural circulation, we ought to see a positive floor in hot legs and cold legs in the same loop combined with some -- measurements, and those were patients. We have to have those measurements. We haven't been so successful so far to get these measurements. Or -- hot legs combined with the inventory change in the cold leg and in inventory change in general.

It doesn't have to circulate it will collect. You might just change the inventory and still condensing or having a heat adjustment. It a changing condition.

Now, we'd like to have a distribution in hot --

CHAIRMAN CARBON: Stan, excuse me, let me interrupt. You're talking about the general calculational ability.

MR. FABIC: I'm talking about this.

We have to be able to show how well can we predict circulation of two phase character. And let me now point out -- I am showing here two kinds all on the same graph. One is when you have a fore going through primarily on the downflow part of the tubes and you have a liquid going through the coil. The other one is where -- when you have a significant from the station in the upward, in the first part of the -- which is running back -- it can happen after you -- what kind -- if we wish to show the ability to copy that, what measurements do we need?

DR. THEOFANUS: Is it always that the first leg is going to -- more than or equal to the down leg?

MR. FABIC: Yes, unless you build up sufficient thickness of the condensate so that you are still sending a lot of lost steam through the down leg. You might be

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condensing them both, but you're right

DR. THEOFANUS: More than you're able --

MR. FABIC: Yes, yes.

MR. BENDER: Do you have reference to some specific experiment or just any kind.

MR. FABIC: I was talking about specifics.

MR. BENDER: Yes, but when you say what you have to do here, are you talking about a -- all experiements need this kind of information?

MR. FABIC: I'm talking about experiments IES is sponsoring. Or experiements that foreign researchers are going to conduct.

MR. BENDER: In existing experimental facilities?

MR. FABIC: Experimental facilities are trying to -- semi-scale and loft are trying to make this phenomena. They are very difficult things to measure.

MR. BENDER: And the equipment that you are faced with is what exists in those facilities?

MR. FABIC: What exists today and what improvements we feel we have to make in order to make these assessment factors.

MR. EBERSOLE: Your picture shows, in my view anyway, an ideolized state of affairs if you're going to do that.

Is that an operation in which you have finally achieved a reasonable level of void above the core, you are steaming freely to the hot five, then going up and coming back in a partial reflux --

MR. FABIC: Yes.

MR. EBERSOLE: On the other hand, in order to get there, you go through a lot -- you may be halfway up the tubes, and it's a different picture.

MR. FABIC: As a matter of fact, when there's a froth or mixture going through the hot leg, that measurement is easier. We don't have to differentiate between --

MR. EBERSOLE: Suppose the water in the thermoloop is halfway up the tubes?

MR. FABIC: You mean these tubes here?

MR. EBERSOLE: No, no, the steam aero tubes.

MR. FABIC: Oh, steam aero tubes. For the purposes of cold calculation, it's fairly easy -- but on occasion where those levels that we top-lid are there require knowledge of the ground vp measurement from the top to the bottom, so we know where the levels are in each of these legs. Those vp measurements do not exist yet in our test facilities. They are being planned for semisphere. You cannot put a -- in a generator in lock because -- so this is a very difficult measurement to make.

But, you're right, we like to know where the levels are before we send them. And we calculate those levels.

MR. EBERSOLE: Would you be concerned if you were halfway up the rising tubes in aspect to boron laydown at the innter base, because you have a concentartion negativism at that point?

MR. FABIC: We do not track boron, of course, but we are more concerned about a lateral heat transfer. I don't know what's going to happen right at the interface.

MR. EBERSOLE: Well, there's not much negativism in that you feed boron -- you lose --

MR. FABIC: I'm sure you are right.

We are concerned about real condensation in the presence of noncondensables.

DR. SCHROCK: I don't think there is a mechanism there, the steam is generated down in the core.

MR. EBERSOLE: The steam is generated at the water steam interface in the tube. It's released at this point.

DR. SCHROCK: But it's not generated there. In order to get there --

MR. EBERSOLE: You're talking about voids being formed an traversing the --

DR. SCHROCK: Yes, it's not superheating water which is splashing at the top.

MR. EBERSOLE: You're talking about voids being carried up?

DR. SCHROCK: Right.

MR. EBERSOLE: That will keep the boron intercore?

DR. SCHROCK: The water liquid.

MR. FABIC: Since I have a stipulated amount of time, I will really have to move fast.

Let me just tell you that the test that was conducted so far in semiscale and loft, we have seen that we have measurement problems to be overcome, and the test that we have is really not adequate enough for me to tell you today that the cores are good or bad, okay. I think you'll see a lot of composites, some good and some bad, and the reasons for these composites are also not necessarily measurement problems, but also we don't know the state of the facility. Here's the example.

CHAIRMAN CARBON: Theo.

DR. THEOFANOUS: Stan, as a matter of clarify first of all, when you refer to cores, do you -- which cores? There are many cores.

MR. FABIC: I'm glad you mentioned that.

Most of the composites, as you can see in the handout, are with Relab 4.17 which hasn't yet been released to the public and Relab-5. They are still working on the so-called fast-running version which will be used for small breaking houses, though you don't see those composites.

All calculations with Relab 4.17 are pretest predictions, some are post-test -- all those done with Relab-5 are post-test.

In fact, when calculating law -- it has been found that there is a leakage path, and that's after the fact, so the knowledge that there's a leak built into the calculation of the -- so, include a leakage-- and there's significant differences, and I'll just mention a brief --

DR. THEOFANOUS: Excuse me.

I want to take a couple more minutes because yesterday we were quoting a figure with the Staff, in fact, what is the appropriate level of ambiguity or uncertainty that they should accepting -- models, making judgments about present things that have to be decided upon, and -- I want to see how you pursue your job, so when you talk about experiments -- which core do you have in mind, because I think if you have something different in mind than what the licensing staff has in mind, and in addition to that, I would like to know what is your perception of what is the present capability of the current evolution models from the licensing jrs

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MR. FABIC: I am not prepared because I have not studied, at any depth, the current evaluation models. But, I might be able to project something from the knowledge of some of the best estimate models that we have as to what I believe the evaluation models can do.

But, I will say a few words about what our codes that we have been developing, what the status is, what they can do and what they will do when we are through with them. And these codes are best estimate codes not used for conservative analysis for licensing calculations.

The purpose of these codes, especially the advance codes, is to finally end up with some quantative knowledge of the uncertainties if we use the best analytical tool we can for a PWR, okay? With what uncertainty can we predict the phenomena that are important to quantify the uncertainty. Consequently, we have to use a lot of experimental data to access these tools in order to then finally extrapolate those uncertainties that we get from measurements in small scale facilities to large scale plants.

DR. THEOFANOUS: Let me stop you now. So, you view your job as primarily working with advance codes; is that correct?

MR. FABIC: With best estimate codes.

DR. THEOFANOUS: Best estimates.

Number 2 question: can you tell us in a couple of words if the fruitfulness of trying to develop an understanding with some of the transients by using present vendor codes; do you think that it is something that is possible --

MR. FABIC: Let me then ask this question: if we feel, if NRC feels, okay, that this mode of flow during natural circulation is important, okay, and if therefore, is representation of this mode flow is necessary to tell us whether we are going to have a cooling or not, then my guess is that the current evaluation mode -- and I don't know them all; I don't know the more recent ones -- cannot handle this. You need separated -- you need two fluid models to do --

DR. THEOFANOUS: Sure. Do you think this is a first order of fact or a second order of fact? I guess I heard you say that this is a first order of fact.

MR. FABIC: Okay. I would say that there are some transients in which this lasts a long time, for some breaks, for example. Some small breaks where this separated flow lasts a long time. In others, you go -- the level drops past this nozzle diameter very fast and you have, you know, mixture before that and you have a more or less single phase vapor after that.

And, again, still, if you have to rely on this backflow even when there is a single phase gradient, again you have a two phase -- two fluid model.

DR. THEOFANOUS: I'm in full agreement with you and what I would suggest is somehow, you get in better communication with the people in licensing because we are hearing a different story from people in licensing and then we hear from you; and somehow, I feel that there is a gap of communication there that makes me be very concerned because I cannot feel the same way that you feel about some of those things.

And, yesterday, all day long, I had a hard time myself and other Consultants and Members to kind of see some of the licensing people's views of those things with the same urgency that some of us do. So, maybe you can do a better job what we can --

DR. CATTON: I have a little bit different view than Theo so maybe I should express it. To me, the small break analysis is basically a quasi-static process.

MR. FABIC. Yes.

DR. CATTON: It seems to me the first thing you want to know is reflux boiling going to be efficient enough to do the job.

Second, you want to know what the impact of inert gas is going to be. I think that simple measurements will tell you that and then how it fits into the advance codes becomes a long term kind of thing.

MR. FABIC: Yes. A simple measurement -- which simple measurements will tell you that? I started to talk about measurements that I feel we need to tell us what's happening in reflux boiling.

DR. CATTON: There are two kinds of measurements. There's the kind of measurement you need in order to advance your advance codes. I don't think you need to say the level of experimental work in order to answer the safety questions we have at hand.

MR. FABIC: Maybe -- I might be able to answer your point a couple of slides later.

DR. CATTON: I didn't mean it as a question; it's an opinion.

DR. PLESSET: Ivan, let me see if I understand your first point that it's quasi-static. I think that's right, but that doesn't mean from Fabic's point of view that the problem is terrifically simplified.

DR. CATTON: Oh, of course not.

DR. PLESSET: Okay, just to defend his position.

DR. CATTON: It's a complicated problem. But, I'm not sure that you need to know other than academic reasons, and I think it is a very interesting problem, but you don't really need to know in order to make the licensing people to make their judgment which is the point that Theo is making is that you do need to know these things.

I don't belive you do. You have a bunch tubes flowing down; they either work or they don't. If they work, you've answered the licensing questions and now let's use the universities as to the second part of the question.

DR. PLESSET: I'd like to get those answers, too, whether it's the university or --

DR. CATTON: I agree; but there are two parts.

DR. THEOFANOUS: Ivan, let me just say on a couple points: since you bring it up that way, I think as you probably remember from yesterday, I came up with very, very serious difficulties with the philosophical approach formed by the Staff. And, I think what you are expressing today is more in agreement with them than what I perceive you to be saying yesterday.

However, let me say that I understand from the fact that in order to be able to give the correct information to the operators, in order for the NRC to feel that they are in good position to pass a judgment even during some of those things happening, if ever they were to happen. You have to know what is the responsible system and I don't care if that is quasi-static, quasi-transient, what have you.

And, if you go with this idea that --

DR. PLESSET: No, I don't think he says that, if I understand him.

DR. THEOFANOUS: How can you learn the response of the system if you don't know how to --

MR. FABIC: There are several levels --

DR. PLESSET: How microscopic and complete do you want your description to be and I think that that's --

DR. THEOFANOUS: But, what is a liquid and what is a vapor, Milt? That's not very microscopic.

If part of the system if liquid and you have vapor and you don't want to put the demarcation line.

MR. FABIC: I think they are all pertinent questions and I think we know that they exist and that's why, really, we tried to analyze experiments for which we had measurements with different codes. Codes that are similiar to licensing codes and still, the best estimate--we don't have conservatisms built in.

But, they have thermohydrolic modeling features that are similiar to the licensing codes.

DR. PLESSET: Which you hope are right.

MR. FABIC: We want to see how well they do; vis-a-vis, more advanced codes where we do the best that can be done today, and then receive the sensitivity; can you get away with much simplier representation or do you have to have much more complex information?

So, I think, after we run through this process, we'll be able to answer that question, you know, truthfully with some knowledge. Today, it's just anybody's guess.

We have done a number of comparisons with predictions, for example, for the last block small break test, L3-2, which had a very small orifice and which gave us a lot of pain to cope with. Let me just say one thing that was frustrating to experimenters as well as to us, the analyists, was the fact that we discovered that when you have a very small leak, very small break, that there are leakages in the system that are uncontrolled that we didn't know about that existed that were -- that gave flow rates there larger than even the break.

For example, I am pointing out to you all the places where there are leakages that can occur that the

Loft Staff believes are possibly there. This leakages in the line, since it is downstream of the breaker orifice goes directly out, okay? And, you'll see in a minute that this causes --

DR. PLESSET: What is that leak?

MR. FABIC: The valve leak. You're talking about a type of this diameter and a hole of this big an orifice, okay, a small leakage in the pipe is as big as a break through which caused the prediction of pressure time history to be wrong, because we didn't know that that was happening.

Now, there are leakages in these reflood assist bypass lines which could have short circuited the hot and cold legs. There is a leakage in flange which also the PWR's have.

DR. PLESSET: I thought that was a big one, Stan; wasn't that the big one, that bypass?

MR. FABIC: Well, I don't think we know right now whether -- what's the split, okay, which is the main culprit. But, it is of the order of 5 percent or more; while the vendors keep telling us that this leakage in PWR's is just a few percent less then 5 percent.

Now, it turns out that in the analogy, it makes a big difference; is it 5 percent or more or less than

5 percent? Because, in one case the loop seals blow and in the other case they don't; all right? So, the knowledge of the system itself, whether you have leakage in it or not is important for pre-test predictions.

And, we have to rely on pre-test prediction rather than tuning after the test in order to tell whether we have credibility in our analysis or not.

The consequence of that leakage is clear here; this is a pre-test prediction for L3-2 that shows RELAP 4 and RELAP 5 fairly similiar, but depressurizing much later in time than the data. And, this was the reason.

Obviously, leakage probably persevered, but it was somewhat small due to lower pressure; an effect of the pressure time history.

Now, you see long term transient rather then short term; this one lasted for a long time. RELAP 4 calculations stopped at the time when the operator was supposed to do something to enhance cooling. But what it shows is that there was a loss of natural circulation predicted in RELAP 4 calculation, because in that calculation, they did not include any leakage, any bypass, all right? In RELAP 5 calculation at 5 percent bypass was included because this was done after the fact and they're able to come with the same trends; the initial bypass for depressurization was not accounted for because we didn't know about it.

DR. ZUDANS: I noticed that RELAP 5 started at time zero, a different point; is there any reason?

MR. FABIC: I really -- I don't think so. They started with well-known conditions' these were done after the test.

Now, let's look at L3-1; these are not predictions at all, but I would just try to point out that with a larger break, and we're interested in natural circulation, obviously for all small breaks, the fact was that the steam generator pressure was higher than the pressure in the primary coolant system for a majority of the transients.

So, you can't have natural circulation at this period; in fact, natural circulation only took place in a very short time.

DR. CATTON: In the reverse.

MR. FABIC: Well, you can't even -- right, you were added heat, okay? So, you are adding heat.

So, that was not a very good data source to --

I will not go into a lot of discussions of which core did better than the other. Primarily because of all these uncertainties that we saw and the uncertainties in management. Let me show you an illustrated point. L3-2 was a long term transient, all right? We'd like to see, did the natural circulation take place and how long? Well, here is the pressure difference between the steam generator and the primary site, within the uncertainty band; you can't tell from that. Although, clearly the core was being cooled; there must have been some kind of a cooling taking place, but was it natural circulation, we're not sure. And which kind of natural circulation, we're not sure either.

Why? Well, let's look at this picture. This is the data that shows the temperature in the downcomer of the steam generator, that's the secondary side of the steam generator. The difference would be in the temperature of the steam -- in the steam generator, between the primary system inlet plenum, that means the primary side, and the secondary side downcomer.

All right; now that temperature difference has to be positive to have any cooling. What they're showing here during this long time period, a negative temperature. Well, you couldn't have any cooling in this way; but, the Staff suspects that now that the thermocouple that was mounted on the secondary side near the tube sheath, had a hot wall effect and was showing too high a temperature.

So, it is very hard from temperature measurements, we find, to tell the story, okay? And, it's very hard from pressure measurements to tell the story because they are very close. So, this is why in my requirement list of measurements, I did not rely on temperature measurements and did not rely on pressure measurements. I'm relying on flows and temperatures of fluid in the primary system, distributions.

DR. THEOFANOUS: How about densities?

MR. FABIC: Of course, I didn't really want to go through this point-by-point, unless you want me to.

DR. THEOFANOUS: No, but that's another very important scenario.

MR. FABIC: That's right. Here's a good example: here's a density in a pipe in loft and you see that -- I'm sorry, these are temperatures. The temperatures on the top side of the pipe, this is bottom side of the pipe, need the ECCS injection. This shows fairly well stratified flow; need the ECCS injection.

Whether you don't have any disturbance by the ECCS, okay; stratified flow, a liquid subcooled flowing along the bottom and when the nitrogen started in inject, you have a lot of oscillations of temperature and in the steam temperature, okay. We definitely have seen very clearly, even on semi-scale visually, that there is a very good level definition of the water flowing on the bottom of the pipe, the horizontal pipe, and the vapor above it. In fact, you couldn't even see ripples on it; that lull was the steam flowing over it.

Well, if you have that situation, the question is: could you rely on long parameter codes that only consider the mixture? Especially, if you have to calculate that one fluid is going in one direction and the other fluid is going the opposite direction. Now, there's no way on earth you can calculate that with the licensing codes.

So, I'd say in conclusion without going through a lot of representation of test data comparis ons and measurements, I mean calculation, I would say that we have certain modeling problems to overcome, vis-a-vis, test facility.

For example, I had a picture of reflood as boiling. I made a big story out of this -- this mode of cooling. What happens if you now have an orifice here? What is our chance of predicting this flow if you put an fice in here? This orifice does not exist in a PWR, b they are in loft, okay. What do we do? I don't know. I just keep my fingers crossed and hope that this orifice is not small enough --

DR. THEOFANOUS: How big is that?

MR. FABIC: Well, I don't know exactly the size, but I haven't checked yet whether it's going to be limited providing the CCFL, for example; it might provide CCFL.

MR. EBERSOLE: In that connection, if I arbitrarily raised the water level until the pipe is literally full except for a small portion of it; haven't I, in fact, orificed that?

MR. FABIC: If that level is --

MR. EBERSOLE: Yes.

MR. FABIC: -- really up there --

MR. EBERSOLE: And, isn't that one of the transitional points that you have to go through?

DR. CATTON: The pressure will rise.

MR. EBERSOLE: I know. It's one of the transition points. But, how does it test through?

MR. FABIC: Well, the more -- the less flow we have for vapor to go, okay, the more entrainment you can expect to take place. And, we do model entrainment, because there will be a higher velocity of vapor.

MR. EBERSOLE: You can accommodate the case then when that pipe is nearly full or fully full, completely full.

MR. FABIC: We don't have a problem there, okay. And, I think we -- our entrainment -- we can calculate entrainment fairly well. We don't think that this is fairly high there, okay; or are you saying the flow going backwards is ending up the pipe -- you don't mean that.

MR. EBERSOLE: Well, it's standing there. The head of water is near the top of the hot leg pipe.

MR. FABIC: Oh, from here?

MR. EBERSOLE: Yes.

MR. FABIC: All right. So, the flow is going, still going this way.

MR. EBERSOLE: Yes. A portion, not all. Some of it's laying there.

MR. FABIC: All right. In that case --

MR. EBERSOLE: As a matter of fact, there's countercurrent flow in the liquid.

MR. FABIC: The liquid would have to go this way; I mean, it cannot go this way, right?

MR. EBERSOLE: Well, unfortunately, the liquid would be rolling around and the steam would be carrying it along.

MR. FABIC: Countercurrent flow in here.

MR. EBERSOLE: There's a countercurrent flow in the liquid phase.

MR. FABIC: The top layer being pushed by vapor and the bottom going down -- I see.

DR. PLESSET: For a time.

MR. FABIC: We will never be able to do this without advance codes, because we're not doing any monthly dimension analysis.

MR. EBERSOLE: But, that's part of the transition points.

MR. FABIC: Yes, but hopefully, it is such a short time.

MR. EBERSOLE: Well, if you can knock it down deliberately; I mean, it's just like carrying a turbine through the critical regime, if you could really knock it down and get to the level that you wanted to, you could get past there.

DR. CATTON: Are you suggesting a level sensor to control it?

MR. EBERSOLE: Yes. I'm getting around to that.

MR. FABIC: Let me briefly say that this whole problem of horizontal flow, countercurrent flow, and this reflux condensation taking place; this is where we are right now putting in a lot of effort trying to model this in advance codes.

MR. EBERSOLE: This is why a while ago I was saying that an important part of that arrangement is to know where the level is in order to know what you are doing, of course.

MR. FABIC: We will know where the levels are; you'll hear that from Harold Sullivan, how we will know that.

But, let me just say another frustration that we have in analysis that came to us lately is when you put a break in a pipe like this, whether it's a cold leg or hot leg, and the break is a horizontal orifice, okay; it's not on top, it's not on the bottom, it's horizontal-- somewhere in the middle of the diameter.

If the level fluxuates and harbors around the orifice and it did in L3-2, we just have no hope today to describe that at all. We'll have to rely on imperical evidence and where does that come from? Well, there are being tests run at Wiley Laboratory where a loft pipe has been actually modeled, the same geometry, and the fluid condition upstream of that break has been carefully noted or has not been done so far, but it will be in the future, is to not the fluid condition entering that small orifice, okay. And, derive some imperical correlations that can be put into the code. I don't see how we can describe that kind of a flow.

We have always looked at flow where the pipe is filled, with whatever the fluid is; single phase, two phase mixture -- that we think we can handle reasonably well.

But, when you have this kind of a situation, it would have to go out a small orifice and we have a big problem.

MR. EBERSOLE: It would be important to know whether the break in the hot leg was at the upper or lower portion of the pipe; wouldn't it? Because, in one case you're going to lose inventory at a tremendously --

MR. FABIC: Yes, but suppose I have a break here on the bottom, okay? We believe that you are going to be sucking vapor; there's going to be a small vortex in there, that will be sucking vapor through this layer of liquid.

MR. EBERSOLE: If it's there. If I move the break further down in the liquid system, then it's going to be a liquid leak.

MR. FABIC: Put in down in the liquid system.

MR. EBERSOLE: Say on the cold leg.

MR. FABIC: You mean if it's all liquid coolant; of course. But, I'm saying, if you have this situation

MR. EBERSOLE: Yes, and a vortex.

MR. FABIC: -- you still have vapor.

And, if you have this level fairly high up and you have a break up on top, you'll be sucking some of the liquid, too, by entrainment.

It's very tough.

DR. LIENHARD: Is it possible that a break will stablize in a pipe with that pressure?

MR. FABIC: We have seen --

DR. LIENHARD: I thought they had to rip open.

MR. FABIC: The L3-2 showed that the mixture level as hovering near the break.

DR. LIENHARD: No, the break.

MR. FABIC: Oh, near the break; I'm sorry.

DR. PLESSET: No, his point is a metallurgical one.

DR. LIENHARD: A metallurgical one, yes.

DR. PLESSET: He's worried about a crack like that just propogating and becoming --

MR. FABIC: No, no. Let's say there are no cracks, but there are some lines attached to this. And, there are lines attached; in fact, I think that's the way it showed at the bottom; the majority at the top, some at the side, okay? The majority was attached at the top, small lines in a PWR.

So, if they break, we have a small break.

DR. THEOFANOUS: Stan, if your purpose was to show us that learning some of those things is not academic and that it may be quite important, I think you succeeded very well, in fact, in doing that; in fact, you convinced me even more than I was before and I particularly appreciate that because I had a hard time yesterday and even today with this point.

But, in fact, I will say that you succeeded too well because you go now to the other extreme of maybe --

CHAIRMAN CARBON: You're as worried as I am.

DR THEOFANOUS: Maybe if I am as worried as you are about too many more things and I think there is a need of sorting out quite a lot of all this complexity and difficulty is crucial and what is not so crucial and I think that needs to be sorted out even before you spend a lot of money on those very expensive experiments.

And, I don't see that you and the Licensing Staff, again, I keep coming back to that, you are apart in doing that.

MR. FABIC: I don't think we are separate islands not talking to each other. For example, we have been doing a lot of discussion in what kind of a test -- how do we resolve the pumps on/pumps off issue, okay?

DR. THEOFANOUS: But, I don't see any of that. If there is, I wish somebody would bring it forth, because I hear you talking today and we got a presentation yesterday, we hear discussions yesterday, we have discussions today; there's nothing that is coming through to us that will convince us that there is already even a proper plan in getting done with some of those issues and certainly now, what is academic and what is not academic.

There is even a basic disagreement here, as you see, even within the Committee; some people think some of those things are academic, some people think they are not academic. I'm sure if you went and you asked your Staff and the Licensing Staff you will find people on both sides of the fence and in between.

Meanwhile, nothing is happening to help somehow get things on a line to get this down to some solution.

MR. FABIC: I thought you heard me say a while ago that when we have measured -- what we think are relavent experiments , we have relavent experiments in the best test facilities that we have showed there are some small scale, some are a larger scale. But, they are relavent experiments. We have problems with measurements that we are trying to overcome and we will.

The next point is: if we do predictions of these experiments, simply and uncomplicated, okay? Would that give the answer that you are seeking?

DR. THEOFANOUS: Sure. I hear you; that's fine. You see, the only thing that concerns me is these kind of things you are describing; they are one or two years into the future and I think that we cannot put some of those things off --

MR. FABIC: I don't think they are that far in the future. As a matter of fact, the pumps on and off test issue we hope to resolve by November.

DR. THEOFANOUS: Well, I'd like to know how you are going to do it. If I look at all these uncertainties you are putting in and all the difficulties with advanced codes, even, as well as with evaluation models; if some of those things are very personal and relavent then I'm sure some of those things are detailed naturally.

Then, how are you, in yourself, going to sort those things out without doing something different or more than what you are doing right now? Or the Staff is doing right now?

MR. SULLIVAN: Can I make a statement?

Theo, I think we agree with you. We don't think we are doing enough analysis of the experiments that we are running and trying to assess where are the important phenomena?

And, we are trying to take care of that in two ways. As Stan pointed out, there is an experimental program to look at the pumps on/pumps off issue; that's not a subject of this, but it is relavent in the fact that we are trying to look at a way to solve the experimental problem to the reactor problem. And, that is through the code assessment program.

DR. THEOFANOUS: When you have some results, I'd wish that you'd bring them to us as soon as you can because right now, although I get assurances from you, yes, and I like to hear what you are saying; I guess I would be concerned as long as I know that there are many, many different philosophies in all corners: Staff, Research, ACRS and Consultants, and so on. And, I don't see a kind of free discussion and then somehow crystalizing to a reasonable approach that's got a beginning, it's got a middle, and it's got an end; and to know how far that end is.

MR. SULLIVAN: Well, I think that you do have a good point and Dr. Catton and Dr. Wo (?) came to Idaho as ACRS Consultants to review that program to some extent and we took a lot of their comments and are trying to fold those back into both the experimental programs and how to solve this issue of jumping from the experiments to the reactor.

And, you know, we would like to present those plans to you; we just don't have them completed right now. But, we are working on it; we realize the problem.

DR. PLESSET: Well, I'd like to throw a little gasoline on flaming Theo.

DR. THEOFANOUS: That would be very dangerous.

DR. PLESSET: I think that you are going to have to compromise rather strenuously and get away from the microscopic description into an average or more global description. And, I think the problem is going to be, how far do you have to go in that direction, because if you stay completely microscopic, it will be Fabic's son who will be carrying this thing.

MR. FABIC: Grandson; I'm sure of that, you're right.

MR. BENDER: Otherwise, their codes depend on microscopic kinds of information.

DR. PLESSET: That's got to be taken care of, too.

MR. BENDER: And, so they have to go back and start all over again.

DR. THEOFANOUS: But, Milton, I hope you are not saying that, or you don't understand me to say that we should go to a microscopic description.

What I'm saying is that we don't know at this point what is that level of adequacy? We don't know that. We have to find that and unless we find that, we won't even know what kind of experiments to write. And, you will be hearing presentations like this not until Fabic's son, but his grandson and then that will be no problem.

MR. ETHERINGTON: We won't, Theo.

DR. CATTON: On the other hand, I understand that semi-scale is one of the best codes around for predicting loft and probably cheaper than any of the others.

MR. FABIC: Yes, that's one way of doing it, providing you take care of what some people fear are typicalities with the PWR, right?

DR. CATTON: Yes, but haven't the pre-predictions made with semi-scale been the best yet for loft?

MR. FABIC: For large breaks, yes.

DR. CATTON: What about for small breaks?

MR. FABIC: I haven't seen -- we haven't seen enough of that.

DR. CATTON: But, it does look like semi-scale is the best so far.

MR. FABIC: Well, you see, semi-scale is a very tight system, it doesn't have leaks. Or, I'm told that, okay? Consequently, this leakage -- how do you put that, how do you make a prediction with semi-scale with a system you don't know whether is has or doesn't have leaks?

DR. CATTON: Of course, you always face that problem; if your boundary conditions are wrong, you can't expect correct --

MR. FABIC: On the other hand, there is a heat loss, heat leakage in semi-scale that is about ten times higher than in loft.

DR. CATTON: If you know what it is, you can handle it.

MR. FABIC: If you know what it is.

DR. THEOFANOUS: Ivan, this one is an easy one; with loft, for example, you can do pretty good predictions or aspects, okay? For semi-scale, you can. Both are more than pretty good, they are all in the same reference.

However, for small breaks, the semi-scale, of course, has done a very miserable job, even for standard problems.

DR. CATTON: I wasn't sure how well semi-scale had done in predicting loft for small breaks. I guess that remains to be seen

MR. FABIC: I think if you'll see some of those notes that I left with you, codes are done fairly well on predictional semi-scale results, primarily, because of knowledge of the break flow in that case. It's comforting, not bad.

CHAIRMAN CARBON: Let's break for lunch and come back in an hour.

(Whereupon, the meeting was recessed for lunch at 12:55 a.m.)

CHAIRMAN CARBON: You're leading off, are you, Harold?

MR. SULLIVAN: Yes.

CHAIRMAN CARBON: Before you start, let me make a comment here. We're going to lose at least five people by 4:00, so, Harold, would you aim your presentation and our questions to wind up by four? I think we'll have some discussion beyond that, but if you will finish your presentation by then, it would fit well.

MR. EBERSOLE: May I start with a kind of a topic? Before you get into this which is the discussion on bleed and feed, I guess I'd like to hear you say something about whether we really are at a point where we've got to have it, or is it a vague thing that might be nice to have.

I can go back nearly 12 years to where when we first looked at SEQUOYAH, we were digging away having had the experience of the SAR design to have the design modified to guarantee a capacity to blow the primary system down and the secondary system down to get a low pressure position because we were suspicious of the convection process and the adequacy of the secondary, and we were aiming to get in a condition of low temperature cooling invoking low pressure water and sufficient flow rates to remove the heat by sensible heat transport.

We were driving towards what you would call a

PWR SAR complex. If you had it, of course, you would be using bleed and feed in a true usable form without much question about it.

There would not be much theoretical question of whether it would work or not. It would work. You would have enough water flow to take water right off the primary side without any secondary system.

Alternatively, if you had primary and secondary coupling, you would have the prerogative of getting sufficient slowdown capacity on the secondary side to reduce the pressure below. Do you follow me?

To jump over all the theories of whether feed bleed is going to work or not and go to the end point of getting this kind of performance, I think, deserves some consideration. I mean if I can leapfrog over the problems and come to a solution, I always do, if it doesn't cost too much.

I never was impressed by the fact that it cost too much.

CHAIRMAN CARBON: Let me ask here for clarification. Your discussion this afternoon is primarily on natural circulation, isn't it, rather than bleed feed, or is it?

MR. SULLIVAN: That is correct. In fact, you'll see that the presentation doesn't cover feed and bleed at all, and the reason that we haven't looked at that aspect of it, and we are going to look at it in the future is because the NRC staff, I don't think, has come to a decision on where it's going to be required or how much research they would like in that area.

The facilities are currently being designed, or we're going to try to take in the considerations for feed and bleed to run those types of experiments, and depending on what they decided to do and our priorities in terms of looking at probablistic assessment, that would be the determining factor whether we would end up running feed and bleed or not.

MR. EBERSOLE: Well, a little bit analagous, if I had a contest between concrete and aluminum airplanes, I wouldn't work on the concrete airplanes very long.

MR. SULLIVAN: Let me see if I understand your position is that you would not recommend --

MR. EBERSOLE: Something that had a vague assurance of success in the future. I would go towards something I had assurance in that I thought would justify my effort in refining. I don't know whether -- I really don't know whether natural convection on the basis of using it is reliable or not. Maybe you're going to prove that to me. I'm willing to listen.

MR. SULLIVAN: Now, I'm not here to -- we don't have the data yet to prove it to you.

CHAIRMAN CARBON: Are you from the Idaho

organization?

MR. SULLIVAN: I was. I worked for Idaho for a while, and now I'm working for research, so I'm on the research staff.

CHAIRMAN CARBON: A moment ago you referred to the staff. Did you mean the licensing staff?

MR. SULLIVAN: The licensing staff.

CHAIRMAN CARBON: Okay.

MR. SULLIVAN: I'd like to open by a statement. I think it's the ACRS view that there are little problems with what I call single-phase loop natural circulation.

There is a question on if the system, if you've got a lot of gas in the system, how that affects it, but the codes seem to do a reasonable job on that.

MR. EBERSOLE: I've got one thing to add to that. If in the course of meeting a transient you do suffer a secondary side trial for a period of time, six minutes, except maybe longer, you lose, in the short-term natural convection, you come to a homogeneous temperature condition, and no longer in the circulation.

Now, I think I can always argue, and I think I would get general agreement that sooner or later I'm going to get water in the secondary circuits by one means or another, with a fire hose, if necessary; however, if I don't have the capacity in a solid liquid system to restore natural convection, I'm up the creek.

MR. SULLIVAN: I think that that is a legitimate question. Now the codes have said that you can start natural circulation from those conditions, and it seems to be reasonable, but it's something that ought to be investigated.

MR. EBERSOLE: The times, by the way, during which you get to this state are quite short.

MR. SULLIVAN: Yes.

DR. CATTON: Harold, that's not a new problem, by heating and cooling.

MR. SULLIVAN: Yes.

DR. CATTON: And I think there have been measurements made of the temperature overshoot. Have there been any comparisons of the codes for just a simple loop?

MR. SULLIVAN: Yes, they have compared the codes to -- they have not done it in a large facility, and I understand SEQUOYAH is also planning on doing one from rest and then starting the system to a natural circulation condition.

DR. CATTON: Both SEQUOYAH and NORTH ANNA too, when they do this test, as least the way I read the test, they're going to sort of creep up on the tower. If you creep up slowly, what you have is just essentially a series of quasi-study. I think to get to the question that Jessie is addressing, which you want as a step-in bound --

MR. SULLIVAN: Yes.

DR. CATTON: --there are those kinds of experiments around for small loops. The only difference I see between a big loop and a small loop is how well you know the --

MR. SULLIVAN: The resistances.

DR. CATTON: -- the resistances.

MR. SULLIVAN: We plan on running an experiment like that from rest to an increase in power, a step increase in power to start natural circulation and look at the inertial losses or the inertial effects to see if the codes are capable of predicting as well.

DR. CATTON: Semi-scale?

MR. SULLIVAN: Yes.

DR. CATTON: I would think that would be excellent, because you could step the power as high as you want.

MR. SULLIVAN: Right. So there are a few questions in single phase. Most of the questions that we see are in the two-phase portion of the transient, and the codes predict that the full size machine go through a mode of two-phase natural circulation, and they say that things are okay.

DR. THEOFANOUS: Which codes are those now?

MR. SULLIVAN: Okay. They are the vendors codes and the relap 4 mod 7, and the relap 5 code. I'm not sure.

Stan, are you familiar with it? Have they run --

MR. FABIC: I made a point a while ago that there is track PF1 under development which will be used for small breaks. There will be no capacitors done, because it's not finished yet.

They have used track P1-A for TMI calculations, but you call that tuning. They can show they can do it with comparison after many calculations, just this and that, so they can show they can calculate that problem fairly well although measurements are not --

DR. THEOFANOUS: Do you think it does an honest to God comparison with TMI?

MR. FABIC: With a lot of tuning it will.

DR. CATTON: What about if you don't have the proper inputs?

MR. SULLIVAN: Yes, it's -- they're running it on all of the semi-scale and loft tests now, and so it's predicting those transient, and Stan has shown some of those predictions.

DR. PLESSET: Harold?

MR. SULLIVAN: Yes.

DR. PLESSET: You say you have confidence in handling two-phase, let us say water, water vapor, but now let's not add another phase, just another component, an inert gas, can you handle that?

MR. SULLIVAN: You mean in the codes?

DR. PLESSET: Yes, you made a statement that you can handle the two-phase.

MR. SULLIVAN: I'm talking about the experiments now. The experiments as I see them are providing a data base for the code assessment process.

DR. PLESSET: Okay, all right, but will the experiments include this second case?

MR. SULLIVAN: Yes.

MR. EBERSOLE: We already did accidentall', didn't we?

MR. SULLIVAN: Well, not accidentally, but in semi-scale, they ran TMI type transients and have injected non-canisi. ˜e gases in it.

DR. PLESSET: But this is not a survey. It was just one.

MR. SULLIVAN: There was a series of tests runs on that, and they were run very quickly, and we did get a sizable data loss, because of how quickly we ran them, and they were more interested in where the gas ended up than in looking at the phenomena in detail, so that's the reason that we needed to go back and look at these in some details.

The way that I see the experiments are to show or verify that these modes do exist in our experimental facilities. I think it's important to determine what the parameters are that affect its existence, so that we can get in an optimum, if it occurred in a plant such as TMI, that we could get an optimum arrangement to take maximum advantage of its existence, and also to look at the kinds of data that would be presented to an operator to show that he actually is in these modes of natural circulation.

So I agree that we ought to run some experiments, and they ought to be for code assessment purposes, and then those codes should be applied to large plants.

The extent that the phenomena has to be modeled, I feel, is that it has to be modeled to the extent that it can predict the experimental facilities, so I think that addresses some of the concerns that you have, that we may be fine-tuning things, past the point of returns.

DR. ZUDANO: Did I understand you to say that the data that will yield parameters will come from tests directly?

MR. SULLIVAN: No, I did not mean to infer that. The thing that I would like to present to you is that right now there is more instrumentation is almost all of our test facilities than any one of the plants, and from that instrumentation, we ought to be able to determine the modes of natural circulation and infer from that data what should be the indications at a plant.

Once you run the code, then you can infer.

DR. ZUDANS: Okay. Do you have another element, a code that you identify for plant?

MR. SULLIVAN: Yes, that is the process, run an experiment, assessing a code, and then applying it to a plant.

DR. ZUDANS: And the real purpose of a test is to identify and understand the phenomena and that would be a code.

MR. SULLIVAN: That's correct.

DR. ZUDANS: That is one, and then you have some confidence in which you can then apply to the plant, and then determine the parameters.

MR. SULLIVAN: Right.

DR. CATTON: And possibly parameters that the operator doesn't have available.

DR. ZUDANS: That may be.

MR. SULLIVAN: Yes. There was a question about the gas in the system. I'd like to tell you that we are looking at it. The NRC staff has done a survey of it. We have several experimental programs that are going to put non-canisible gases in the system, and we need to know how much, and so we are looking at that issue.

One of the things that we are not looking at is the question that you brought up about the boron plate-out, and I think it's something that I personally don't feel that it's a problem, but I'm not a chemist either, and so I think it's something that we ought to address.

MR. BENDER: Let me go back to the question. How do you propose to find out what the right proportionate -- would be in one of the systems?

MR. SULLIVAN: The question that I have right now is how much there is in the system, that is one of the problems that we're looking at.

The method that we're using is to try to put the non-canisible gases in a place that the flow patterns in the test facilities might tend to take it to wherever it might go, so we would try to relate that to the experimental facility, so we'd be injecting the non-canisible gases in parts.

MR. BENDER: In what quantities and in what portions?

MR. SULLIVAN: You mean the gas mixture?

MR. BENDER: Surely if you put enough non-canisibles in, you'll get the system in trouble, and you'll short.

MR. SULLIVAN: Yes.

MR. BENDER: The problem is to decide when to put it in and how much and how to model its disbursal, if I can use that term.

MP SULLIVAN: Well, the way that I see it is I'm not sure -- it all depends on what the survey of how much generation is there, okay, and I think we ought to go to a maximum generation, and then maybe overstep that a little bit to make sure that we have covered the range.

Now if that takes you to complete covery of all the steam generator tubes, I wouldn't feel that's an unacceptable position to be in, because we're not showing a reactor has that problem.

What we're trying to show is that codes had a capability of calculating that, but it is a question that needs to be addressed, and we are trying to look at how much gas to put in it and where to put it in.

MR. EBERSOLE: On that subject, SEQUOYAH is coming up. It's a UHI plan.

MR. SULLIVAN: Yes.

MR. EBERSOLE: But sooner or later you'll come to a parting of the ways where you'll say I will or I will not cool core after an accidental ingestion of the UHI maximum or some fraction of it.

In order to get there, there are a number of paths, like pressurization with or without primary systems. There's a certain low probability, certainly not zero, that this can occur. If you ingest a substantial fraction of it and you've lost the pumps, and I don't know whether feed bleed will work, I'm in trouble, because I'm not going to get a coupling to the secondary loop unless I have some remaining fraction of the other method which is a reflux condensation.

Certainly one or the others of those methods is going to have to do for me, because I have lost liquid convection.

MR. SULLIVAN: Maybe you've lost what I would call single-phase loop natural circulation.

MR. EBERSOLE: Lost my liquid convection.

MR. SULLIVAN: Yes. Now, I think it's important that we understand that if you did have a case like that where there is gas in the U tubes of the steam generators, will the system go into the thing that I would call for the lack of a better word is a reflux condition.

MR. EBERSOLE: Yes, right, now then so say we're at the point. We have to understand. First of all, we don't have to admit that that will happen if we want to be less conservative like we used to be.

MR. SULLIVAN: Yes.

MR. EBERSOLE: The other side of the coin is we have to admit that it might.

MR. SULLIVAN: Yes.

MR. EBERSOLE: And, finally, one has to look at the merits of having a UHI on there at all which, I think, probably are not easily outweighed by the disadvantages. I mean UHI is there for a rather discreet function associated with a large load bearing. It brings a modest amount of improvement in large loads primarily, and it's designed for, as I understand it, utilization in load following plants for which that plant is not going to be used.

In short, it may be a millstone around our necks rather than an asset if we look at it hard enough. What I want to get at though is the final end point. Are we going to have to admit that we have the facility of delivery if some of that gets to the core, or are we not?

MR. SULLIVAN: I think that's more the licensing staff. The thing that we're trying to do is to generate a data base to assess the codes, and I'm trying to --

MR. EBERSOLE: I'm trying to find an end point of your work.

DR. CATTON: Harold, if your first test were run with the maximum amount expected of nitrogen, you'd answer Jessie's question once and for all.

DR. ZUDANS: You would answer that for the facility, the test facility.

MR. SULLIVAN: Yes, that's correct.

DR. PLESSET: Well, that is a fair understanding.

MR. FABIC: Some of you may know that in five antitrack, we have now included the non-canisible gas field, so, for example, we have seven conservation -- the question is how well do we represent the transport of that gas throughout the system in the presence of two-phase flow.

In order to verify that capability, we have to have good enough measurements, believable measurements in facilities like this. In order to get credible measurements, you have to put a lot of gas.

If you put small quantities, there's no way on earth you can measure them. I don't even know how we're going to measure a lot of gas, okay, unless we just tap at one or two points. That doesn't tell you much about its diffision. It tells you that you've got gas there or not, but how deeply did it penetrate. Do you go half the lengths of the tubes and only the top? You don't know unles you define it.

DR. THEOFANOUS: How about tugging it?

MR. SULLIVAN: That's what we're looking at.

MR. FABIC: People are now starting to look at how we're going to measure the location of the distribution of the gases, factual time by the calculations. Once we have some confidence in the calculations, then we can say at what phase of an accident in the field.

DR. CATTON: That seems to me the long-term goal. What's wrong with a short-term goal finding out whether or not the amounts of gas that are in there are going to shut off the reflux boiler? If you put that much gas in and you don't shut off the reflux boiler, then you're talking about the degree of degradation, but you sure have hell have moved a lot of it out.

MR. EBERSOLE: I think I'm probably being difficult if you decide not to work on it and jump to a different field, and this is what we were trying to think about when we went to SAR and PWR. They didn't want to try to work out the problem so you jump to hard firm conclusion in another area entirely.

You know, you walk around the problem.

DR. PLESSET: I think Jessie has raised this point repeatedly, and I'll say again what I said this morning. Westinghouse maintains that they can ingest all of the nitrogen in the UHI system and still have reflux and heat transfer which is adequate.

Now what will happen, the staff hasn't evaluated that yet, but I'm sure they'll come to research and ask them to help in this evaluation, so it's a fairly near-term question in addition --

MR. EBERSOLE: I wasn't getting that impression.

DR. PLESSET: Well, I'm just saying that it might be.

MR. EBERSOLE: I thought he was giving some message that we really --

DR. PLESSET: No, it's straightforward. They have a calculation and an analysis. The staff should either reject it or accept it.

MR. EBERSOLE: And we're not far from that. I don't know that the analysis is available.

DR. PLESSET: Well, maybe it's not a complete analysis, but they have a presentation.

DR. ZUDANS: They said they had 3100 --

DR. PLESSET: That's true, but it looked kind of persuasive, I would say that.

DR. CATTON: They then argued that if you had this much volume and if it displaced this much, and you had this much area left in your tubes, and that's enough.

DR. PLESSET: Well, but it was enough by a big factor, they maintained, to take care of your concerns.

DR. CATTON: A single run on something like semi-scale would just give you a nice --

DR. PLESSET: Fine, that's why I'm urging them to put it up a little way.

MR. EBERSOLE: You can understand my logic is really if I can't get something with a rifle, I'll use a shotgun, and I won't bother with any expertise on the rifle.

DR. PLESSET: Well, I think that one test would help a lot is all that I'm saying.

MR. EBERSOLE: Okay, I don't know that.

MR. BENDER: You're saying if we have one experiment, if you put a lot of gas into the system and saw what's its heat transfer characteristics were --

DR. CATTON: The upper limit that you could get from the entire --

MR. BENDER: If it's still operating as much as you can expect, then you could go ahead, and figure out what you need to put in.

DR. PLESSET: That's what I'm suggesting, that's all.

MR. SULLIVAN: Maybe I raised more questions than I tried to.

DR. PLESSET: We'll just give you one more experiment.

MR. SULLIVAN: Right. The talk today is on natural circulation, and I play not to address the feed and bleed until such time as we are preparing the facilities to look at questions like that.

We are not planning on doing them. We have a space that we could do those experiments, but we have not planned on doing them yet, but we are considering them.

MR. BENDER: Are we using the more general definition of natural circulation now?

MR. SULLIVAN: Well, I had divided the presentation into three parts. I'd like to discuss what I mean by the modes of natural circulation, then the experimental plans and draw some conclusions, so let's look at what I mean by natural circulation.

There is the single-phase liquid loop, and that is the conventional natural circulation and SEQUOYAH is going to run some of these transients.

As Dr. Fabic pointed out, there is a two-phase loop, and I'm using a nomenclature that we have kind of developed, and I'll try to be consistent through the presentation, but the two-phase loop is when there is two-phase liquid all over say the top of the candy cane, all the way down in the B&W plant or all the way through the steam generator or all the way to the top of the U tubes and back down the other side so --

DR. PLESSET: Let me ask for a clarification. It's two-phase. Is it one component? In other words, H_2O liquid or vapor, or will you add N_2 or H_2 or whatever to the gas?

MR. SULLIVAN: It will be only one component.

DR. PLESSET: One component, but that's kind of trivial Harold.

MR. SULLIVAN: These are definitions, okay?

DR. PLESSET: Oh, okay.

MR. SULLIVAN: So that when I say that, you'll know what I mean, and then when I say we're going to look at non-condensible gases, you'll know what that means also.

DR. PLESSET: It would be more exact to talk about two-phase, two component, one of them non-condensible. That would be very easy for me then to follow you.

MR. BENDER: I may have a better definition of two-phase. I think you said the mixture all the way through the system. Did you really mean that?

MR. SULLIVAN: It could be solid, and --

MR. BENDER: Normally the system has liquid water in one end and a two-phase mixture at the other end.

MR. SULLIVAN: Yes, I meant over the top of the U tubes. That's what we're talking about. It could be single-phase in the core boiling or boiling in the core and going onward.

MR. BENDER: Thank you, I just wanted to be sure.

MR. SULLIVAN: Then the two-phase hot leg, I mean the type that Dr. Fabic showed you earlier where there is the so-called reflux condensation or reflux boiling where there is liquid running down the steam generator tubes in condensation, that countercurrent flows in the hot legs and flows back into the vessel.

So the core could be completely covered, or it could have a fixture level in it, and it could begin to heat up or steam cooling. Then I've added the other one, the transition between the modes, and it really is a transition.

It's not that we can turn one of these on and one of these off. It's probably a very gradual transition from one of these modes to the other.

MR. ETHERINGTON: Then to pick up Dr. Plesset's question, we don't have a two-component --

MR. SULLIVAN: Not be definition. I have used adding a non-condensible gas to the --

MR. ETHERINGTON: I see, it's in your test series then.

MR. SULLIVAN: So then, starting with each of these three modes, I'd like to let you see the things that we're currently thinking about it, and it's not a complete list. It's some of the major things that we'd like to look at.

There is the initiation of natural circulation, and we look at it as a fluid at rest to a stable or a steady state natural circulation mode, and I have listed the phenomena and the possible experimental facilities that are involved, and the reason that I say possible is that some of these experimental facilities have not finalized on their test matrix, and we're trying to make sure we cover a wide range of parameters, and so it may be that later on, we would drop some of these facilities out looking at these particular phenomena.

SS is semi-scale. The FS is the Flecht Seaset facility and I'll be talking about these. The university is university contracts that we have, and I'll try to discuss that.

I don't think I can discuss it in a lot of detail, because it's in a contractual arrangement right now where we're getting ready to either approve the funding or disapprove it. I don't think it would be too nice to discuss the thing before it got funded. We would tell you if it was not funded.

MR. ETHERINGTON: Are any of these single minded, single tube type of experiments?

MR. SULLIVAN: Yes, in the university facilities are in the class.

DR. PLESSET: All pressure, I guess, glass.

MR. SULLIVAN: Yes, glass, and the tubes are -- well, I'll try to discuss it a little bit more. The PKL facility, the German facility and the Japanese large cylindrical cord test facility, so we -- the possibility exists of looking at the initiation.

I know that two facilities will probably do those tests, the semiscale facility and the Flecht-Seaset facility. The imbalance between steam generators, that's something that occurred at TMI, and we'd like to look at as possible candidate test. Mass injection and removal, this is from make-up and letdown. We would like to understand how that affects the natural circulation, and non-condensible gases, so we'll be adding.

MR. BENDER: I'm not clear on the mass injection removal. What's the mechanism?

MR. SULLIVAN: Well, the feed and bleed is like PORV open high pressure injection. This is high pressure injection letdown using another part of the system, or if you had a small leak in the system, say you went through a transient and you had a pump leak or something.

We'd like to know if that has a big effect on natural circulation.

DR. PLESSET: In connection with the cylindrical core test facility if you had a good feeling of confidence in being able to go from test pressure which is somewhat low to a much higher pressure, that would be a very interesting facility, because a very good simulation of steam generator relationships to the core.

My question is how will you be following those tests? Will they be adequately instrumented? Will they add non-condensibles, because that could contribute quite a bit to your fund of information in a very useful way.

MR. SULLIVAN: As you know, that's part of the 3D program, so that we will be getting the data from the facility. The way that I understand it is that that test matrix has not been approved yet, so that we are currently looking at it, and we have a promise from the Japanese technical people that they will be evaluating this, and they would like to include both the modes of natural circulation, the injection of non-condensible gases over a range of hours.

DR. PLESSET: Will anybody be there to watch the tests from USNRC? I regard that as crucial, because it's a valuable facility, reasonably well instrumented, and the relationships between the steam generator and the core are good, but it would be nice to have a lot of confidence in what you get out.

MR. FABIC: There's always somebody there from NRC or NRC complex.

DR. PLESSET: Well, transients I don't care so much about. I've been there and back, you know.

DR. FABIC: Dr. Tomy just came back from Japan, and he just heard since he came back that the Japanese government is seriously going to go ahead with a full-scale small break.

MR. SULLIVAN: That's the last slide.

DR. PLESSET: Well, I'm still interested in the CCTF being made useful.

MR. SULLIVAN: We're trying to put into the possible test facility things that we feel exist and have a good possibility of adding to our information in the next year or so.

So to answer that question directly, I don't think that there is anybody permanently stationed in Japan. I don't think there is any plans to do that. We do have contractors there all the time, and people that are stationed there are for our contractors, but there is not a US NRC person assigned to that.

MR. FABIC: There is a person that's funded by US NRC as a liaison man stationed there.

MR. SULLIVAN: But he does not belong there on staff.

MR. BENDER: Harold, there's one other item that may be covered there and maybe not. Are you going to investigate how a change in the pressure level in the system might affect it?

MR. SULLIVAN: Yes, and the reason it doesn't show as a parameter there is because the test facilities more or less preclude doing them all at the same pressure. There are some low pressure test facilities here, such as PKL is up to a 1000 PSI. The CCTF is a reflux facility, and it doesn't have the pressure capability of going to very high pressures. The semiscale facility can, of course, go to high pressures. The flight facility is a rather low pressure facility.

MR. BENDER: I don't think I quite made my point right. The thing I'm interested in is if the system is running a natural circulation at one pressure, and for reasons that I won't define, you decide you want to operate it under some different pressure, the transition that comes about when that event occurs, I think, is of interest.

Itdid happen at TMI. They changed the pressure levels several times, and I think is one of the places that we never understood what was going on.

MR. SULLIVAN: In single phase, I'm not sure it's a really important parameter if there is no non-condensible gases in the system. Now in two-phase, I think you have a good point, and that's one of the things I will put on our list.

MR. BENDER: I don't know in single phase. I guess I haven't thought enough about it.

DR. CATTON: As long as it doesn't boil.

MR. EBERSOLE: In the mass injection and removal, I can't quite see what the difference between that is and, say, the small breaks where you have a break below the liquid line.

Does that include consideration arbitrarily defined liquid leaks where you have to make up as well as preserve the natural convection process?

MR. SULLIVAN: Well, the thing that we were trying to address here is if you open the PORV valve or some valve in the system and had a leakage and closed it, would that upset the natural convection.

Also, can you go back to normal make-up and let-down. TMI -- excuse me?

MR. EBERSOLE: The greatest liquid loss is when you continue to have a liquid lead.

MR. SULLIVAN: Yes.

MR. EBERSOLE: TRV is in an advantageous position in this context. Does this include looking at leaks which would be like the small break activity, like seal favors?

MR. SULLIVAN: We would be looking at things more or less like letdown and make-up flows where, you know --

MR. EBERSOLE: Do you mean more like in a probablistic context, or are you going to arbitrarily define a leakage rate, and say I'm going to naturally cook under this condition?

MR. SULLIVAN: I think that what we would like to do is make sure that the plant would be okay or the test facility, we could get data in a test facility where you had a scaled maximum letdown flow and make-up, and it doesn't make any difference which way you're operating that and that should pretty well cover any small leaks. It would not cover complete seal failure in a pump.

MR. EBERSOLE: Letdown the seals anyway.

MR. SULLIVAN: Yes.

DR. CATTON: The mass injection could be cold water.

MR. SULLIVAN: It would be. It would be high pressure injection.

DR. CATTON: And that could interfere.

DR. THEOFANOUS: Could I ask what you mean by this in the context of single loop? Is it like localizing?

MR. SULLIVAN: Yes, right.

DR. THEOFANOUS: But not in --

MR. SULLIVAN: We would put it some place in the system and see how that affected this mode of natural circulation.

DR. PLESSET: Well, I'd hope you'd follow the migration of the non-condensible.

MR. SULLIVAN: The program we've done the most looking at it is the Flecht-Seaset program, and we plan in injecting it into a location and look at its migration to any one component. But also, we would like to force it to be someplace in the system such as injecting it in the hot legs.

DR. SCHROCK: I had the same question, I guess, that Theo just asked, but I have looked ahead at the next couple of slides, and I was confused as to why you have not convinced on the single phase, but not in the --

MR. SULLIVAN: There's a good reason for that, and it's an oversight. I was going to add that. Everyone of the slides thereafter should have had the --

(End 7)

MR. EBERSOLE: -- there's a statement given to them about convection fluid velocity was sufficiently high to Skagit non-condensibles from the upper portion of the U bend, and I didn't quite swallow that very well.

Is that a misstatement?

MR. SULLIVAN: I think they did make that statement, but I'm like you, I'm kind of skeptical.

MR. EBERSOLE: I'm going to discount that until somebody tells me something else.

MR. SULLIVAN: The experiments would be able to tell you if that occurred.

MR. EBERSOLE: Yeah, I can believe it if the non-condensibles are in a microscopic form.

MR. SULLIVAN: Yes.

MR. EBERSOLE: But I can't if it's in the aggregation.

DR. THEOFANOUS: But if the non-condensibles are in the microscopic form and if the natural circulation is sufficient to keep them suspended, then you will never--

MR. EBERSOLE: Yes, right.

DR. THEOFANOUS: And if we keep in mind that the --

MR. EBERSOLE: This is the dissolution problem.

MR. SULLIVAN: Okay. Moving to the second mode which is the two-phase loop is that we were interested in the steam generator heat transfer, the separation in the vessel in the loop, the identification of the wind two phase natural circulation start, and can you tell from the instrumentation when you have it and when you don't, and in what indications might be available in a control room.

Again, from doing code analysis after we've assessed them, the transitions between single and two phase natural circulation, the mass injection and the removal and the lift out on non-condensible gases.

I think you can see that that is in our test records.

MR. EBERSOLE: Each time you say something like identification of two phase flow, like you had up there, or verified with such and such, there is inferred that if you go through this process, you will always find out that you verify or else there's a problem.

Now what is frequently not present is that a course of action be taken if you find you didn't verify, and it's almost useless to say verify something unless you've got an escape route if the verification process doesn't pan out.

You deal with that.

MR. SULLIVAN: The thing I think that we have to rely on is to assess the codes and then to apply them to a plant, so that would be the mode. Now, in that you need a good data base, and if you found out that one of these modes was particularly unstable or that you were having problems getting into one of these modes, I think that we would investigate how you could start.

MR. EBERSOLE: You can do it on the experiments, but in real life, you can't.

MR. SULLIVAN: Yes, that's true, but the only way that I feel that we can do it is through providing a data base from the experiments and then assessing the codes.

MR. EBERSOLE: When you say it here then, you're in the spirit of doing an experiment.

MR. SULLIVAN: Right.

MR. EBERSOLE: But when it's in real life, the same is still there, the escape route is not defined.

MR. SULLIVAN: Yes.

MR. FABIC: What we mean by assessment is to try to contain knowledge about the uncertainty of the prediction, and I know we'll have enough data to find it for experiments. The question is whether that uncertainty is now transportable to a PWI. There's a lot of heated discussion going on now whether we'll have enough information on that. I won't talk about that, but so the escape is there.

Suppose we do not predict location in every experiment. That's going to broader the uncertainly of prediction, so we'll be able to say, okay, the probability of this situation has been corrected to such and such. That's the goal. Whether we'll be able to do that for a PWI is the question.

MR. SULLIVAN: As I understand your question, it is not exactly that, right?

MR. EBERSOLE: It's a little bit different. Here you're speaking in the context of an experiment and verifying that the circuit phenomena takes place. That's fine. If it doesn't, either you don't get the answer or something else.

MR. SULLIVAN: Yes.

MR. EBERSOLE: The same words are used in emergency procedures to verify that this or that takes place, but in that case, there is no time or no opportunity to take an ultimate course. You either verify and find it, or you run out the door.

MR. SULLIVAN: Yes.

MR. EBERSOLE: And that's all it is. The same words are there.

MR. SULLIVAN: But, I think the code analysis is the way of finding the so-called out.

MR. EBERSOLE: Yes, it's a different spirit in which you mention verification.

MR. SULLIVAN: And we're trying to assess the codes and make sure they do that such that you can with a great deal of confidence find these modes.

DR. CATTON: I think from your instrumentation you're going to find what the symptoms are when you're being led away from this.

MR. SULLIVAN: Yes.

DR. CATTON: And I think on semiscale they would even have the possibility of exercising some negation action to see if it pulls them back or not.

MR. SULLIVAN: The two phase hot leg is in the case of the countercurrent flow and the hot legs. We are interested in steam generator condensation. The separation that occurs in the vessel, the core heat transfer, particularly if it has an uncovered top of the core so we have to steam cool, the hot let counter current flow, the identification of this mode of natural circulation, the mass injection, and then we're going to look at the injection of also non-condensible gases.

DR. PLESSET: Isn't there overlap between THTF and some of these other facilities?

MR. SULLIVAN: Yes.

DR. PLESSET: Are you dispersing your effort a little bit to include it in the program? I see it up there.

MR. SULLIVAN: Yes, let me try to -- it's one of the things that I'd like to talk about.

DR. PLESSET: Okay.

MR. SULLIVAN: The experiments are divided into two classes, separate effects and the interval type. The interval type are going to be discussed in late April, and they are going to be the semiscale.

The separate effects I'd like to address now, the Flecht-Seaset program, THTF, and the proposed university contract. In addition, TLTA appeared on the agenda, so I'll address that a little bit, and then some foreign experiments that we are getting data from.

Looking at Flecht-Seaset, it was originally a large break refloodfacility, and since TMI, we have tried to narrow that reflood aspect of it and look at the modes of natural circulation, so we have simplified the design of the facility to save money in the reflood area, reduce the reflood test matrix and are now looking at doing the natural circulation experiments in both the single phase, the two phase and the two phase hot leg, and Westinghouse calls that the reflux condensation mode.

The loop design that is attractive to natural circulation is that it does maintain full elevations which we feel is important.

It is power to volume scale which we also feel is another important aspect of the facility. The modifications that are needed to change it from the reflood to the natural circulation are possible and not terribly expensive so it also lends to us going in that direction.

The contract we have talked to Westinghouse on several occasions, and we are planning to go on this mode. All three parties have agreed to it, and so we are proceeding down to this mode of doing natural circulation experiments.

The objectives are to provide a data base for the code assessment work, to examine the core cooling as you transfer from one mode of natural circulation to the other, to examine the system response and stability in the three modes and the transition between those modes, to examine the response of collate injection and the injection of non-condensible gases, so those are the types of experiments we'll be doing.

This slide shows the original Flecht reflood facility, and basically there's a broken loop and an intact loop. It has a steam generator, the vessel, it's a full-height facility. There is a down comer, and there is an opening to a containment which is shown on the right side of the slide. It's the same type of experiment that you've seen for Flecht-Seaset before. There's been some modifications to the upper plenum, separations of the liquid or any liquid carry-over after you get out of the steam generators, and the test was designed to provided a data base for code assessment.

Just looking at the facility as it needs to be changed, first you need to heal the break so the containment is gone. There is a complete secondary side added so that you can have a closed loop secondary for long-term operation, and there is a let down and make-up facility at the lower portion of the slide in this area, so the closed loop secondary is up here, and the make-up in a let down system.

DR. LIENHARD: Could you say just a word about the geometical scaling on this?

MR. SULLIVAN: It is full height. The lengths are about the same length as in a normal plant. That's the reason the down comer looks so funny. The crossover is the scale resistance between the down comer and the plant and the center of the core. It's a ten by ten bundle. The bundle is full of height. The upper plenum is full of height.

DR. PLESSET: He'd be interested in the volume ratio, I think, is what you were getting at.

DR. LEINHARD: Well, I'm curious about cross sections, yeah.

DR. PLESSET: Well, the ten by ten gives you some clue.

MR. SULLIVAN: It's power to volume scales, so it's roughly 50,000 rods into 100. That's roughly the scale. I think it's 150.

DR. PLESSET: About what?

MR. SULLIVAN: I shouldn't tell you.

DR. CATTON: One over 150.

DR. PLESSET: So this is better volume ratio than semiscale.

DR. CATTON: It's a little larger.

DR. LIENHARD: How are cross sectional areas scaled, the pipes?

MR. SULLIVAN: They are shortened some and fattened up some to keep their resistance down. I can give you the size of the pipes later if you like.

DR. LIENHARD: No, no, I was just trying to get some idea of what rationale.

MR. SULLIVAN: The power volume scale, if you did every component, every component would be volume scales once you had that ratio, but the resistance would be very hard, because you have long very skinny pipes, so you'd shorten them up and make them a little bit larger at the cross section here, and this facility they're currently planning on making the pipes a little bit larger than the reflux facility also to keep getting larger and larger collate pipes to see this reflux condensation mode.

This is the proposed test matrix to the extent that it's been developed. There is a liquid or the single phase loop. You're looking at power effects, the effects of the secondary side, the effects of injection and mass removal, and the effects of power.

The two phase system will look at the same parameters with a reference power unit. If you continue to look at it, here is the reflux boiling, and that's we had determined as the two phase loop, and they will be looking at the same kind.

They're looking also at transitions from one mode to the other, and they're looking at non-condensibles. Looking at THTF, and this is the --

DR. CATTON: What about the gas?

MR. SULLIVAN: There's a non-condensible gas.

DR. CATTON: How are you going to decide how much to put in?

MR. SULLIVAN: That was the question we phrased later, and we're looking at that, trying to decide how much is the maximum we should put in.

DR. CATTON: Okay.

MR. SULLIVAN: The THTF loop at Oak Ridge is doing small break type core recovery tests, but it's also lending data to this mode also, and I think that was your original question.

DR. CATTON: When did THTF become a test facility? I thought it was --

MR. SULLIVAN: It was listed as a separate effects facility.

DR. CATTON: That's small breaks on interval test.

MR. SULLIVAN: No, it's small break, core recovery heat transfer. You're correct. I should have said that more clearly.

But they're currently looking at core uncovery experiments, and mainly the heat transfer in the level swell in that facility. There have been six tests completed. There's a pressure range from 400 to 600 to a 1000 PSI. The data should be available in mid-April.

The core recovery has the same pressure range, and in looking at core recovery rates of one to eight inches per second, and, again, the data will be available.

The significant thing that turned up here is that you can put word into a facility at one to eight inches per second, but it doesn't necessarily mean it's going to quench that fast, and some of the analyses have shown that some vendors that you can quench at those kinds of rates which the experimental data is showing that to be untrue.

DR. PLESSET: Well, have you any other results that fit for that?

MR. SULLIVAN: Yes.

DR. PLESSET: That's kind of interesting.

MR. SULLIVAN: It shouldn't have been a great surprise today.

DR. PLESSET: No, no, but I think it's important to be accepted that this is more or less the case. Okay. You have other data?

MR. SULLIVAN: They have run experiments at lower pressures that also verify this.

DR. PLESSET: UCLA.

MR. SULLIVAN: So I think it's going to be an area for model development work in the future to show that the quench rates are governed by something like conduction.

I skipped over the diagram of the facility. We are only using interval tests. We are only using the test section.

The proposed university contract, and it's a very small experiment, a very small scale, and it is looking at phenomena mainly, the steam generator and heat transfer and the stability and several tubes are being looked at.

It is a glass facility. The tubes are the diameter that you would expect in a power plant, but they are not full length. The facility is also very small. We're looking at modes of natural circulation, the effect of non-condensible gas mainly on the steam generator heat transfer. The scale of the experiment is very small, and the reason is performing a set of experiments to look at phenomena in a very flexible facility and looking at large parameter ranges.

MR. ETHERINGTON: This is U tube, is it?

MR. SULLIVAN: Yes, it is. The proposed test matrix, if you want to call it that, is to look at natural circulation in U tube arrays, and we're bearing the number of tubes and the length of the tubes, looking at the natural circulation in an incomplete field system. This would be our two phase loop configuration or the two phase hot let configuration.

We're looking at the steam generator heat transfer.

MR. BENDER: What's the heat source in this?

MR. SULLIVAN: It's one heater in it to represent it, just to provide a heat source. Excuse me?

DR. PLESSET: Harold, could they add some of these chemical questions that have been raised, put a lot of borate in there. That would be easy for them to do.

MR. SULLIVAN: You know, we would not like to do that in a large facility.

DR. PLESSET: No, but you could do it here and clean it up easily.

MR. SULLIVAN: Yes, the clean-up problems are really significant.

DR. PLESSET: But not here.

MR. SULLIVAN: But not here, and I think that's one of the ways of addressing that problem.

MR. BENDER: Is it a multi-feed heat source?

MR. SULLIVAN: No. The heat source?

MR. BENDER: I think if you're going to address the boron question, you need a configuration. It has some of the characteristics of a fuel matrix.

MR. SULLIVAN: I think the main problem is addressing it in the steam generator.

MR. EBERSOLE: I was thinking more along that line.

DR. PLESSET: Yeah, I think that's what I was thinking of, Mike, in the steam generators, because Jessie raised it.

MR. EBERSOLE: And the other problem is already pretty much solved for the local case?

MR. SULLIVAN: You know, you're left with a system that is going to boil for some time and getting high concentrations and that's been looked at, so I think it's condensation or the phenomena that's going on in the steam generator too.

MR. EBERSOLE: I was thinking in the context of flooding.

MR. SULLIVAN: Yes. Going to the interval experiments, there's the LOCA semiscale, and, like I say, they are going to be covered in more detail in a later meeting.

There is the measurements that have been taken for the L3-1 test and then L3-2 test, and the break sizes are shown there. The L3-2 test was a test that there was a long period of what we think is natural circulation. Would you like to add any more?

MR. LANDRY: What we had on L3-2, because we think three periods of natural circulation, and we'll present that information in April, but we believe for the first couple of thousand seconds, we did have significant natural loop flow. We're calling that natural circulation.

We had a period up to about 8000 seconds, 6000 second period, which we believe that we went into another cooling mode, and we have some theories on what was occurring, but we do not feel it was natural circulation.

It may have been a reflux action, and at about 8500 seconds, we saw what we are defining as natural loop flow, but the details we'd like to wait and present as part of the whole story.

MR. SULLIVAN: This was to wet your appetite to make sure you wanted to attend the next meeting.

DR. PLESSET: That's a dirty trick.

MR. EBERSOLE: But in this context of time, are you willing to say we are justified in cutting these off at time X, and that we don't anticipate a change in phenomena 100 times that? How do you justify that?

Altogether most of the experiments prior to TMI were curtailed. We don't know what happened until two days later.

MR. SULLIVAN: Well, we probably didn't run the right experiments either.

MR. EBERSOLE: So you will now look at time.

MR. SULLIVAN: Time is going to be a factor, and the experiments are being run, say the LOFT experiments are being run very far out.

MR. LANDRY: L3-1 is only run out to be -- L3-2 we ran out to almost eight hours. We went to the point at which we were pretty well out of below 200 degrees F.

MR. SULLIVAN: So the transients are now -- when you go to one of these tests, you can't go and see it all in a couple of minutes. You go out and look at it for eight hours if you wanted to see it which also brings in another point that I've never realized which is that if you're in a control room, you know, after you get through with all of the experiments, and you get all the plots and you can flip through them, you see the whole transient.

In eight hours, you kind of lose where you're at unless you're being quite watchful, and it adds another load on the operator.

They're continuing to run small break transients so we will see natural circulation in those. I would say that the largest problem that the facilities are now looking at is the instrumentation. We realize that we really have a problem in terms of trying to measure these very low flow rates and establishing what modes natural circulation are occurring, and if they are occurring, so LOFT is on an improvement of their existing instrumentation that they have in the plant and also looking at adding more.

The same goes for the semiscale facility. Looking just quickly at the semiscale, there are natural circulation experiments planned. They have not been firmed up. The will be after the Mod 2A conversion which the facility should be completed by roughly the end of August. There are some tests that are going to have to be sequenced because of UHI . They want to run some UHI tests before they have the facilities licensed for UHI to get ground power license.

So the tests that are being considered are the three modes, the natural circulation, the effects of the non-condensible gas, and the single phase with a steam filled upper head such as is postulated to occur in TMI.

They have completed one natural circulation test, and that was done early in the spring and it was a scoping type experiment, and what we wanted to find out was what kind of problems we were going to have when we started looking to running the experiments.

The instrumentation turned out to be one of the largest problems that we have. Heat loss has also turned out to be significant, but the flows are so low in the facilities that instrumentation, the type of instrumentation that's available now, currently available, really is unable to see a lot of that, so we're looking at trying to address that in terms of building or including a lot of instrumentation than what I call advanced instrumentation, looking at separated flow in the hot legs, steam generator secondary side conditions, and condensation in the steam generators is very hard to measure its currents and to the extent that it's occurring, and doing a primary system energy balance.

The flow instrumentation that we're looking at is the TNA which is a pulse neutron activation, and it favors the liquid component. There is a transient timed thermal couple that we're considering the Stuart's lense, and I'd like to thank the committee for sending two of their consultants out.

This is where Dr. Woo actually indicated a way to use our storage lens to measure the velocities of the liquid which we're considering. Dr. Cadman has also helped us in that. There should be -- to be looked at.

TLTA has done some core boil-off experiments. They have been completed, steam cooling, and they ran very low powers so you could see nearly stagnant natural circulation steam cooling in the upper portions of the bundle.

There were two small breaks experiments run which are without any ECC injection to the end of the test and with ECC injection. The ECC injection -- excuse me -- without ECC injection, that experiment has just been completed.

The plans for a TLTA is that we're currently negotiating with GE to upgrade that facility to make it a small break transient facility. The first plans are to at the end of this month or the beginning of the next month is to have a meeting with GE which we would get the first indication of what they think the facility is and how much it will cost, so we will be reporting the progress of that.

I'd like now to turn to the foreign experiments. There is a PKL facility and that text matrix does exist. They are looking at the three modes with non-condensible gas. The CCPF experiment, the test matrix has not been committed on. There are plans to run two phase bloop and the two phase hot leg with non-condensible gas. The slab core facility is currently, we think, uncapable of running two phase natural circulation tests, because of the mock-up of the steam generators.

They're looking at two phase level swell in the core and the effect of low blockage in the core heat transfer.

There is a two phase test facility which is a very large -- has very large pipes. They're up to the 36-inch pipe diameter.

DR. PLESSET: Where is it?

MR. SULLIVAN: It's in Japan, and it is part of two parts, the ROSA IV which is the next facility on there, but the loop is capable of looking at vertical and horizontal components, and it has a limited capability of looking at U tube condensation.

As Dr. Fabic pointed out, the ROSA IV facility has a new name. It's LSTF, and I'm not sure exactly what those initials mean.

It was the ROSA IV facility before. You've probably seen a system diagram with that. It has the chain, but the -- when the facility is constructed and in operation, it will probably be the most extensive transient facility in the largest scale that will be in existence.

DR. PLESSET: Is that for liquid steam test facility?

MR. FABIC: Large scale test facility.

DR. PLESSET: Large scale. Is it that big?

MR. FABIC: It is that big.

MR. SULLIVAN: It's not full scale. The pipe, it has, I think 4000 rods in it, 3000 rods. The loops are one-quarter scale, but it is a very large facility.

DR. PLESSET: High pressure.

MR. SULLIVAN: High pressure, full scale high. I can get more information to you.

MR. FABIC: The first idea was to go single loop, and Dr. Tom persuaded them that they ought to look at two loops rather than single loop.

DR. PLESST: Stan, is this part of the 3D program or separate?

MR. FABIC: Separate.

DR. PLESSET: Separate.

MR. FABIC: Right.

MR. SULLIVAN: They're going to look at non-condensible gas and possible feed and bleed. The facility is currently doing some large break blow down experiments. They plan on looking at small breaks, and they're considering doing natural circulation.

MR. EBERSOLE: Let me ask you. On feed and bleed, what's the difference between feed and bleed as we're talking about it here, and an old BWR operating with a --

MR. SULLIVAN: Well, I think with an isolation condenser it's more of a closed loop.

MR. EBERSOLE: But it's a center for water.

MR. SULLIVAN: Yes.

MR. EBERSOLE: It just doesn't go out on the floor is all. That's the only differences.

Is it possible to transfer some of the BWR experiences?

MR. SULLIVAN: The thing that I'm not exactly sure of is in a PWR you may be solid or close to being solid, and trying to feed and bleed. In a BWR, that would not be the case.

MR. EBERSOLE: True.

MR. SULLIVAN: You could try it at two phase conditions.

MR. EBERSOLE: Well, there's no inhibit on a BWR, if you're in an emergency.

MR. SULLIVAN: Yes.

MR. EBERSOLE: You just fill it. But don't we have a body of experiments in the BWR area?

MR. SULLIVAN: Yes, you may be right. I'd like to --

MR. EBERSOLE: It might save a lot of work.

DR. CATTON: Only the things that you're trying to find out, the configurations aren't the same.

MR. EBERSOLE: Well, the core is different. I think we're talking about a core performance problem.

DR. ZUDANS: On the feed and bleed, aren't we trying to find out what is the point it is reaching, right?

MR. EBERSOLE: Well, we're talking about it as thought it were steam if we can ever get it to a stable condition. You know, there's some transient conditions where it's a mixture.

DR. ZUDANS: Somebody pointed out, I think rightly so, that you can do simple test with the vales to see how much they discharge, but the problem is what is the fluid reaching that valve, and I don't think you should be looking at a BWR test facility to find out whether you can't, whether you can predict, whether you know. You should be looking at realistic geometries, right?

MR. EBERSOLE: Because you have a level, and you don't know where you are.

DR. ZUDANS: So I think that's the crux of the problem, to find out whether we know how the fluid is reaching the valves.

MR. EBERSOLE: The ultimate, of course, is to get level information and to know where we are.

MR. SULLIVAN: And I think we're on the road of doing that. I think you're right. There is some data there, and I think we ought to look at it. It's not going to address all the problems we've got, but it may help out to look at some of them, and it would be a nice transfer of data between the two systems.

I included the PKL test makers, and it just shows you that you're going from liquid, and looking at ECC injection and removal all the way down to an uncovered core situation which is the thing that I would say is two phase hot let where you have countercurrent flow. Also at the bottom, we're looking at some small breaks and some intermediate size breaks and the effect of the steam generator on those.

They have completed 14 experiments to date, and we are receiving that information. There are some

US instrument spools in PKL and, therefore, we feel that we'll get all the data from the PKL experiment.

(End 8.)

I have two slides at the end for test facilities and I will go through that. It is divided into two parts. There is one loop on one page. The other one is on the other one. There will be a very complete representation of not only the primary system, but some of the interacting secondary components. So it will have a large capacity to look at variable modes of injection.

MR. BENDER: When does this operate?

MR. SULLIVAN: Excuse me?

MR. BENDER: When is it supposed to operate?

MR. SULLIVAN: I looked at that and I think that it is in '83.

MR. BENDER: Thank you.

MR. SULLIVAN: It's not something that is going to be right away.

DR. PLESSET: What pressure?

MR. SULLIVAN: Full pressure.

DR. PLESSET: Full scale low pressure.

MR. SULLIVAN: It's an unbelievable taking in terms of designing a facility. It has two very large steam generators. It has a capability of operating a steay -- The power requirements are just astronomical and the size of the facility. The instrumentation ought to be really a good problem because of the size of the pipes and trying to determine some of these low flows.

In conclusion, I believe that the experimental programs that I have outlined to you, and it is that, only an outline, will provide an adequate data base for code assessment. The instrumentation that we have in the facilities is a problem and I don't see any cure for that right now. I think it is going to be a problem right to the end of looking at natural circulation.

The above separate effects and very small scales looking at phenomena, all the way to interval experiments and rather large scales in terms of LOFT, there are -- we are investigating the three modes of natural circulation with the non-condensibles and trying to look at a very wide range of parameters and as I indicated, that the instrumentation is probably the major problem that we are going to be facing as we run these experiments.

MR. EBERSOLE: Then we should steer clear of non-condensible experiments in LOFTS. That's because you can do better someplace else.

MR. SULLIVAN: Yes, it does -- I wouldn't say that we have precluded it. It is just not in the current plan. LOFT has a -- is a very nice experimental facility in several ways, but in several ways because of the nuclear fuel that you have, you don't want to run experiments that jeopardize the core. So it does limit it in a certain respect, but its size is also a very important aspect to getting the scaling that we need from very, very small experiments, such as University to Semiscale to LOFT and then that makes the step a lot easier to make to a full size facility.

MR. BENDER: Are you planning to boil in LOFT?

MR. SULLIVAN: Yes, they go two phase. The last test, the eight-hour test was two phase for quite awhile.

MR. LANDRY: Still having problem with D&B. It's just that adding things like non-condensibles and uncovering the core, we have to deal with DOE, creates some problems. They own the site and they are not too thrilled about --

MR. SULLIVAN: That's about all I had.

DR. PLESSET: Are there questions? Thank you, good presentation..

DR. LIENHARD: Maybe I'll ask a stupid question because I'm kind of bothered about this whole scaling business here. What's the objective there? Are you providing results, using test codes against or are you trying to find out what real systems will do?

MR. SULLIVAN: We're providing data to assess the codes. Now, you look at that and what you would like to do is run typical transits. They are very -- They are almost identical to the ones --

DR. LIENHARD: They have a great deal in common with the --

MR. SULLIVAN: Right. So there is a large part of our task is to look at the scaling of the facility and to identify the atypical parts of the experiments and to make sure that those are not the dominant. The thing that you can do is to stay in one mode of natural circulation much longer than you would, say in our reactor, if you had not looked at the scaling and gotten all the scaling questions out of the way that you can, but you still in every experimental facility there is the question of being atypical and that has to be addressed.

DR. LEINHARD: I do wonder about the rationale that sets of the scaling laws. I recall for example the Mark III containment problem where GE attempted to do this with using a square root of 3 scaling and horizontal dimensions and full size and vertical dimensions and so forth. And they blew it because they weren't looking at dimensionless groups or that simply didn't replicate the real system. What they should have done was look a time stretching factors and other dimensionless groups.

MR. SULLIVAN: Dr. Catton and Dr. Woo both looked at the scaling, the last scaling that we had done on the Semiscale. It's a question that you can't answer completely. You can always think of something that you could have done differently. The money is involved and the instrumentation is involved. There is a large amount of input from a whole bunch of different parts of the design.

DR. LIENHARD: Sure, but there are certain -- part of that is looking at dimensionless groups and making judicious conclusions, for example, rentals numbers are sufficiently large that certain things can be neglected and blah, blah, blah.

MR. SULLIVAN: And they have done that. If you're interested in that, I'd be glad to send the Semiscale document to you and let you review it. Any comments that you on it, you know, I would appreciate it.

DR. PLESSET: That's the report we looked at.

MR. SULLIVAN: Yes.

DR. PLESSET: I'll make sure that you get one. I have been a little remiss in circulating that. It's my fault.

MR. SULLIVAN: I'm not sure --

MR. EBERSOLE: It's on the record, now you have to do it.

DR. PLESSET: I have to do it, which means tomorrow we'll start.

MR. SULLIVAN: I'm not sure it's all your fault because I'm not sure that report is out in a final form.

DR. PLESSET: Well, but they can get the report that they sent to the ACRS. That I think we can circulate very easily and I promise that you'll get it.

DR. CATTON: They are actually doing a fairly meticulous job of looking at all the different options that you are suggesting. I think what they haven't done, the non-dimensional parameter route which we did recommend that they do. I don't know that they are going to be able to do anything any better, but at least they will have a better feeling for where they are.

MR. FABIC: Those non-dimensional parameters were looked at way back. What we found out is that they obviously can't solve them, preserve, some of them are in conflict. You just can't --

DR. LIENHARD: But some of the conflicted ones can be ignored in some cases.

MR. FABIC: Well, unfortunately, that wasn't the case.

DR. LIENHARD: In this case, maybe not.

MR. FABIC: You're forced to --

DR. LIENHARD: By the way, are you, in all your work, locked in on water?

MR. SULLIVAN: I'd say yes.

DR. LIENHARD: Great things can be done if you can relax the requirement that everything be done in water.

MR. SULLIVAN: You're talking about running things like freon?

DR. PLESSET: I think that the Environmental Protection Agency would get on their backs, the amount of freon that these fellows are playing with would be fantastic. The ozone protective layer --

DR. LIENHARD: Well okay, don't use freon.

(Laughter)

DR. CATTON: -- introduces more parameters. They've already got time constant parameters because of the fuel in trying to scale. Now, if you use freon, you've got other kinds of time constant parameters because you shifted the coolant side and the surface tension --

DR. LIENHARD: I wasn't thinking of freon. I was thinking of actually putting surface tension suppressants into water, for example.

DR. CATTON: That's possible, but --

DR. LIENHARD: Another thing you can do is alter Reynolds number by mixing a little glycerin in with water. You know, there are lots of things you can do. They are just shy of water, that retain a lot of its features and figure other things like viscosity and so forth.

MR. SULLIVAN: What I have seen in experimental -- they have used other fluids besides water. It leads you to more questions than you can ever try to answer and that yes, you get good trends of data, but you -- when you try to relate that back to water, then you're in trouble.

DR. PLESSET: That might be nice for that University glass facility.

CHAIRMAN CARBON: Thank you again. Let me divert the subcommittee's thinking for a minute here. We've got a little bit of time left. I'd like to raise some questions as to where should we go from here, more particularly, where is the whole system weak and what ought we and the staff be trying to zero in on, in what direction ought we to be pushing the staff? Where should our thrust be?

MR. ETHERINGTON: It seems to me a little bit, most of the activity is to try to find out how close we can calculate, but I think the biggest question in my mind is whether things are worked the way we postulate.

DR. PLESSET: You mean in a reactor.

MR. ETHERINGTON: No, I was thinking in particular with reference to non-condensibles.

DR. PLESSET: Oh, yes.

MR. ETHERINGTON: And this climbing over the loop. There is only one small part of this whole program, apparently addressed to that. Maybe you can't address it any more. I don't know.

CHAIRMAN CARBON: Is that in your view perhaps almost the major thrust?

MR. ETHERINGTON: I shouldn't have opened my mouth because I am the least qualified person here to talk about --

DR. PLESSET: Well, I disagree with that. Honesty will get you nowhere.

MR. EBERSOLE: If I can go back into ancient history, and I suggest that you do so also, I believe, but I am not dead certain, that our ancient shipping core reactor invoked feed bleed as a final requirement as design. I'm not sure, but I think it has a capacity to force primary coolant through the core to a relieving system of valves -- qualified at rates that will reject energy at sensible heat levels, not without, that is without evaporation. I suggest you go back and look and see whether this is the case, what was involved in making it that way, if it is that way and how we in fact got this complicated set of -- as we went on into the exploitation of the PWR Program, and whether we ought not to take a back view if that is the case.

My impression is that that is the way we started and I don't know how we got off the track, if in fact we were on that track. I believe we were.

MR. BENDER: I was going to express person views I have about direction in which the natural circulation concept might go. My personal concern is with minimizing the number of things an operator has to do in the event of an emergency. I guess my inclination is to say there ought to be something he can do that's right and which he doesn't have to correct for thereafter. Consequently, I have been a strong component of just saying we ought to be able to establish whether the operator can depressurize the system and allow it to operate under depressurized mode, even if the system is boiled and we come forward with that situation and never mind the non-condensibles. I'm not too concerned about non-condensibles if I can make the case that I can despressurize the system and let it boil because --

MR. EBERSOLE: -- RHR?

MR. BENDER: And let either the steam generator or the RHR system, either one take the heat away. But if I can't depressurize the system, then I've got a problem with things like being able to operate in the pressurized mode, feed and bleed kinds of operations which involves shutting things off and turning things on. Those are operational problems that challenge the operator more than I'd like to challenge.

Now, I don't know enough about the question of -- about the depressurized mode of operation to be able to comment on its validity and what risk you get into by doing it, but I really would like to have the subcommittee at least address the question of whether the operator could get in trouble, if he had enough capability to depressurize.

MR. EBERSOLE: Well, his main problem is, the -- doesn't have a big enough Quench tank, that's all.

MR. BENDER: Well, he may also not have a big enough relief system.

MR. EBERSOLE: Well, I'm assuming we would get the relief capacity. If you got the relief capacity though, you are going to have a problem --

DR. CATTON: He's got to have level to do that.

MR. EBERSOLE: Oh yes.

DR. CATTON: If he's got level, I think --

MR. EBERSOLE: We were talking earlier about the old attempt in '68 to get the pressurization -- both on the secondary, which is the more graceful way to do it, but if that didn't work, on the primary and it didn't seem to be a lot of money. The big valves, it did have the nasty problem of messing up the containment, which led to a halfway conclusion we need a big Quench tank.

DR. CATTON: -- as far as the boiler, I'm not sure you are concerned --

MR. EBERSOLE: Well, you might not be, considering the increase --

MR. BENDER: Well, we're insisting on some kind of level sensor now. I don't know whether we need one that shows exactly what the level is. We need to show that we've got water in the core, if we are going to operate under that mode of operation.

MR. EBERSOLE: I would like there to go not for a level sensor -- or a saturation device or a synthetically heated probe or whatever --

DR. CATTON: Saturation device doesn't tell you anything.

MR. EBERSOLE: What I'm talking about is with synthetically heated probe, particularly when the heats on, it will detect what the transfer coefficient is on the outside. Really, that's an animometer.

MR. BENDER: We need to show there is water is the core.

DR. PLESSET: Let me follow up on both what Harold and Mike have said. I agree with Harold, if you have -- don't have non-condensibles in the system, that the secondary side saying,I don't care what the pressure is, Mike, you are going to be able to cool that system.

MR. BENDER: I think --

DR. PLESSET: Well, I'll give you a personal guarantee. If there are no non-condensibles in it, it would be easy, regardless of pressure. Now, I think the central point is what do we have when we have a significant amount of non-condensibles in the circuit and I think that that is an area which is a very vital one. I think it's essential to get to that as soon as possible. You would agree with that too, Jesse, if you don't have --

MR. EBERSOLE: I would agree with the thesis that we work around the pile of problems, to come a satisfactory conservative conclusion earlier on.

DR. PLESSET: Now, let me also defend Fabic and

Sullivan a little more and that will answer your second point in part, an answer that will touch on it.

Hopefully, they are going to get to an understanding of how a reactor behaves in various transient conditions with well developed codes. That will lead to a great aid for operators. If they understand how a reactor is going to behave in various transient conditions, they can fix it, so that life is simpler for the operators. Now, that's asking them a lot and it's going to take time and I think if they want more tests for that, I say fine, they should do it. But I think that in this natural circulation area, which is what we're supposed to be worried about, the central issue is what happens with varying amounts of non-condensibles -- If it's a negligible amount, forget it. No problem.

MR. ETHERINGTON: We must have a criteria --

DR. PLESSET: What's negligible?

MR. BENDER: I think you didn't get my message.

DR. PLESSET: Oh, okay. I didn't want to --

MR. BENDER: If there are non-condensibles in the system, I think we have to worry about them.

DR. PLESSET: Why?

MR. BENDER: I said if there are.

DR. PLESSET: Oh, oh.

MR. BENDER: I didn't say there are any. There is a pretty good chance that under most circumstances there won't be any, but there may be a lot of times when I would like to tell the operator you can depressurize a system and be comfortable that you're safe. I would like to have some kind of investigation of the way of getting to that condition as being the objective of getting a good shutdown cooling arrangement that isn't subject to these concerns about whether we've got the right pressure gradients in the system and things of that sort that have been associated with them.

DR. PLESSET: What you're concerned about then , if I -- let me try to restate your concern. Are there situations which would make it very difficult to depressurize. Because if there, you know, if there really aren't any serious ones, I can't envision any where you don't -- if you don't have non-condensibles in there, I don't see any difficulty.

MR. BENDER: If the operator is constrained now not to do it, he is discouraged from doing it.

MR. EBERSOLE: Because he doesn't have a Quench tank.

MR. BENDER: He doesn't have a Quench tank. He doesn't have enough relief --

DR. PLESSET: Also, if he has a large amount of non-condensibles in there, he is going to get in big trouble.

MR. BENDER: Look, I agree if he has them in there, but normally he wouldn't have them in there. If he had a simpler mode of operation, if he could deliver his water under low pressure --

DR. CATTON: UHI and he went down in pressure, he'd have it, unless he locked it out.

MR. FABIC: If you depressurize to a low pressure, you get your non-condensibles from accumulators.

MR. BENDER: Well, that is because that is the way we are set up to do things. I don't like that. I think that's a threat to the system. Let's just worry about Harold's concern.

DR. PLESSET: I agree.

MR. EBERSOLE: Well, the first stage of depressurization should be to depressurize the nitrogen in the UHI --

MR. BENDER: And so we are going to sit here and bite our fingernails and try to calculate ways of living with the non-condensibles in the system and we may prove that that's alright for most systems, but if we find a way of not having to be concerned about that mode of operation, by finding some simpler one, as a matter of fact, like the BWR's where they just depressurize the system when they get in trouble, I think we'd be very much better off.

DR. SCHROCK: We heard in LA that these pressure vessels on the BWR system would likely not be serviceable after one automatic depressurization.

MR. ZUDANS : -- go slowly.

DR. PLESSET: No, no, that's extremely --

MR. EBERSOLE: -- frequent challenge --

: It's happened many times already.

DR. CATTON: Mike, why did they say there is a problem there? We don't know that there is a problem there. I acknowledge that we find out.

MR. BENDER: Well, I'm not trying to -- I'm certainly not opposed to looking at it. I guess my point is that I would like to eliminate a threat and also I would like to minimize the number of things that the operator has to do.

DR. CATTON: -- It can be answered a lot quicker.

MR. BENDER: I think it can be resolved with a Westinghouse reactor yesterday because the volumes are so large and it may never be resolvable for the B&W reactors because the volumes are not very large and so you are going to have to look at it differently for different systems.

MR. ETHERINGTON: I think also sometimes someone has to decide are we going to design for one percent metal water reaction, .1 percent which I heard today, Three Mile Island or what are we going to design for.

MR. BENDER: A little farther down the trail, but it has to be considered.

MR. EBERSOLE:I've looked greedily sometimes at the recurring water storage tank and said to myself, what a beautiful Quench tank that is, if I could just get a moderate size pipe to it and it's a good containment too, if you modify it.

DR. CATTON: It's big.

MR. EBERSOLE: It's got plenty of water.

DR. CATTON: Does it have --

MR. EBERSOLE: Only for shutdown, for the problems that we've talked about --

DR. CATTON: Use it for the vented containment as well?

MR. EBERSOLE: Whatever.

DR. CATTON: Let's not abuse that too much.

MR. EBERSOLE: It's just a volume of water that keeps you from messing up the containment.

DR. CATTON: And I think there is plenty enough water in there to do it.

MR. EBERSOLE: Oh yes, you would hardly warm it to get down to our -- pressures.

CHAIRMAN CARBON: I bring another point here. At the April 24 meeting we have scheduled further discussion on LOFT, Semiscale, Sequoyah.

Do we have anything else scheduled? Do we have the vendors --

MR. BATES: We can ask the vendors to come in, if you would like. Do you want us to ask the vendors in to address what they are doing --

DR. CATTON: I would like to see some sort of a layout description of all of the instrumentation that they are going to be --

MR. BATES: On Sequoyah?

DR. CATTON: Either one, yes, for these preliminary tests. I would also like to hear something about the one where they -- tower, where they bring natural circulation --

MR. EBERSOLE: Oh, that brings up, we need to be sure that nitro convection process is restartable, even though there is no gas --

DR. CATTON:: Right.

MR. EBERSOLE: That's the final test in both Sequoyah and --

DR. CATTON: That's something you can really demonstrate.

CHAIRMAN CARBON: Are there any other comments anybody care to make on any of the topics? If not, I guess we thank the staff and close the meeting.

(Whereupon, at 5:30 p.m. the hearing was adjourned.)