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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Docket No.

SUBCOMMITTEE ON EMERGENCY CORE COOLING SYSTEMS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON EMERGENCY CORE COOLING SYSTEMS

Conference Rooms A and B
Babcock & Wilcox Alliance
Research Center
1562 Beeson Street
Alliance, Ohio

Tuesday, July 19, 1983

The Subcommittee convened, pursuant to notice, at 9:30 a.m., David Ward, Chairman of the Subcommittee, presiding.

ACRS MEMBERS PRESENT:

D. WARD, Chairman
J. EBERSOLE
C. MICHELSON

ACRS CONSULTANTS PRESENT:

I. CATTON
V. SCHROCK
Z. ZUDANS
C. TIEN

DESIGNATED FEDERAL EMPLOYEE:

P. BOEHNERT

NRC STAFF AND PRESENTERS PRESENT:

R. LANDRY
B. SHERON
N. KADAMBI
M. E. KEANE
M. YOUNG
Y. Y. HSU
J-P. SURSOCK
R. CARTER
J. TAYLOR
J. KLINGENFUS
C. MORGAN
B. JONES
T. HOLLOWELL
G. WILSON
B. TURNER

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PROCEEDINGS

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

This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on ECCS.

I am David Ward the Subcommittee Chairman. Other ACRS members in attendance are Mr. Ebersole and Mr. Michelson. Also in attendance are ACRS consultants, Mr. Catton, Mr. Schrock, Mr. Tien and Mr. Zudans.

The purpose of the meeting is to continue a review of the NRC/B&W/EPRI integral test program. We will focus in particular on the scaling problems for the proposed MIST facility.

This meeting is being conducted in accordance with provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act.

Paul Boehnert on my right is the Designated Federal Employee for the meeting.

Rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on Friday July 1st, 1983.

In view of the extensive meeting agenda proposed, it has been decided to extend the meeting through tomorrow morning. Therefore, the closed session noted in the above Federal Register notice will be held

tomorrow.

A transcript of the open portion of the meeting, that is today's session, is being kept and will be made available as stated in the Federal Register notice.

I request that each speaker first identify himself or herself and speak with sufficient clarity and volume so that he or she can be readily heard.

We have received no written statements from members of the public nor requests to make oral statements.

At this time we will proceed with the agenda.

First, I would like to express on behalf of the subcommittee our appreciation for the opportunity to come here and discuss this important program with you. It is a great help to us sometimes in particular to leave Washington and the abstractions of words and numbers on paper. In that respect the tour just a few minutes ago of your GERDA test facility was very helpful to us. It certainly looks to be a well managed, good, solid facility and it is very much appreciate that we had the opportunity to walk through it.

I think even the weather man cooperated. It wasn't nearly as hot as you had threatened.

(Laughter.)

We will use the agenda that was modified, the recent one proposed by the Babcock and Wilcox folks with one modification. Before Brien Sheron of the staff leads off, Ralph Landry of the staff has asked for the opportunity to make a few remarks.

So, Ralph, if you would go ahead, please.

MR. LANDRY: Thank you.

My name is Ralph Landry. I am from the Office of Nuclear Regulatory Research.

I would like to just update the committee on the status of the negotiations with B&W on the contract for the ISP program.

On July 8th, 1983 a contract was signed by the NRC, by B&W, which is a McDermott Company, and by the Electric Power Research Institute. The owners of B&W plants throughout the country have signed individual contracts with B&W to participate in this program.

The IST program is a response to an interest expressed by the Office of Nuclear Reactor Regulation. The program will consist of three phases. The first phase is the once through integral system or OTIS. The second phase if the facility design of the MIST program, which is the third phase, the multiloop integral system test.

The program will be managed by a program management group consisting of Mike Young of the Office of

Research, Chuck Morgan for B&W, Tom Hollowell for Consumers Power who will be representing the B&W owners and by Jean-Pierre Sursock from EPRI.

The senior project officers which have been specified by the contract will be Bob Turner for B&W, Randy Carter representing the facility operation here at Alliance and Jim Gloudemans in charge of the scaling and analysis effort from Lynchburg.

This completes the introduction that I would like to give and we can just go into Brian's presentation now.

MR WARD: Very good.

Any questions for Ralph at this time?

(No response.)

MR. WARD: Thank you, Ralph.

Brian.

MR. SHERON: My name is Brian Sheron. I am with the Reactor Systems Branch in NRR.

I am going to spend a little bit of time this morning discussing the licensing considerations or basically the way we intend to use the IST or the GERDA facility data in the licensing process for B&W plants.

Just a quick background on what got us here. Right after the Three Mile Island accident there was a recognition by I think everyone involved, the staff, B&W,

the owners and the like, that for the B&W design, that for small break LOCAs as well as other transients and accidents that one postulates could occur in these plants that there were modeling problems, analytical modeling problems that were posed due to the geometry dependent or design specific aspects of the B&W machine.

Particularly one can say that when gravity dominated flow effects, natural circulation and the like were dominant as oppposed to inertial flow which we were so accustomed to in the large break LOCA, that geometry effects played an important part, the elevations and the like, whereas in inertial effects the elevation really doesn't come into play.

What we also learned from Three Mile was that the ability to mitigate accidents was really a unique combination of the interaction of both safety systems as well as the operators perceiving what was happening in their plant and taking the appropriate action.

When the staff looked at this and assessed the adquacy of the B&W models, there were I guess two approaches from which we looked at it.

One was the strict licensing compliance approach, which was the Appendix K, do they meet the regulations. The second one was can they accurately predict the behavior of their plant during these accidents

so that the operators can be instructed on what to expect when they get these accidents and are we sure that the instructions that the operators are being given indeed reflect the way the plant would be expected to respond.

The two levels are rather separate here from a licensing standpoint. We looked at the adequacy of the B&W model from an Appendix K standpoint, do they comply, is it conservative, et cetera.

Given this new understanding and the analytical predictions as best we could perform them with the codes as they exist today, the interruption of natural circulation and the like, what we concluded was that we had not identified any scenarios that resulted from the very small breaks which we were concerned about which interrupted natural circulation. We could not identify any scenarios that indeed could lead to a more severe set of consequences than the existing limiting small breaks that had been analyzed for Appendix K.

Even taking into account the uncertainties that may exist in the analytical models and the fact that RELAP 5 gave one answer, TRAC gave another and CRAFT gave another answer, none of these showed that for the very small break into the spectrum one was getting into any sort of trouble.

So I think what I am trying to tell you is

that we are not really saying that this data is absolutely needed to demonstrate compliance with the reglations today. Our conclusion is that the current B&W model still does comply with the regulations.

The data will be useful to help confirm the margin which we believe presently exists in the B&W model, but for the most part we believe this information is needed as a tool to help us understand the behavior of the plants, to make sure that the instructions an operator is given are consistent with the understanding of the plant behavior and to make sure that there are not hidden phenomena that would tend to make an operator misdiagnose an event and take the wrong actions.

As I point out in this last bullet here, ATOG, which is the abnormal transient operator guidelines, which the staff is about ready to issue its SER on, does consider in a very general sense this uncertainty that still exists in the detailed behavior of the B&W plant response to a small break and to other events.

However, it does so by not specifically recognizing the unique phenomena that may be occurring. From a standpoint it doesn't say you are going to get a bubble in the candy cane, watch out for it and this is what the exact symptom is or not.

What it does is it tries to tell an operator

treat the symptoms which you see which include keeping the core covered, maintain pressure control and maintain decay heat removal capability.

What we feel that this facility will indeed offer us is the ability to look at the plant behavior, to be able to tell operators the way we think this plant is really going to respond to an accident and to sort of augment the general guidance given by ATOG which a more detailed knowledge of our expected plant behavior.

MR. CATTON: Brian, before you leave that, your fourth bullet, it seems to me this is the primary reason for the facility. Could you maybe fill in a little bit underneath that bullet for me and tell me what the behavior is that is not considered in regulatory reviews, because obviously that is what you are looking for here.

MR. SHERON: Yes. As I said before, the regulatory review for a small break loss of coolant was guided by the criteria of 50.46 and the model requirements set forth in Appendix K, Part 50.

MR. CATTON: What I am looking for is just sort of a recitation of the behavior that we are looking for here.

MR. SHERON: Okay. The behavior that we are looking for here is basically the interruption of natural circulation. Let me point out that there are two kinds of

behavior that we are looking for. One is the behavior we think may exist and the other is to seek out any other behavior which we haven't previously identified.

MR. CATTON: I understand. I am trying to get a feeling as to what you are driving for.

MR. SHERON: The basic behavior we are looking for is the interruption of natural circulation due to steam collection in the candy canes, the re-establishment of two-phased natural circulation, boiler condenser, the re-establishment of single-phased natural circulation following the refill phase and the ability to I guess conduct a long-term cooldown of the plant following an accident without getting any unstable behavior. I think those are the primary objectives. There are a number of secondary objectives.

MR. CATTON: I understand. I am trying to get an idea. Let me just repeat them back to you to make sure I got them right. The first was interruption of natural circulation, and that is the void collection at the top of the candy cane, the establishment of the boiler condenser mode, re-establishment of single-phase natural circulation and the ability to carry out long-term cooldown.

MR. SHERON: Right.

MR. CATTON: Now under the last one, the ability to carry out long-term cooldown, is that where the

loop-to-loop oscillations and one pump on and one pump off comes in?

MR. SHERON: Not necessarily. It could, but I think the primary concern here was that when you refill the primary system you have a possibility of collecting a steam bubble at the high points which does not condense readily.

As you refill you just compress the bubble and if you cannot compress it sufficiently to re-establish flow over the top of the candy cane, you may get into an oscillatory mode from the standpoint that the pressure will come up, the leak flow increases, the HPI flow decreases to the point that you start losing inventory again and the level drops until you re-establish a condensing surface.

You establish a condensing surface and the pressure goes down. As the pressure goes down, the HPI flow increases, the break flow decreases and you start to fill up again.

Essentially the system pressure would tend to go into like a dying oscillation which the operator could not control.

MR. CATTON: And this may be different in loop than the other?

MR. SHERON: It could. I really don't know. I

understand your concern about the ---

MR. CATTON: I am trying to get clarification as to why loop-to-loop oscillation is of interest and I didn't hear you say it when you cited your four areas.

MR. SHERON: The effect of two loops versus one obviously is of interest to look a asymmetric behavior in general.

MR. CATTON: Is this a secondary concern or a primary concern?

MR. SHERON: I would probably say it is primary since we do want two loops on it.

MR. MICHELSON: Along the same line, from time to time questions have been raised about the effect of having a steam generator full of hot water being isolated during say a small break LOCA situation such as happened at TMI. Is that going to be studied as a part of this program? The hot steam generator becomes a pressurizer as you attempt to lower loop pressure. It becomes a heat source and this causes considerable disruptions and disturbances in the normal natural circulatory modes.

MR. SHERON: I am going to defer the response to that question.

Mike, are you going to cover the test matrix?

MR. YOUNG: It will be covered.

MR. MICHELSON: Is that going to be tomorrow?

MR. SHERON: I don't know. Let me take a commitment to find out if either later on in a presentation someone will be discussing the detailed test matrix and whether that specific scenario would be covered within the context of it or not. I don't know offhand.

MR. CATTON: There was a reason for me trying to bring these out. We have in hand two different scaling analyses and we have heard all kinds of discussion. I would like when we hear about the scaling to make sure that these five areas are addressed when it is presented, and that is interruption of natural circulation, establishment of boiler condenser mode, a re-establishment of single-phased natural circulation by whatever technique and the ability to carry out long-term cooldown and loop-to-loop oscillations, and as to how these things are brought to bear in the scaling analysis because I have not seen it in what I have been reading.

MR. SHERON: Okay. Well, I went back, based on our discussions before, and looked at the two-by-four study which was done by EG&G, and although there was not what I would call a detailed dissertation on scaling, there were analyses performed of the expected behavior of a two-by-four loop which is extremely similar to what we are proposing here for the MIST facility.

My understanding is those anlayses did show

the interruption of natural circulation and the establishment of a boiler condenser mode. Now they were not carried out for the long term. I admit that. The calculations stopped at I think a thousand seconds.

MR. CATTON: Well, the question here is one of if you are going to run an experiment to investigate these five items, I am trying to establish in my own mind that that experiment that you are going to run to look at those five items is the correct one or that somehow you are taking care of that.

MR. SHERON: Yes.

MR. CATTON: I believe that they all exist.

MR. SHERON: I asked Mike Young, who is going to make a presentation later, if he would be able to address the big integration of ---

MR. CATTON: What I am hoping is that you can go into a scaling analysis and you can throw equations up there like there is no tomorrow, and if you do that we are all going to get lost. You have itemized now for me the critical issues and the reasons for running this test at all. I would like to see the scaling address the five issues.

MR. SHERON: As a matter of fact, Mary Ellen Keane is going to give you a more expanded list when I get done, because I just gave this to you off the top of my

head, which is what I sort of remember. As part of the TAG group they had a very specific negotiated list.

MR. CATTON: I saw that list.

MR. SHERON: Okay, which is more comprehensive than what I just told you.

MR. EBERSOLE: May I ask a question?

MR. SHERON: Sure.

MR. EBERSOLE: There has been an extraordinary lack of enthusiasm for the B&W plants to add certain things which came out of the two-by-two case, significantly the several vents and some level measuring devices. We have put in quite a few attachments for information gathering, well, for instance, the vent on the vessel in the candy cane.

I presume this experiment will have as a base line the presence of all those devices to determine how useful they are.

MR. SHERON: Yes. The level device I will defer to people who are much more close to designing it.

MR. EBERSOLE: Or the equivalent inventory measuring system, whatever.

MR. SHERON: Okay. I do know that there will be the high-point vents. As a matter of fact, one of the tests that will be run will be to help confirm for three plants that have requested an exemption to the

requirements to put a high point vent on the top of the vessel claiming that any gases that accumulate in the vessel can be safely removed through the high-point vent at the top of the candy cane.

There will be a test run which is designed to hopefully demonstrate that that can indeed be done, in other words, remove non-condensible gases in the upper vessel through the high-point in the candy cane by a slow depressurization.

MR. EBERSOLE: Will we know about the ups and downs of the liquid line in the vessel and in the candy cane?

MR. SHERON: I am going to have to defer that to somebody that understands the instrumentation in this loop. I see Bob Dietrich shaking his head yes.

MR. TAYLOR: Pardon me a minute. Jessie, I think one of your comments was a misrepresentation of this considerable lack of enthusiasm on the part of the B&W owners to add certain devices after Three Mile Island.

Just for the record, I think that it was not a lack of enthusiasm, but it was a sincere interest on their part to try to understand exactly the kind of things that Ivan was talking about of why are the B&W owners adding those instruments and are the things that are being prescribed going to answer the questions that are to be

answered.

All the B&W owners have now committed to put in one form of level and inventory measuring device or another, but it was not the kind that was originally prescribed which was bottom of the reactor vessel to the top of the reactor vessel level. We think we have something that is ---

MR. EBERSOLE: It is narrow band now.

MR. TAYLOR: Well, no, it is actually better. With the configuration of the B&W system, which is very unique, it covers about 70 percent of the inventory above the core by measuring the Delta P across the hot leg.

I just wanted to make sure for the record that that gross lack of enthusiasm was picked up and not allowed to stand unchallenged.

MR. ZUDANS: I would like to ask one question for my own edification. If you have a good handle on inventory, is there anything else you are concerned about.

MR. CATTON: Its rate of change.

MR. MICHELSON: Moving it around.

MR. ZUDANS: If I have a control of inventory, the rate of change doesn't matter. I know I am not losing inventory. Is there any other problem?

MR. WARD: Does anybody want to answer that? To whom are you addressing that, Zenons, to anybody who will

answer it?

MR. ZUDANS: To anybody who knows it because are defining and discussing several sets of different problems, and I think the only problem in my mind is the control of inventory.

MR. CATTON: I think Peter Griffith put together a really nice chart that showed if you knew what the inventory was and had a rough idea of where it is, that you can make all the decisions you need to make, like pumps on/pumps off, everything.

MR. ZUDANS: Well, that is easy to understand, and that is what I would like to know, whether or not anything that we do in this new facility has this as a key question.

MR. EBERSOLE: Well, that gets back to the point can you see it.

MR. CATTON: And they said yes.

MR. EBERSOLE: They said yes.

MR. ZUDANS: Then all the problems are solved.

MR. CATTON: Well, it is a matter of what you do with the data when you get it. You have to look at it with the view that you are taking now or these questions won't be answered.

MR. ZUDANS: If this is a key issue and we don't take proper care of it ---

MR. CATTON: It is proper use of the data.

MR. TIEN: I would like to come back to Ivan's question. I think perhaps that is the key element for scaling. We have to set a tone correctly.

We talk about scaling. We must decide what kind of major phenomena we want to study. If we don't define that, I don't think we will get anywhere and we will just get confused.

Now you mentioned five items and then you say you even have more. This is very much confusing me. I don't think you can scale all the different phenomena at one time. I think you have to set a priority and say this is No. 1, No. 2 and No. 3 that we must scale and then we can study other phenomena, but you have to have a very clear understanding of what phenomena you are going to scale and then proceed from that.

I think our discussion today should follow along that line, exactly what we have in mind. The material I read, I think some of it is relatively irrelevant to the particular problem problem you are trying to address. You lay out all the equations and discussions and really it doesn't mean much. I think we have to set a tone for the whole day or otherwise we will get lost again.

MR. WARD: I think I have to agree with you. I

think even presenting this as a discussion of scaling has been perhaps a little misleading and some of the papers we have seen have been kind of an abstract analysis of scaling without paying attention to what the particular problems are.

I hope as we hear more perhaps from Mary Ellen that we will get a picture of the situation as Mr. Tien has suggested.

MR. SHERON: Okay. Let me give you a little philosophical overview here real quick on this, and I realize that there are varying opinions on this between the industry and NRC historically, and that is whether one can solve analytical problems with separate effects tests only or whether one needs an integral system test only.

Historically industry has always that many of the problems that we have had in modeling could be solved effectively by separate effects tests and that we would use the code as the great integrating device to integrate all these separate effects tests.

The staff has sort of historically come at it from the standpoint that while we agree separate effects testing is useful and necessary in many respects to develop the individual models and the like, the code itself cannot be relied upon a hundred percent as the great integrator, as I call it, but in effect one needs to

take an integral system test as well to provide the basis for saying the code is indeed a good integrator.

So I kind of look upon GERDA and OTIS and MIST as again that same bridge, that integrating bridge which ties separate effects to the code. I don't look upon MIST or GERDA or OTIS or whatever as being able to answer all questions. This is the purpose of the University of Maryland testing and the like and you will hear more about that.

I just want to go back a little bit. With that as a starting point, how we kind of came at this is that there had to be an integral system test somewhere in this whole process to tie it together and where could we best get this integral system data.

It was identified in 1980, really in '79 as part of the task force. There were recommendations that the various modes of natural circulation, both single and two-phased which were expected to occur following accidents should be experimentally confirmed. This also was manifested in the need to upgrade small break models under Item 2K330 of the Action Plan.

We looked at what was available, what could be done and the like. Mary Ellen is going to talk to you in a lot more detail about this because this was the ultimate charter of the TAG group.

Just briefly though we had sort of a choice of facilities and it was build a new one, and this could be anywhere from a one-by-one to a two-by-four facility, or we could go to existing facilities and modify them, which means go to the existing Semiscale or go to a facility like GERDA.

Funding, there were a number of options here, basically three. One was that the NRC could pick up the entire tab. The other is we could have the industry, just tell them they had to do it and let them pick up the entire tab and, thirdly, was there could be some sort of cooperative program between the NRC and industry.

If you look most recently, there was a question asked by I think it was Chairman Palladino to Research, which was what are the criteria Research uses to determine who pays for what, and there as a response provided which identified three criteria, and if a need for data satisfied any one of those three criteria, then one could consider it a candidate for government funding.

This type of information, this integral system test data fell under Research said it was just one and I felt there were two that it really came under. One is that it would help us to independently confirm the margins that exist in the analysis models, and the second is that it would provide a basis for us to independently benchmark

our analysis models.

So, as you will hear more about, the decision was made that it should be some sort of a jointly funded program to get this data.

There were some studies done by Research. I just mentioned one contracted to EG&G which is called the two-by-four study and the like. All of these came down that modifying the GERDA facility appeared to be the most cost beneficial to all the parties involv-d.

I think that is why we are here at GERDA today, and that is that there was a facility here and it was configured very similarly to what we were looking for. I think one major plus, which I always like to point out, and that is that it has been built by the industry and it is being run by the industry.

If you recall on Semiscale, we normally got about a letter a month from the industry telling us why Semiscale was no good. I am hoping that we won't get those letters any more because it is the industry's facility.

MR. CATTON: Doesn't that depend on the results you get?

(Laughter.)

MR. SHERON: So I think to look at why we are here today with GERDA as opposed to somewhere else or some other facility, all the cards all seem to point in the

direction of GERDA.

Now I want to address one area where I think there has been concern already expressed, and that is that I have read the consultant comments that were forwarded here and I guess I perceive that there is some concern that these test facilities may not exhibit all the phenomena of interest that we are concerned about. I think we would be the first one to stand up and say yes, we agree a hundred percent that there may still be some unanswered questions regarding the behavior of the B&W plants that may not be answered by these facilities.

MR. CATTON: I am sorry, Brian, I jumped to your next bullet and it says certain phenomena. I think that is what has to be brought out, and that is what is that certain phenomena that you have to sacrifice, and that decision can be made as to whether or not it is worth it.

MR. SHERON: What is it you are not going to get.

MR. CATTON: That is right.

MR. SHERON: Let's know ahead of time what you are not going to get.

MR. CATTON: Hopefully it won't be parts of these five items that you mentioned a few minutes ago.

MR. SHERON: Yes, and I think we agree that

that study has to be done. It is something that can't be ignored and pushed on the back burner.

MR. CATTON: It should be done before the facility is designed.

MR. SHERON: Well, let me address that if I could. We looked at that and if one went through and did an exhaustive study which would involve a fair amount of analysis I think and the like, I am concerned that one wouldn't get off the dime and start building this thing and start getting it constructed.

When you think about it, there is not too much variation that can be made to the facility. You are not going to make all the pipes twice as big and the like. I mean you are pretty well locked into the scale of the facility.

MR. CATTON: But if that certain phenomena that you have to sacrifice is key, then we ought not spend the money.

MR. SHERON: But the two-by-four study already showed that at least one of the major phenomena we were concerned about, which is the interruption of natural circulation, is predicted to occur in a two-by-four type of facility.

MR. CATTON: Certainly, but you don't need a two-by-four facility to study interruption of natural

circulation.

MR. SHERON: Well, you carry it a step further, and that is that what else do we want to look at in the future. And now you carry it a step further, which is okay, we get over the hump on the small break, but now there is steam generator tube rupture, there might be steamline break or it might be other transients that we don't even think about today, pumps on/pumps off type of testing.

I will get into this a little bit later, but we envision that although this initial program may only go through 1985, that there would possibly be a need for further testing beyond 1985 which perhaps the government would fund solely or something.

The point is that one shouldn't go into it with a very narrow gee, I am only interested in interruption of natural circulation and therefore I only need one loop and I don't care whether it is raised or lowered. The point is that I need an integral system facility that is flexible, that has capability to look at a variety of different kind of events, of transients so that I am not sorry later on.

One question that we are struggling with now is whether it is full power or decay power and are there any events down the line that we want to look at that may

be full power.

One could argue that I don't need full power now to study the events that are of immediate concern and therefore I shouldn't put it in because it is not cost beneficial. But prudence says that three or four years from now I may come up with something. Maybe I want to ATWS. I don't know. Should I have it there now and should I pay for it now rather than have to pay three times as much later on. So I think you always have to keep that in mind when we talk about having two loops and four pumps and the like.

It may not be necessary to examine the phenomena we are interested in today, but then one has to look forward to the future and say is there something that is going to come down the road that is going to say boy am I sorry I didn't do that, that I didn't put that in when I built this thing.

As I said, the two-by-four study did show that it would pick up a number of the key phenomena which we are interested in, but I think another thing that we have to consider is that if you look at the whole program it is sort of a multistage program. We go from GERDA, which you will hear the results of the data later on in the presentation, to OTIS which is sort of an upgrade of GERDA, and then we go to MIST, which is the two-loop, four

pump system, lowered loop, et cetera.

I think that if we see something coming out of GERDA data which is available today that makes our scratch our heads and say this loop isn't doing what we think it should be, or we are not seeing the phenomena that we should be, we have time today. MIST isn't built and there is nothing that is irreversible yet. So it can be fixed I think in the future. We can consider it as we develop the MIST design.

As we move down into MIST, into the two-by-four and supposing we come up with something we don't like there, as I said before, we envision some sort of a follow-on program and I think we can make a decision at that time of do we have to modify something to make it better or not.

Now this won't answer the question of there is no way in the world I can ever modify that facility out there to answer the question.

MR. CATTON: I take it that somewhere somebody is actually looking at these five items and saying gee, I am interesting in interruption of natural circulation. How well is this facility going to represent it, what am I doing to make it represent it better or worse and that there will be a report or something that can be reviewed prior to your starting construction.

I would think you would have one something like that on each of these five major items, and frankly I haven't seem it. I don't see it in Ishii's scaling analysis and I don't see it in Gloudemans' scaling analysis. I see lots of words and lots of different phenomena described, but not a clear focus on those five issues.

Now I am not trying to see you shouldn't build your facility because I really think there is a lot of value in an integral facility and I think Semiscale has demonstrated that, but I really would hope that you are trying damned hard to address the issues that you have raised in order to justify the facility, and I don't see it. Your words are the right ones, but I don't see five studies addressing those five issues anywhere.

MR. SHERON: Well, they don't hang on those five issues. As I said, there is a more ---

MR. CATTON: I asked you because are you are licensing what you thought the key issues were and you cited them.

MR. SHERON: Okay.

MR. CATTON: Now maybe one might change, but clearly there should be.

MR. SHERON: They represent a basic set.

MR. CATTON: Yes. They are not different from

the ones I have heard before. I mean I agree that the only one I am not too concerned about is this ability to carry out long-term cooldowns. I think once you are into that mode the scaling is not much of a problem.

But the other four, if you can't get at them, you somehow have to have either separate effects or somewhere you have to be addressing those, and I think you have to address them to a certain extent before you build your facility or else you are not going to know how they impact your facility and you may built the wrong facility, and I don't see that happening.

MR. TIEN: I agree completely on this, but I would like to add one more point. I think this is supposed to be an integrated facility. Perhaps another justification can also be made of how do you integrate all of the separate effects tests into, how they connect to the integrated facility.

Again, the words are very nice that you can hear, but I don't see anything to discussing in depth. You talk about separate effects tests and how are you going to integrate them and how are they related. I think this really needs to be addressed, too.

MR. SHERON: I think as I said in that previous slide, we agree that this work has to be done.

MR. CATTON: But, see, I can't really tell

where you are on your diagram with respect to these dates. I hear things like 1985, and if it is fiscal '85, that is two years.

MR. SHERON: You are going to hear two more presentations on scaling and on the research program involved with this. That may be the most appropriate place for your question.

MR. CATTON: That is right, but what I am getting a little nervous about is that I envision somewhere out past these walls a major design effort going on and that this thing is getting firmed up awfully fast and there is not enough attention being paid to these items as to whether or not you are going to be able to handle them. I mean to me that really ought to come before or at least some attention to it.

MR. SHERON: During. It is a feedback process.

MR. CATTON: I understand, but there are things you can do before you start the design of your experiment.

MR. ZUDANS: Ivan, maybe you can help me a little bit. Are the key questions why this facility is needed raised and stated?

MR. CATTON: They are right here. He just gave them to us. They are not new. These are things that have been discussed at each of the meetings and they were also discussed at the TAG meeting. These are the four or five

items that they are building the facility to address.

MR. WARD: Let's see, I think the next speaker is going to give us a little more on the items that need to be explored. Is she then systematically .going to show us that the facility as it is being shaped up in the experimental program will address each of these? That is sort of what we are looking for, some assurance that the facility and the test program aren't being designed based on some abstract conception of scaling, but rather to address the particular issues that are being us now.

You have said well, you hope it could be designed or perhaps built to be modified to address issues that come up in the future, but even that has to be a lower priority than addressing these issues which you already are concerned with today. I hope we can see a systematic ticking off of how it is going to address these.

MR. SHERON: I don't think Mary Ellen is going to give you the big integration picture which is what you are looking for.

MR. WARD: Okay. Is someone going to do that today on the agenda?

MR. SHERON: I would ask Mike if you are going to address that?

MR. YOUNG: What I had planned on doing is

talking about NRC's support program which includes our lab involvement and tests. I can briefly go over how everthing is going to tie in which will be talked about in detail by the upcoming speakers.

MR. WARD: Well, maybe we had better go ahead and try to draw out ---

MR. SHERON: You may not hear it today what you are driving at.

MR. WARD: I am beginning to suspect we might not.

(Laughter.)

MR. WARD: Do you understand what we are driving at?

MR. SHERON: I understand very well what are you looking for. As I said, I can't tell you today whether the rest of the speakers are going to satisfy your concerns on this, but I think we share your concerns and I think that we will have to do exactly what you are asking for somewhere before this facility is constructed and operated.

MR. ZUDANS: Are these five points only the key points for the whole package, the ones that Ivan stated, or is the effort now directed in such a way that they would be explicitly addressed? In other words, interruption of natural circulation, as Ivan said, is one

thing that would be addressed, and the establishment of boiler condenser load, that would be explicitly addressed, too?

MR. SHERON: Yes.

MR. ZUDANS: Re-establishment of natural circulation, that will be explicitly addressed?

MR. SHERON: Yes.

MR. ZUDANS: And Loop-to-loop interactions and the ability to carry out long-term cooldown. Now that is kind of a generic one.

MR. CATTON: I think if they have the other four in hand, you don't need that one.

MR. ZUDANS: You only need this one and you don't need any of the others.

MR. CATTON: That is certainly true.

(Laughter.)

MR. ZUDANS: I think Ivan has done a beautiful analysis here stated in a nutshell and it would be easy for those who are not as expert in the field that all the conversations would be guided in such a way that the response would be to the relevant points.

MR. SHERON: You have to remember, too, that this is a little bit of the chicken and the egg. In other words, we are saying we are looking for phenomena. The only way we can tell whether a facility is capable of

producing that kind of phenomena is if we try and predict whether that facility will indeed produce that phenomena.

What we are trying to do is confirm our codes from the experiement. So to some extent there is always going to be an uncertainty as to whether that facility is going to produce the phenomena you are worried about.

MR. CATTON: Well, in a way I have kind of gone through that exercise. The reason I keep harping on this is in some respects I don't think that MIST as anticipated is going to do it, and let me give you an example.

Your first item is interruption of natural circulation. If you just do a simple analysis where you do the time it takes the bubble to cross the pipe, which is nice time constant to work with, and the horizontal transit time, I think you come to the conclusion that everything is just going to collect at the top of the pipe and that the ratio is quite different in a natural plant.

Now I haven't seen this kind of analysis being done. Then I would like to have somebody tell me why it matters or doesn't matter when I get this particular number. Do you follow me? In other words, if it is much shorter or if you are going to get the loss of natural circulation much sooner or much later, what is it going to do to the rest of your simulation?

These are simple kinds of calculations and where are they? They have not been done. I will give you another example.

MR. SHERON: I keep saying that the two-by-four analysis study ran the analysis and showed that steam would collect at the top of that candy cane. It would interrupt natural circulation. The loop would be calculated to drain down and it would be calculated to re-establish boiler condenser. Is that not sufficient for what you are saying? I don't quite understand what more.

In that area, for example, you would need ---

MR. CATTON: Well, let me just say it again. If you lose the natural circulation much sooner in this facility than you would in a full-scale plant, then I begin to wonder about all the arguments leading me to wanting to do real time scaling. Now what does it mean as far as the rest of the system is concerned? If I get it too early, what does it do to what is happening in the rest of the system and if I get it too late what does it do?

Those are key questions to me because you want an integral facility. You want everything to happen roughly right. If it is not going to happen roughly right in as time sequence point of view, where are you at? I think this question needs to be addressed.

MR. SHERON: Well, one, I disagreed that to have an integral facility means I want to have everything roughly right, as you say.

MR. CATTON: Hey, I am paroting back what you said in the past. I am not creating new words. I don't really ---

MR. SHERON: You would like the facility to exhibit as much of the major phenomena that you believe will exist in a large plant.

MR. CATTON: If the key phenomena is loss of natural circulation and now you don't really care if it does it that well, then why do you have it as the key phenomena? I don't understand.

MR. SHERON: I never said I didn't expect it to do very well. As a matter of fact, if the loop didn't interrupt natural circulation I doubt if we would really be endorsing the continuing of this program on it.

I think I understand what Ivan is driving at, but ---

MR. WARD: Good. I think we ought to move ahead and maybe some of this will come out with other speakers.

Thank you, Brian.

The next speaker is Mary Ellen Keane.

MS. KEANE: My name is Mary Ellen Keane and I am a member of the Reactor Systems Branch in NRR.

What I would like to cover today is just a summary of the TAG effort.

(Slide.)

The test advisory group was composed of representatives from B&W, the B&W Owners' Group, EPRI and the NRC. It was formed last September and was charged with four tasks.

These tasks were to first identify what experimental data needs there are for code verification and assessment of a B&W reactor.

The group chose to do this by compiling a list of concerns or areas of concern that we felt needed to be addressed.

The group was then to identify what operating data and what experiemental facilities are available now or in the near future and then to evaluate how well these facilities were able to address the data needs.

Then, finally, based upon this evaluation, we were to make recommendations for future programs.

Now the program that has evolved out of the TAG recommendations is being called the integral systems test program and it is comprised of several facilities, including GERDA, MIST, the OTIS facility and the University of Maryland facility, SRI 2.

I think the point to remember about this is

that we feel that any one of these facilities looked at individually will have problems and it can't answer all of the questions that we have, but what we are hoping is that this program taken together will go a long way towards answering some of our questions.

(Slide.)

What I would like to do is go through the process that the TAG group when through in coming up with its recommendations.

The first one was to come up with this list of issues and it can be broken up into four groups or into four major areas. Those are natural circulation, small break loss-of-coolant accidents, feed and bleed and then once through steam generator tube ruptures.

Under natural circulation you can see we have got several subject categories. The first of these is the boiler condenser natural circulation.

As you all know, B&W is calculated for a certain range of break sizes that it is necessary for a boiler condenser mode cooling to take place. Several questions have arisen on this, whether it actually occurs and how effective a method of cooling the core it is.

We have two-phase and single phase natural circulation. I think we could probably say we have a good handle on single-phase natural circulation, but again the

same kind of questions have arisen about two-phase natural circulation in B&W reactors and the code's ability to calculate it.

We have steam generator-driven instabilities. There are questions on what happens if these generators are operated asymmetrically and what it will do to the primary loop performance.

We have cold leg oscillations. Now cold leg oscilations were calculated to occur in certain calculations and it probably can be said that it would be very difficult to see this sort of performance, that is the relatively wide swings in temperature of the cold leg following small break loss-of-coolant accidents. It would be diffiult to see this in any scaled facility because it has been shown to be very sensitive. I am referring to the calculations that were done by one of the national labs in which they showed these cold leg oscillations.

MR. CATTON: Have you seen Peter Griffith's little PVC model of a B&W reactor?

MS. KEANE: No, sir, I haven't.

MR. CATTON: You ought to. When he runs that thing it gurgles and burps and flow goes this way and that way through the whole damn system.

(Laughter.)

MR. CATTON: Now you have got two items up

there, the steam generator-driven instabilities which can lead to loop-to-loop differences, and the cold leg oscillations, plus this basic draindown kind of process. That means you are going to have flow first going in one direction in a cold leg and then maybe going in the other direction as a result of this.

How does the core interract with this, and has the analysis been done to tell me what role the core plays when these loops are going first one way and then another?

MS. KEANE: I am not aware of an analysis.

MR. CATTON: Well, I think that analysis is needed if you want to make any decisions about what role the vent valves play, and that you can't put one vent valve at the top of the downcomer until you have done that analysis. Either that or you strike those two items.

MS. KEANE: I would first like to make the point that I think as far as the cold leg oscillation goes I think it would be difficult to see it in any scaled facility. I think what we have to depend on as far as that phenomena goes is trying to gain enough confidence in our codes that we can apply the code and then make a decision if it does or does not predict these things.

MR. CATTON: So you are going to run a test where some of these things can't happen and you are going to compare the code with that place where it can't happen

and conclude that the code is fine. You can't do that.

I won't interrupt you again. I am sorry.

(Laughter.)

MS. KEANE: As far as the steam generator-driven instabilities and the way that the reactor vessel vent valve, and I think that later on we will be hearing a little bit more about the design of that RVVV ---

MR. CATTON: RV cubed.

MS. KEANE: Right.

(Laughter.)

MS. KEANE: Right. It has been my understanding that we will be able to see the steam generator-driven instabilities with this vent valve design. Some of the things that we won't be able to see are things where there is something going wrong with the vent valve itself where one sticks open and one shuts closed.

Again, I think that is just the degree to which we can take these experimental facilities, and something like that is really beyond the sort of thing we could see in an integral system facility.

MR. MICHELSON: Let me comment on the vent valve problem. It appears that the vent valve is going to be controlled in the facility by a differential pressure indication. In the real world it is also controlled by a

differential pressure but of a little different hydraulic arrangement. It is not clear to me in the facility that using a signal in either opening or closing that valve is really going to simulate what the vent valves in the real world will do. So maybe later on you will want to comment on why you believe these facilities can simulate reactor vent valve operation.

MS. KEANE: Okay. I think I will probably have to defer that to the detailed design of this vent valve. Again, I think this design will show some things and not other things.

MR. CATTON: It is my understanding that that vent valve opens and shuts with something like a tenth of a psi difference in the Delta P. Is that right?

MS. KEANE: I believe so. Yes.

MR. CATTON: So it is an extremely sensitive little flopper valve and just subtle changes are going to open and shut those things.

MR. WARD: I think we are scheduled to hear more about that this afternoon.

MR. CATTON: I am trying to sort of forewarn the people with what is coming up.

(Laughter.)

MR. MICHELSON: It is too late to do their homework now.

MR. CATTON: That is true.

(Laughter.)

MS. KEANE: The next topic was interruption/re-establishment of natural circulation. This whole area involves exactly how the U bend volume acts, the behavior during interruption, refill and then re-establishment of natural circulation.

There are also questions on the long-term stability of the system and what happens following an accident. You have got voids in the system and whether you will be able to cool down following re-establishment of natural circulation.

The next point was the use of high-point vents, and that is particularly in view of some of the exemption requests we have gotten from certain B&W reactors on having a vessel vent valve. So that we thought we would want to answer some questions with regard to that.

We also had questions on the use of the effective noncondensible gases in the system and the action of the reactor vessel vent valves during natural circulation.

MR. TIEN: The order of your listing of issues, your order has changed a little bit from the TAG final report. Are you setting a priority?

MS. KEANE: No, but I will tell you why I did that. In certain presentations we had single-phase natural circulation up at the top and people were saying well why that. We have a pretty good handle on that I just kind of wanted to take the connotation of the top being the most important away from it. So I just kind of switched that a little. There is no priority related to the listing of these phenomena.

MR. CATTON: Except for vents.

(Laughter.)

MS. KEANE: Except for that one point.

MR. MICHELSON: Would you comment now on why you felt the bypass, the hot leg bypass that occurs between the shroud and the hot leg interface was not considered important and therefore not simulated?

MS. KEANE: Okay.

MR. MICHELSON: This is the intersection of the hot leg with the shroud of the reactor vessel in the mechanical joint, a very loose one, as a matter of fact, having an eighth inch or so clearance, and therefore it bypasses the fluid from the hot leg back to the downcomer. It is not a large bypass necessarily and the question is is this significant, particularly if there is steam in the hot log and liquid on the cold leg side or the downcomer side.

MS. KEANE: I am not sure why it didn't show up on this list. It didn't occur to us.

MR. MICHELSON: Would the staff care to comment?

MR. SHERON: I think again that is an item that has to be studied as part of the design of the test facility. With respect to the layout of the plant with the external downcomer, the vent valve itself is being represented as a valve in just sort of a crossover line, and I would see very little difficulty in putting a parallel type of bypass line around that vent valve.

MR. MICHELSON: Well, it looks like what you would want is a line passing from the bottom of the hot leg back to the downcomer as oppossed to a line from the top of the reactor vessel to the downcomer. It is at a different physical location.

MR. SHERON: Yes, I realize the elevation is different on there.

MR. MICHELSON: But it is easy enough to do if it is thought out and considered sufficiently important. I was just asking have you thought it out or what is the plan. It wasn't on the list.

MR. SHERON: We haven't really seen too much of the details of what this MIST facility is going to look like in the sense of its final design, and I think this is

one of many questions we are going to have to ask with respect to how well it simulates or mocks up the actual flow paths in a B&W plant.

MR. MICHELSON: And whether it is important to even simulate that feature.

MR. SHERON: Correct.

MR. MICHELSON: That takes care of it.

MS. KEANE: The second category was small break loss-of-coolant accidents. I think what we were after here was just the full range to get a range of break sizes, plus the location of breaks and emergency core cooling system operation during small break LOCAS.

There were additional questions on what happens if you isolate the break while the reactor is in a stalled flow condition, and there was also just the area of the reactor vent valve action during small break LOCAs.

The next cagtegory was feed and bleed. Although this later on was considered relatively low priority, we did feel that it was necessary to address this issue for B&W reactors.

Finally, we have the once through steam generator tube ruptures. As we all know, B&W has got a unique steam generator design and we felt that we would want to be addressing issues associated with tube ruptures.

MR. MICHELSON: Would that be also where you would consider the role that a standby steam generator might play if it were isolated for some reason during a transient situation?

Let me restate it differently. In the case of TMI, for instance, they for a long period of time isolated a steam generator in a hot lay-by condition. If you try to depressurize under that condition, the steam generator becomes a pressurizer and it tends to empty itself because it is building up pressure and it starts the inventory arrangement in the loop. If you suddenly go back now and start up that steam generator, which they also did at TMI, then it suddenly provides a large sink for the inventory.

Are you going to do those tests at all as a part of the tube rupture?

MR. SHERON: I wouldn't think that one would them as part of a tube rupture because in a B&W plant the way they manage a steam generator tube rupture and to prevent overfill of the generator is they continually steam the faulted generator which is isolated itself and then it is steamed.

The only way that you are going to cool that plant down is with the intact generator. Since there are only two, if you isolate that intact generator you will be in kind of big trouble. In other words, you have to remove

decay heat from the faulted generator. Such a test is obviously feasible with respect to performing it.

MR. MICHELSON: Well, I think it is important to stress in terms of the management of small break LOCAS, as evidenced by the one ---

MR. SHERON: I think a small break LOCA would be a more opportunne place to conduct such a test and we can certainly look at that as part of developing the detailed matrix.

MR. WARD: So you think that ought to be added to this list of issues?

MR. MICHELSON: I think at least it ought to be thought about and determined whether it should be added.

MR. SHERON: I would call it in the category of a secondary issue. There are a number of issues which we are concerned about. This may be the type of event which is run as part of a follow-on program. Again, we are trying to recognize the fact that the B&W owners are in this for a limited period and for a fixed amount of dollars.

MR. MICHELSON: If you look at the ATOG procedures though you can see that the operator could be misled if for any reason he isolated a generator along the way, which he might very well do if he starts the activity and we have a small break and he is not sure where it is

coming from, which they did at TMI.

Later on he is going to be surprised when he finds he can't reduce this pressure, and the reason he can't is because the steam generator has become the pressurizer and until it is cooled down nothing more will happen and it will level out at a different condition than expected. Then he becomes confused and he starts adlibbing his emergency procedures.

MR. LANDRY: That sequence is not specifically in the test matrix that we now have. However, we do have five tests unidentified which we can identify later. We set up 35 tests which were specified with five tests to be specified at a later date.

Now as we get through the program we will have to decide what tests we are going to do as those optional tests and what tests we may want as a carry-on program if we decide to have a carry-on program. We will have to make a value judgment as we get into the program and determine what are the most important tests to run as our five contingency tests.

MR. EBERSOLE: Do you tests envision operator control of the power relief valves on the secondaries to control pressure as a deliberate maneuver to control some of these oscillations and get a heat sink?

MR. LANDRY: The operator control of the steam

side?

MR. EBERSOLE: Yes, of the power release.

MR. LANDRY: No, we have not specified that.

MR. EBERSOLE: So you let them sit there and cycle in their natural mode in all these tests? You don't drive them. CE, that is their only escape is to manipulate the secondary PORVs.

MR. LANDRY: Right now we have not specified on that secondary side any operator control of the relief valves.

MR. EBERSOLE: Why is that? Is it important that you hold secondary normal pressure up while you are going through all these horrible transients?

MR. LANDRY: I think we will have to look at these transients and determine what the operator procedures are before we decide if we want operator action.

MR. EBERSOLE: I think you should take note of the fact that that is CE's escape, is manipulation of the secondary, and you can do it, too.

MR. LANDRY: As the PMG goes into the more detailed description of the tests, they will undoubtedly take into consideration ATOGs and operator guidelines of all types.

MR. MICHELSON: Well, eventually you have to go

to the secondary relief valves to bring the system on down. You can't get to the condenser. I mean it is a proposed mode of operation. In fact, it is the only way to get the hot steam generators on down. The system won't come down otherwise.

MR. LANDRY: What we are trying to present right now is just the conclusions of the TAG. The long details of the tests themselves were specified by the TAG to be developed by the program management group after the facility specification is completed and we see the hardware available and the scaling of the facility and the capability of the facility.

So the kind of things that you are talking about now we will have to defer to the PMG for the detailed definitions.

MR. MICHELSON: One other you might want to put on your list, although I think you may be able to analyze your way through it, and that is what happens if you do get a secondary side stuck open safety, for instance, on one of the generators and what does that do to the natural circulation capabilities of your recovery on the primary side. Is that going to be one of your tests at all?

MR. SHERON: I think the tests you are describe, Carl, are all which we are interested in. We have all identified the stuff we would like to see. We

may run some of those actually in Semiscale fairly soon. They are starting up a tube rupture test series.

Let me suggest this because the couple of scenarios which you have identified and some of which Jessie talked about, the secondary control, I think are all good and stuff that we are interested in and maybe I can propose, if Ralph agrees, that we have a future subcommittee meeting after the program management group does firm up to some extent a proposed test matrix and spend a good part of, if not the entire meeting on discussing the merits of each test as well as other proposed tests which are in there. That would be time I guess where we could see if we could get the tests the subcommittee is looking for factored into the overall test matrix.

MR. MICHELSON: Yes, I think that is a quite good suggestion.

MR. WARD: What we have here seems to be a more or less comprehensive list of issues and you said they aren't prioritized, but later on I think you say these issues were weighted as to their safety and licensing concern. I think certainly that prioritization has to be done.

What we would like to see is a prioritized list of the issues and then an evaluation. You are not

quite to the test matrix yet and we want to find out if the facility that is being proposed for design will have the capability to capture and reproduce in some manner the phenomena that are important to each of these issues. I think that is the sort of thing we are groping for here. Whether they are perfectly scaled or not maybe isn't as important as to whether the facility even has the capability of recognizing the phenomena that are important in each one of these issues.

People have said many times you can't simulate everything. So that means you have to prioritize them. We would like to have an understanding of what are you leaving out and what are you emphasizing that you are going to be stuck with because of the design choices you have made in the facility.

MR. SHERON: I think I understand what you are looking for. Basically you want a quantification of the degree of compromise which we are accepting for each of the phenomena of interest which we would rank here according to importance; in other words, how well is this facility going to address that.

I think as Ivan was saying before, not just whether or not it addresses it, but how well it addresses it in terms of this various scaling criteria that one would impose, time scaling, volume scaling, et cetera. Is

that a fair assessment of what you would like?

MR. WARD: Yes, I think that is fair.

MR. CATTON: We haven't had two different sets of scaling that lead to essentially a different facility. Why are you choosing one over the other? I think I would like that thrown into the hopper, too.

MR. EBERSOLE: Brian, recalling Ginna, will you produce information that will tell the B&W operator when he has a tube rupture and he has the choice of a condenser or the safeties that he has the basis to make a choice? At Ginna they decided not to dirty up their generating condition.

MR. SHERON: Right.

MR. EBERSOLE: What would he do at a B&W plant which has a worse contamination problem because they don't have the decontamination factor? I guess you will generate these answers.

MR. SHERON: I am not a hundred percent sure we are going to generate an answer like that. That type of decision appeared to be made at Ginna by the operator and, as I perceived it, it was more of a maintenance question, do I want to trash up a secondary system or not.

MR. CATTON: Well, the key is that as a result of this test will you have established in your own mind that you can do the calculation for the kind of process

that Jessie is referring to?

MR. SHERON: Oh, yes. I think before we run any test we will establish by calculation whether or not the test is ---

MR. CATTON: No, no. When you are finished with the tests will you have proven the codes to the extent they could make the kind of calculation that Jessie is referring to with some amount of confidence?

MR. SHERON: I hope so.

MR. CATTON: I do, too.

MR. SHERON: Remember, the type of question that Jessie is asking is primarily on a secondary side.

MR. CATTON: That is right.

MR. SHERON: The secondary side is not necessarily that unique to a B&W plant.

MR. EBERSOLE: It is in a tube rupture.

MR. SHERON: In a tube rupture it is.

MR. EBERSOLE: That is what we are talking about.

MR. SHERON: But when we are talking about whether I got to a condenser or whether I go to the atmosphere, I am not sure it is that ---

MR. EBERSOLE: It is different by a factor of ten I think.

MR. SHERON: In terms of the activity. Again,

that is something we are going to have to examine as we develop the test matrix.

MR. WARD: Okay. Let's move on.

(Slide.)

MS. KEANE: The next thing I have here are the sources of integral system test data that were looked at.

The comment I would like to make here is that each one of these facilities, and you will be hearing more about them later on today, is going to provide good data. It is going to give us more understanding of how a B&W plant behaves, but we felt for a variety of reasons that these alone could not answer as many of the questions as we would like.

What I would just like to go through here is briefly the kinds of reasons why we didn't want to just settle with what we had.

The first category is actual plant transient and test data which of course if very valuable in trying to figure out how the system will behave, but this kind of data is only available for a limited range of fluid conditions. It also doesn't have the kind of detailed instrumentation that you would want for things like code verification and assessment.

In the second category I talk about SRI-11 and the University of Maryland facilities. Now these

facilities have differences, and again you will be hearing more about them later, but they can be categorized as low pressure two-by-four facilities and they don't have elevation scaling. They are not full elevation facilities.

Again, good information, but there was concern that the lack of full elevation was going to affect the natural circulation that we wanted to look at. So again we felt we had to go another step.

Then we have GERDA which is a full elevation, high-pressure one-loop facility. Again, very valuable data and it will be an important part of our integral system test program. However, we had concerns that one loop would not be able to show the asymmetric behavior that we were interested in.

This sort of asymmetric behavior comes in under the issues that I was talking about previously under categories of tube ruptures, under steam generator-driven instabilities, the location of break in a small break LOCA will show us some asymmetric behavior and the effect of noncondensibles.

MR. CATTON: And asymmetric behavior will tie right into how the vent valves operate.

MS. KEANE: That is right.

MR. CATTON: Good. Are those prioritized or anything?

MS. KEANE: No, not particularly.

The next concern we had was that the GERDA facility did not have pumps. One of the categories we wanted to look into was the use of pumps following and during small break loss-of-coolant accidents.

The GERDA facility is only equipped with a U bend high-point vent and did not have a reactor vessel high-point vent that could be used. Again, this was one of the issues that we wanted addressed.

Finally, GERDA is in the raised loop configuration and a majority of the domestic plants are in the lowered loop configuration and we felt that we would like to get some information typical of a lowered loop configuration.

MR. CATTON: What is the issue on the high-point vent valves, whether or not they work?

MS. KEANE: Well, there are a lot of things. High-point vent valves, one of the things that has been considered is asymmetric use of the high-point vents and what that will do to the two loops.

MR. CATTON: In other words, if you vent one of the U bends in the hot leg and not the other?

MS. KEANE: Right. The other thing is that B&W has come up with a variety of ways of meeting our requirements for high-point vents. Some people are talking

about a vent from the vessel up to the U bend and venting the reactor vessel that way. There has been discussion, and this is involved with the fact that some of the utilities are trying not to put in a vessel vent, but there has been some discussion of the way of venting any non-condensibles in the vessel by draining the level sufficiently to get the noncondensibles up to the U bend high-point vent and venting them that way.

Again, I think these were all things that we wanted addressed and we couldn't see how it could be done with just the U bend high-point vent on the single loop in GERDA.

MR. ZUDANS: Could you enlarge a little bit on No. 2, concerns that lack of full elevation will affect natural circulation phenomena. Would that be a negative or positive effect on the natural circulation phenomena? Are you stating it in the wrong or right direction?

MS. KEANE: I am not really sure. One of the things we were concerned with is that it is felt that the relative elevations are important in natural circulation.

MR. ZUDANS: Well, they surely are, but what you get in this facility would show worse or better than you expect in real life?

MS. KEANE: I am not sure if it was a worse or a better. Perhaps somebody else can address that. But I

think what we were concerned with was a distortion of what would go on.

MR. ZUDANS: A distortion, yes.

MR. MORGAN: This phenomena depends on the location of the spillover points in the loop or something like that. You will certainly get natural circulation, but the behavior may be quite a bit different.

MR. ZUDANS: But if you show natural circulation occurrence in these lower elevation facilities, wouldn't that be almost a positive indication that you will have no trouble in the higher differential elevations? In other words, what you have got in the SRI is sure to be there on the other. So this is not a negative. It is kind of a conservative facility. I just wanted to make sure that is true. Intuitively I would feel it is a conservative facility from this point of view. So I wouldn't call this a negative argument.

MR. WARD: Well, I think they are saying the phenomena are too complex to categorize this as being either conservative or nonconservative. That is what it would seem to me.

MR. ZUDANS: The question in my mind is much simpler than that. If the natural circulation occurs in this facility, it will be sure to occur in a full-sized facility or full-sized elevation.

MR. CATTON: On the other hand, maybe the steam bubble in the upper part of the bend ---

MR. ZUDANS: May block it.

MR. CATTON: Yes. That aspect might be different because you have got the longer run.

MR. ZUDANS: You have more chances to mess you up.

MR. CATTON: Yes. The interruption process would be different. What you say is right if it is single phase and it is all subcooled. The bigger the elevation, the better push you are going to get.

MR. TIEN: I think for some probably loss is conservative and for some it is not.

MR. CATTON: The more you move that U bend up, the better the chance you are going get a steam bubble.

MR. ZUDANS: Okay, thank you.

MR. MICHELSON: I have two questions. The first one deals with the possibility that spraying the upper U bend might be a desirable thing. To what extent are you going to confirm that in any of these tests?

MS. KEANE: As far as I know, we have no ---

MR. MICHELSON: Is there some reason why you have decided that spray is not the thing to do and therefore you won't test it?

MR. CATTON: How are you going to get the spray

under the insulation?

MR. MICHELSON: Oh, no, no, spray the inside.

MR. CATTON: Oh, inside.

MR. MICHELSON: With a spray nozzle.

MR. CATTON: Just like a pressurizer.

MR. MICHELSON: Right, and you get rid of the condensible.

(Laughter.)

MR. MICHELSON: Have you thought through and decided that spraying up there would not be helpful?

MR. LANDRY: That wasn't brought up when we were discussing the high-point vents and the basic design of the facility.

MR. MICHELSON: You might want to add it to your list. I would like to personally be satisfied of why that wouldn't be useful.

MR. LANDRY: We can ask B&W to consider it.

MR. MICHELSON: I am sure they already have, but I just haven't heard it discussed.

MR. LANDRY: We will see what their thoughts are on the subject.

MR. WARD: If you can give us five minutes, we can design it right here.

(Laughter.)

MR. MICHELSON: The other question is with the

205 plants, at least one of which is coming down the pike, which uses a different auxiliary feedwater arrangement, as I understand it. It floods from the bottom instead of spraying at the top. Is there anything going to be done during any of this testing to confirm the differences that flooding the steam generator from the bottom will make?

MR. MORGAN: A large number of the GERDA tests are sprayed from the bottom because that is a 205 facility that they are looking at there.

MR. LANDRY: We had to make the decision with this facility that this was going to be the lowered loop design since that is the most common design on line now.

MR. MICHELSON: Then I have to ask the academic question of what are you going to do when you finally get to Bellefonte and license it and now we will ask the same question of how do you know how Bellefonte will work, and you say, gee, we don't know, we haven't done these tests. I am just trying to think ahead a wee bit of questions that will undoubtedly be asked in the future.

MR. SHERON: One would hope that looking at the GERDA data, which is a plant of the 205 raised loop variety, and also the OTIS data, which is also a raised loop 205 variety plant, that one can draw the correlation to the MIST data; in other words, somehow relate them

through the codes.

I think we can make a decision at that time whether, based on our understanding of the multiloop behavior of MIST combined with our understanding of the information we got from the GERDA notice, whether it is necessary to have to go and obtain data on a raised loop design two-loop two-by-four or whether we have confidence in our codes based on these two sets of data that we can extrapolate with the codes to the two-loop type of analysis of the 205 raised loop plant.

The other thing we could look at possibly would be, and this I would think more of as a follow-on type program, would be possibly the benefits of injecting feedwater at the lower elevations in the lowered loop plant.

MR. MICHELSON: In terms of timing, when is the review for Bellefonte coming through the licensing process for an operating license? It must be starting pretty soon.

MR. TAYLOR: It should be starting within about the next six months, Carl.

MR. MICHELSON: Now not having any of this information yet, what is the approach to convince yourself that full-power operation there is okay?

MR. SHERON: I think the basis would be the same basis upon which we would say Midland is okay, upon

which we would say that all the operating B&W plants are okay.

MR. MICHELSON: Keep in mind of course this I think is the first time that they will be bringing feedwater into the bottom of the generator instead of at the top.

MR. TAYLOR: I think they are all changing now, Carl.

MR. MICHELSON: Is that going to be top feedwater now?

MR. TAYLOR: Yes, because of the header problems.

MR. MICHELSON: I had heard that, but I haven't had it confirmed.

MR. TAYLOR: I think the generators at TVA are half way changed right today.

MR. MICHELSON: Okay. So that question will go away then because we have become much more similar to the ones we have.

MR. SHERON: I would also point out that if you look at the rasied loop versus the lowered loop, the concerns that one has regarding relative inventory levels and whether one establishes condensing surfaces at the right time and right elevations and the like are much less of a concern for the raised loop plant.

MR. MICHELSON: If it has auxiliary feedwater at the top of the generator.

MR. SHERON: Even if it is at the bottom.

MR. MICHELSON: Well, I won't take the time to argue it right now.

MR. SHERON: Yes, but I am saying the condensing surfaces are well above the top of the core which is really what the concern is. So I think from a standpoint of natural circulation and the like, it is a lot easier plant, if you want to term it that way, to understand its behavior and get a better feeling that it indeed will re-establish natural circulation before core uncovery would ever occur.

MR. WARD: Okay. We had better go ahead, Mary Ellen.

MS. KEANE: The conclusion we came to was that while all these facilities will provide us with information, we felt a high-pressure full elevation two-by-four facility would complete the data base.

(Slide.)

Next I would just like to briefly give an idea of how the TAG group went about coming up with our two-by-four recommedation.

The process that was gone through is that, first, the issues were weighted to reflect two things. The

first of these was their importance as safety and licensing concerns and the second was to reflect the amount of knowledge and understanding that we have at the present time about each of the issues.

Secondly, several facility options were proposed. Now each of these facilities contain different options, whether they had the degree of secondary side modeling, whether they had pumps, whether they had full-scale power and several different things in combination were looked at.

Then, finally, these facility options were evaluated in light of their ability to address the issues and the cost involved.

MR. SCHROCK: Excuse me. Your item A seems to me to be in conflict with Dr. Sheron's opening remarks to the effect that the licensing concerns were not really the justification for this large experiment.

MS. KEANE: No. Safety was definitely a primary concern.

MR. SCHROCK: Did I misunderstand, Brian? That is what I wrote down.

MR. SHERON: I didn't want to leave the impression that we don't have any licensing concern and these plants are just wonderful and we should all just smile and walk away.

What I was trying to say was that we were not trying to tie the data that would be obtained from any one of these facilities, GERDA, OTIS or MIST with any specific regulatory requirement. In other words, one did not want to say one has to have data from GERDA, data from OTIS and data from MIST in order to demonstrate compliance with Appendix K, for example, that was not a conclusion that we reached. In other words, we do not need the data from this facility to say that the B&W ECCS model is incompliance with Appendix K. This data is not needed for that. We can say that today.

What we are saying is that the data is needed to confirm our understanding of the analysis models used for preparing operator guidelines and procedures and for the training programs that the operators go through in understanding those procedures.

The ATOG documents have an extensive background document which provides this basic understanding of plant behavior and response. This information is needed for that.

So it is in an indirect sense a licensing concern, but it is not a direct one from the standpoint of I need this to demonstrate today that they comply with some regulation.

I don't know if that explains it.

MR. SCHROCK: I think it is a little fuzzy.

MR. ZUDANS: It is fuzzy all right.

(Laughter.)

MR. SCHROCK: But I heard it.

MR. SHERON: You can read the transcript.

MR. SCHROCK: Yes.

MR. ZUDANS: I think you have to strike out these licensing concerns on this slide. If you had a licensing concern you couldn't function dispassionately.

MS. KEANE: I think again it was primarily safety concerns.

MR. ZUDANS: It is just not the place to say it.

MS. KEANE: Okay.

(Slide.)

Now I would just briefly like to talk about the MIST facility. Again, you will be hearing a lot more about this later.

MR. CATTON: I thought this facility was not yet designed.

MS. KEANE: No, and you will see that I am really only talking about general ---

MR. CATTON: Well, I would like to just mention the first item there that says "full elevation, 2X4 configuration." It is the full elevation. Now full

elevation, you do that for two reasons really. One is to make sure you get your relative buoyancy forces right and the second is so you have real time scaling.

I think Ishii made a good point about the real time scaling. You may not agree with a lot of what he did, but he did make a good point. You try so hard to get it and you compromise elsewhere.

I would like somewhere to have that question addressed, why are you compromising so much to get real time scaling?

MS. KEANE: I think that perhaps this could be answered better later.

MR. CATTON: I understand it can. I just want to raise the question.

MS. KEANE: I just want to point out one thing. Again, the point I tried to bring up earlier is that we are going to have a variety of facilities. It is my understanding that either SRI-11 or University of Maryland facility may be able to address some of the questions we have about which is the best scaling philosophy to go towards.

MR. CATTON: But if you wait for them to address it, you will already have your facility built and then it is too late.

MS. KEANE: It will have to be in a sense

concurrent, but I think that is just the situation we have to deal with.

MR. CATTON: I am just afraid that your drawings are getting firmed up right now.

MR. TIEN: Can you do it concurrently?

MR. CATTON: I think you have to do it serially, but you have to do what is necessary to make your decisions first and not after. And I said I wouldn't interrupt.

(Laughter.)

MR. SURSOCK: If you allow me to address this question when I make my presentation, I will be talking in some detail about Ishii's scaling.

MR. CATTON: Certainly.

MS. KEANE: Again, just the major facts about the MIST facility. Full elevation, two-by-four configuration and lowered loop.

It will have four pumps, a full-length prototypical core, a full ECCS capability, including high and low pressure injection in core flood tanks and two 19-tube prototypcial steam generators. One of those generators will be the generator that is now in use in the GERDA facilty and the second will be a new constructed, well instrumented steam generator.

The system will have full guard heating and it

will be fully welded. It will have 10 percent scale power, both vessel and U bend high-point vents and it will have additional hog leg instrumentation relative to the present GERDA facility.

Another thing that I would like bring out is that TAG realized that we now in place a raised loop facility. It is going to be torn down. So we wanted to make sure that we had as many questions answered about the raised loop facility as possible.

So there is going to be another facility called the once through integral system facility, and for this modifications are going to be made to the GERDA facility to make it more typical of a domestic plant. Some of these modifications include putting a vessel vent valve in it and putting in a plate in the vessel to make the resistance between the upper plenum and the head more typical. Then they are going to be switching one of the cold leg orifices. It is going to be put in a different place because it was found during the GERDA testing that it was in a position that periodically voided.

This facility is then going to be gone though an additional test matrix consisting of ten tests, and I think those will be discussed in a little bit more detail later on.

MR. MICHELSON: Let me ask a general question

on instrumentation. During the process of trying to get instrumentation on reactor vessels or hot legs or whatever, what discussion occurred concerning the well, these instruments aren't even accurate, they don't work, whatever, and particularly Delta P cells? Why now do we think that Delta P cells are great for this instrumentation and that they will work and so forth? What has happened in the meantime?

MR. LANDRY: We don't think they don't work.

MR. MICHELSON: But I think the industry has made a lot of noise about the acceptability of Delta P as a measure of level and so forth.

MR. LANDRY: I think what they are looking at, Carl, is using instruments in place for extended periods of time. The instruments which we have experienced operation with on LOFT, on Semiscale, on FIST and FLECHT and the other programs have functioned quite well, except when the instrument physically fails, and the response has been quite good. But those are instruments which are specially built and which are calibrated prior to and following the test.

They are a little bit different animal than you would put on a plant that is going to sit out there for a plant life time of 40 years. For this type of a facility, for a research facility we feel the instruments

are quite good and we are quite happy with their results.

MR. MICHELSON: I thought the problems were with frothing and whatever that is occurring during these transient events and the acceptability of Delta P to what is called inventory under those conditions. Then people said well, there are better ways to do it with various heated thermocouples and things of this sort. Yet, I don't that sort of instrumentation proposed here but just simple Delta P. Apparently it is good enough then to get some good information from.

MR. LANDRY: On this type of facility we feel it is. We have asked Idaho to review the instrumentation as planned and they have done that and there is a report that has not been released yet. It is going through the signature change. But they have reviewed the instrumentation and we have asked them to review the more exotic type instrumentation which we could use and make a recommendation.

At the present time based on our experience with Semiscale and with LOFT, we found that the DP cells do work quite well. We have been running them against the conductivity probes, against heated thermocouples and against a number of different methods. We feel, based on our experience, that DP cells are not all that bad.

MR. MICHELSON: The other question is is there

any reason why you don't go to density measurements using gamma rays or whatever to get a better feel for the void fractions around the loops?

MR. LANDRY: We are looking at that. That is one of the specific questions which we asked Idaho. If we put in the gamma densitometers, and we were discussing loaning the program some gamma densitometers from Idaho, where would we put them and would we use one beam, two beam or three beam densitometers?

Idaho has reviewed that. So far I haven't seen the report. So I can't tell you their conclusion, but that is one of the specific points which we have looked at.

MS. KEANE: Finally, I just want to diagramatically show this integral system test program and how out of the TAG recommenations we are getting a program that is based on several facilities and several souces..

(Slide.)

The first is the available plant information.

Next we have the other plant facilities like SRI-II and University of Maryland.

We have the purpose of the GERDA data from the Germans.

We have a modification of the GERDA facility to the OTIS facility, and then that testing and analysis.

Then, finally, the MIST facility and the

testing that will come out of that.

What we are hoping is that from these several different sources when it is all brought together, we will have a sufficient experimental data base to answer the questions concerning B&W plants.

MR. MICHELSON: Is the available plant data such as the ANO-1, natural circulation following loss of off-site power, is that what you mean?

MS. KEANE: Yes. I think they are pretty much restricted to natural circulation transients that some of the plants have seen and the TMI accident, what information is available.

MR. CATTON: What does IST stand for?

MS. KEANE: Integral system testing.

MR. CATTON: Well, I am wondering, MIST and IST. At first I thought their word processor screwed up.

(Laughter.)

MS. KEANE: No.

MR. ZUDANS: Will there later be a more detailed discussion of this full guard heating?

MS. KEANE: I think it will be discussed in a little bit more detail, in fact I know it will be, but it they have got the thermocouples around the pipes and they are able to sense the amount of heat loss through the pipes and try to add that back in. It is a method of

minimizing the heat loss.

MR. ZUDANS: I understand that.

MR. WARD: I think we will hear more about that later.

MR. ZUDANS: The only thing I remember from our tour was that they will be controlled in ten-foot sections and I was just wondering how could that be.

MR. WARD: Thank you.

Let's take a ten-minute break.

(Whereupon, a short recess was taken.)

MR. WARD: We are running about 50 minutes behind. I understand we will want to break for lunch at about 1 because some arrangements have been made. So we will just do that no matter where we are on the schedule.

We would like to complete the agenda today, and unless we can make up some time, that indicates we will probably be running past 5 o'clock. So I hope if that presents anybody with a particular problem, maybe you could let us know.

One other housekeeping announcement is there is a message board out here and you might check that periodically.

One thing I might suggest to the subcommittee and consultants in asking questions is to look ahead on the agenda a little bit and if you think there is a chance

that a later speaker would be a more suitable point for discussion or a question maybe you could postpone it to that and that might help us move along a little faster.

Mike Young is next I believe.

MR. YOUNG: What I thought I would go through is what are the support programs.

(Slide.)

I will go into what they consisted of for the MIST/OTIS program, and particularly NRC support programs. How we have got this broken up is into basically four different areas, support in the form of separate effects tests, then instrumentation and data acquisition of the MIST facility, then analysis support and also consulting support.

(Slide.)

Separate effects studies that NRC is sponsoring is at the University of Maryland and the this is going to be talked about in detail following my talk. So I just quickly wanted to go over what you can expect.

The separate effects tests particularly planned for in the University of Maryland test will include hot leg U bend studies, reactor vessel vent valves and in that, as you may recall, they will plan on using four vent valves with an internal downcomer annulus, and then also do downcomer separate effects studies.

I have list some of these other tests as being in more or less system tests, and that is multiloop oscillations and steam generator instabilities, in addition to hot leg U bend blockage and venting and small break LOCA.

(Slide.)

For instrumentation support and data acquisition, and particularly we will probably rely on INEL for this, we are interested to have them review and look over the possible use of some of our what we call advanced instrumentation, particularly gamma densitometers, drag discs or the use of spool piece.

This is something that they get into very soon and this program is being defined right now on when they can get this information to us and to tie into this program in a good manner.

Secondly, we would like for them to review the proposed instrumentation, as I think you saw quickly this morning, and that includes the typical T/C's, DP cells, flow meters, et cetera. We would like for them to look at not only the types of what is going to be used, but also the location for these instruments.

MR. CATTON: Who is doing this, Mike?

MR. YOUNG: We plan on INEL doing this.

Also, we feel like it is important to look at

the data acquisition system that B&W is proposing to use. We would like for them to look at how the system is characterized and the timing of the system, especially based on the experience we have out at Idaho with our facilities there.

Also, the automatic data qualification system that was used in LOFT and also I guess now it is used at FIST. That appeals to be very successful. I think that is another important point that we can provide some good input into this program and this will be looked at also.

(Slide.)

In terms of analysis support, this is a plan that is more or less within the next couple of years and not necessarily over the total span of this program.

First of all, we would like to include both RELAP 5 and TRAC in this analysis support and intend to use INEL for RELAP 5 and Los Alamos for TRAC.

What we would like to do, first of all, is benchmark these codes against the available GERDA data. Then what I think would be very useful and I think somewhat answers one of your questions, Ivan, is to put together a model of a typical 177 plant, to put together one of MIST and the University of Maryland. Possible we could also do one of SRI-II, with the intention being on doing an assessment of the facilities.

Later today we are going to talk about the scaling some more. I believe we are doing the best job we can on the scaling. This is, as I see it, an extension of that scaling in that what we can do is run some selected analyses on a plant and then run our analysis on MIST and the other facilities and compare how the analytical results compare to each other, is their timing reasonably the same. This is something that we plan on doing and hopefully it will be done within the next year.

MR. WARD: What do you mean run an analysis, Mike?

MR. YOUNG: RELAP 5 and TRAC analysis.

MR. CATTON: As part of the PTS work that is going on there are input decks and so forth set up already. One of the TRAC models even includes the annulus with six azmuthal nodes. It seems to me that, gee, that is 90 percent of the way for you to check out whether or not you have to worry about vent valves working in a strange way.

MR. YOUNG: Yes, but they haven't analyzed the MIST facility.

MR. CATTON: Well, I think the first thing they ought to do is analyze the system itself to see what kind of behavior they should anticipate from those vent valves. The vent valves are already in their model, the TRAC

model.

MR. YOUNG: Right, and they have already done that.

MR. CATTON: They looked at the PTS issue which is different and weren't concerned about your model MIST and you paid for that work.

MR. YOUNG: Yes. You are saying they have got the deck already built for the plant..

MR. CATTON: I think so.

MR. YOUNG: Right, I am aware of that. So what we have got is a plant model already built. In addition, we have to put together this MIST model and possibly Maryland and SRI-II also.

MR. CATTON: I would like to see them run the plant model straight away with the one steam generator upset or something to find out whether or not those vent valves start slamming shut.

MR. YOUNG: I think that is a good point.

Then also there will be some pretest analysis invovled in this for both MIST and OTIS.

(Slide.)

We will also look forward to some consulting support. Specifically I have identified some of these items that I think are pretty important.

One is the MIST facility specification that is

due out the beginning of September. The way our schedule is set up right now, we have got about a month to review that.

In that facility specification there will be a lot of the points on scaling that you all have been concerned about this morning. It will be documented and given a chance for review and comment on these things.

In addition, the GERDA modifications we feel are important, instrumentation as I mentioned before and then reviewing the GERDA data, and then the OTIS and MIST text matrices again as was brought out before.

(Slide.)

I showed this slide once before in a meeting. I simply wanted to refresh your memory of an April 14th scaling meeting that we did have which looked at the B&W approach to scaling this facility and then the Ishii first talked about his rationale.

One of the things that we decided out of that meeting, the general agreement was that we would endorse the two different scaling approaches represented by both B&W and the Univeristy of Maryland. From that recommendation B&W has continued to operate and design their facility based on that.

One of the other things that came out of that meeting was that we feel that both Ishii and B&W should

send a more detailed review of their scaling approach to give the consultants at that meeting a chance to look at it better and be able to comment on some of the advantages or problems that may stand out.

We have received the input from both sources and that was sent to the consultants at that meeting and I think also you all have a copy of that I believe.

One of the things that we did request is that if there are any very obvious or major shortcomings in either of the scaling approaches that they notify us pretty quickly. I haven't received anything yet. I know what you are ging to say, that we have got to know the issues. Anyway, that is the way that stands right now.

We talked about it before and I thought I would let you know where we are on that.

MR. WARD: Well, let's see, you have received some comments from some of your staff consultants, right, on those two?

MR. YOUNG: Not on that last letter.

MR. CATTON: That just did in response to the April 14th meeting.

MR. YOUNG: That is right, yes.

MR. CATTON: Do you have a contingency plan based on what the consultants might say?

MR. YOUNG: No. You mean what are we going to

do?

MR. CATTON: If your consultants come in and say we think that both of those methods are nonsense, what are you going to do, build it anyway?

MR. YOUNG: Well, we will take it when it comes. I think it is quite unlikely, especially from the meeting that we had on the 14th where everybody seemed to feel both approaches were reasonable. They couldn't see any major shortcomings between the two, yet there were some areas which they felt like they would like more information. That was the purpose for sending this out again. My impression is that would be quite unlikely, but still it was worth being sure.

MR. CATTON: What are you going to do if the response is that Ishii's approach is clearly the one that should be followed?

MR. WARD: First of all you have got to turn the planned building on its side, right?

(Laughter.)

MR. YOUNG: We are going to get Ishii out here.

MR. CATTON: I had hoped that we were going to hear from him today.

MR. YOUNG: No, but I believe Jean-Pierre will speak on that.

Let me show this slide quickly and this will

pretty much get into the other facilities as we will be talking about them in the detail that I believe you want to hear.

(Slide.)

First of all, what are the experimental facilities. You have seen this today already. You have got GERDA, OTIS, the University of Maryland, SRI-I and II and the MIST facility.

The major scaling approach that we are taking is shown on the slide there. As was also said earlier, we feel a reasonable mix of these scaling approaches that hopefully will blend together will help us to cover all the phenomena that would be important in the particular small breaks or other transients we want to look at.

The University of Maryland is really an Ishii scaling rationale based model. I call it a modified Ishii simply because Maryland still tried to preserve time around the loop as being an important scale factor and Y. Y. will talk about that in detail.

SRI-II is I guess what you would call more pure in the Ishii scaling logic.

Then again MIST is primarily elevation scaling.

Why don't we get into those right now so we can continue.

MR. WARD: Okay, good. Let's see, one of your consultants I think was Griffith and in a letter to Ralph Landry said the one of the most important missions he saw of an integral test facility was to look for surprises. How are you dealing with that? Are you looking for surprises and in which of these?

MR. YOUNG: Well, I think what he is saying is to base your scaling approach on a phenomenological basis the best you can, and also don't necessarily say look, this is exactly what I want to look for and I am going to build the facility so I can be sure that I am going to see those phenomena period. Then all of the sudden there is something else that comes up and you don't have a facility that can look at these unexpected phenomena. That is what I understood he is saying I believe. I think, as you will see, that is what everybody is doing.

MR. MICHELSON: Well, how does reconcile with the idea of using only one vent valve for bypassing to the downcomer?

MR. YOUNG: Instead of keeping going over this, let's wait and go over the discussion that they have got and they have got some backup.

MR. MICHELSON: I just wanted to state it as a question in my mind to be answered sometime today.

MR. TIEN: As I read Dr. Griffith's letter, he

was saying he would not like to regard the test as a code verification, but look for surprises. Again, I don't think we can carry that too far. I think it is a good idea to look for surprises, but still you have to identify the major phenomena you try to model or try to see and then you look for surprises.

So I think if you don't do that, you would never get any surprises, or you get surprises and you don't even know what you are getting. So I think that we should not carry that too far either way.

MR. CATTON: You have to define what he meant by surprises.

MR. TIEN: Yes, exactly.

MR. CATTON: What he means by surprises is when the codes don't predict what you get. If you think about Semiscale, that is where all the benefits came from.

MR. WARD: I am not sure. I didn't get the definition of surprises as exactly that.

MR. CATTON: Well, I have been interacting with Peter for some time. So I am summarizing my view of what he means.

MR. WARD: Okay, good.

Thank you, Mike.

Mr. Hsu.

MR. HSU: Good morning. My name is Y. Y. Hsu. I

am on the faculty of the University of Maryland.

Since we are way behind schedule and the time scale is determined by the stomach, I will speed up my scaling.

(Laughter.)

MR. CATTON: You can't do that, Y.Y., you are a key part of this.

(Laughter.)

MR. HSU: I am going to report on the status of the University of Maryland two-by-four loop. The principal investigator is Frank Munno, but he is marrying off his son right now. So that is why I am reporting here.

(Slide.)

We are going to cover the following items because apparently you people are not quite familiar with the Maryland project. So we are going to cover the scaling principles for single phase, for two phase and describe a little bit of the facility design so far, the schedule, test matrix and test results of the U bend bubble velicity.

(Slide.)

The first is single phase scaling principles. These I will go very fast on because it is the less controversial one.

Basically if you have two loop and you have

used the first principal equations and balanced the pressure against the loss and so forth, then you end up with the equation which finally leads up to this equation which is similar to SRI derivation and Ishii's derivation, that is the volumetric flow rate is proportional to the third power.

Then we also did an anlaysis for a transient. The one we did before was stead state. This is the transient. The transient in this one is just saying there are two types of time constants. One is for the heat transfer, which is the standard transient heat transfer type of heat up.

Then we also have the loop transient, and in the loop transient we have two types. We can take two approaches. When you use the force against resistance we end up with a transient equation. Flow rate is a function of resistance in the head, and M star is an order of mass in different locations.

Well, this transient loop, time equals infinity of course reduced to the steady state. In the steady state we were able to preserve the real time. The way we come to the transient for single phase, you will find you really cannot, even for the transient we cannot preserve the real time. You are off by 20 percent or so.

MR. CATTON: Why do you care?

MR. HSU: We do not really worry too much, but we think it is close to one which is nice because then you do not have too much difference in the expiration term and so forth. If it is 1.2 of real time, then we feel ---

MR. CATTON: If your model is any good why do you care if it is even twice or half?

MR. HSU: But if you know your model so well, you don't run the experiment.

MR. CATTON: No, you are confirming your model. That is nonsense.

MR. HSU: If you know very well your model, if you know your phenomena very well, then you confirm your model by experiment. But for what we are looking at today, like Pete said, we are still looking for surprises. We had better be not too far from the real time. Although, as I say, 20 percent is there. We are not hiding it or anything and we will still have to live with it. We are not trying to preserve 1.0 real time.

MR. CATTON: I just don't understand your arguments. So what if you have scale time. Time is just another variable.

MR. HSU: We are scaling it.

MR. CATTON: Good.

MR. HSU: I am saying we are scaling it.

MR. CATTON: Don't apologize for the 20

percent.

MR. HSU: Okay, we are scaling it, but 20 percent, we feel it is close enough to real so we would be more comfortable.

MR. ZUDANS: You scale it the way it should be, but you would feel more comfortable ---

MR. HSU: If it is not too far off.

MR. CATTON: The reason I raise this issue is trying to get real time scaling forces it into tall and skinny, and I think that the penalty you pay for that is not worth what you gain.

MR. TIEN: He tried to compromise. I think at some point you try to scale the time as close as possible, real time. All the scaling has certain uncertainties and so on, limitations. Of course, on the other hand, you don't want to really force the time scaling so that you make the whole thing geometrically very much off scale. So you try to compromise in some sense.

MR. HSU: Yes. That is essentially what my point is. We scale, but if we are not too far off from one we feel more comfortable.

We can do two types of analyses for transients. One is from the force equation and another is from the energy equation. Anyway, either one we can get the same time scaling for transients.

(Slide.)

This is the one we talked about. The second one is using the energy equation and we come up with the same kind of expression. We are not going into a lot of detail on this.

By the way, we have a detailed analysis in our report which, unfortunately, we did not bring here, but if anyone is interested, we can send it to Paul.

This is essentially the way it looks. It is so-called fat and short compared with the B&W which is tall and skinny. That is very much consistent with Ishii's which is fat and short.

By the way, Ishii is Japanese and I am Chinese.

(Laughter.)

Ishii has U square over L, which is more or less what we are doing, as the ratio. So as a result your diameter is 1.5 or 1.6 of real ratio.

MR. CATTON: Neither B&W nor Ishii addressed the separation process and the fact that it is two dimensional. It was a one dimensional scaling analysis. Have you done a two dimensional scaling analysis.

MR. HSU: No, we have not, but we are going to run a lot of tests in the separate effect test. That separate effect test will cover a wide range of parameters

so that we will cover enough range that we don't have to worry about scaling. The separate effect test will be studying the physics only and we will have a small model and a small computer to ---

MR. CATTON: Have you built this facility yet?

MR. HSU: This is in the middle of building, but then we have also a small candy cane loop.

MR. CATTON: What contingency plan do you have if you find that when you look at the U tube as separate effects you have done this wrong?

MR. HSU: Well, first of all, we have already got some candy cane data and we are not getting surprised so far.

MR. CATTON: It acts as a good steam separater and you don't need to really test at all.

MR. HSU: I don't say that

(Laughter.)

MR. HSU: You are going one way or you are going the other way.

MR. CATTON: Okay.

MR. HSU: Then again another thing is our facility is fairly simple and small. So we do leave a lot of flexibility in our tests.

(Slide.)

This is the top view of our ---

MR. TIEN: Y. Y., I would like to come again to a basic question in scaling. Single phase scaling is you have ---

MR. HSU: I am going to get to that.

MR. TIEN: When you do the scaling perhaps it is always good to have a priority list about what phenomena you would like to know more.

MR. HSU: That is exactly what I am going to do.

MR. TIEN: You can go into a little bit more details. Say if you want to go to the candy cane part, then maybe you can do a two dimensional single phase scaling and that would give you a lot more information.

So I think again when we talk about single phase and multi phase that you must have something in mind of what exactly are the major phenomena you are trying to do.

MR. HSU: I am going to discuss that in the next part.

This is the top view. Of course, you know that is the two-by-four loop.

(Slide.)

We are going to skip those tables showing the dimensions. We don't have time and they are just numbers.

The important thing is that in our scaling we

end up having the resistances primarily residing in the hot leg and the cold leg, 28 percent, 38 percent prototype and 55 and 30 percent. Volume-wise it is also primarily in the hot leg and cold leg.

This brings us to a very important point, and that is if we focus on the phenomena, I think the the hot leg is the most important one which we will talk about later.

Right now I will just summarize the single phase first. The single phase scaling, we have drived both the steady state and transient. This is a littl bit too abbreviated to make sense. What we did is we preserved the volume ratio more or less, but power and the volume is a relationship of one-third power to the volume. That we had mentioned before. Then the volume-wise prototype is 500 to 1.

For single phase steady state it is real time for each component. For a transient, as I say, it is 20 percent off. Basically it is a fat and short for the hot leg and cold leg. So the result is the diameter is 1.6 times the geometrical scaling and the height is one-third of the geometrical scaling.

Now the two-phase scaling, that is a very interesting part because that is where all the argument is about. Ishii did his analysis, but one one problem with

Ishii's analysis is exactly opposite to what Dr. Tien was describing about.

Ishii covered the whole physics, including heat transfer in the core to the flow in the loop to any place, and as a result he had about ten parameters, ten dimensional groups, including CHF number, change of face number and so forth, to accommodate all of these numbers.

Then he had to come up with this scaling logic which of course ends up that he has a grossly distorted time factor, and I know Dr. Catton is not really worried about that, but for our case if we take, like Dr. Tien said, if we concentrate our attention to the hot leg, which I think is the most important part, and then we conjure up the phenomena and then we find out that Dr. Ishii's criteria of scaling, if we use his parameters, which is the most important to us, and then we compare the prototype MIST and the University of Maryland, we find they all cover the same ranges. This is the bottom line that I am trying to tell you, and let me explain more about this.

What happened is in the two-phase flow if you do not worry about the core, which is like Ishii worries and then overrestricts his problem, if you only worry about the hot leg, and then we look at the hot leg and what flow pattern we have, we are not going to have a slug

flow, even though I know GERDA observed some slug flow, because the pipe is small.

When you have a prototype that big, you are not going to have slug flow period. I can stack all my experience on that because I ran that slug flow in large pipes and I couldn't get except one single bubble. So in the large pipe you are not going to have your slug flow and you are not going to have to separate the vertical like a reflux mode because in the prototype again you don't have a heat sink to have a reflux mode.

So what is left? Well, you can have of course misflow, but that is only when you have a very high quality. Most commonly what we ran into was bubbly flow or churn bubbly, and the bubbly flow and churn bubbly, the most important parameters are the Froude number and drift flux velocity number and some secondary which I will show later.

Then another phenomena which should be considered is in the once through steam generator condensation part, and the way you have the condensation part, the important thing is the subcooled number and how much subcooling you achieve in the end which means how much really you take away the enthalpy.

So now let's look if we restrict our attention to that without looking at the CHF number and the change

of facing that was restrictive for Ishii. Then we look at the parameters. The J is the superficial velocity of liquid in the hot leg. Here is a prototype of MIST and Maryland. Ours is higher because we have low pressure.

Then we have JG which is gas velocity and the total J. Then we have a drift flux and we have diameter pressure and the power. Notice we have a lower pressure here. Our design pressure is 300 pounds, but most of the runs are at 200 or we will run into 300 in a few runs. The numbers were taken from Ishii's report for MIST and for prototype.

When we take all those run numbers and compare with the parameters, the dimensionalist numbers that Ishii came up with, except the CHF number and the change of face number, which is the one we don't worry about, then you can see void fraction is covering pretty much the same range, except MIST is slightly smaller. Beta is the flow rate and they are covering practically all the same.

Then Froude number, again these two are very close and we are covering more than they do. The drift flux number, MIST actually covers a wider range than the other two. Density, because of our low pressure we cannot cover as wide as the other ones.

The subcooled number, that is a very important thing for the steam generator. These two are the same and

we are covering a wide range. So it is covering more than enough. The resistance again is very similar.

What I am saying is you do not try to cover everything like Ishii did and if we concentrate on the physical phenomena which is important to us, then even for the two phase flow our scaling is not that bad. As long as we can study the phenomena, especially if you do have a separate effect test to reinforce your information, then you can come up with a model in which you would describe physics pretty close because you are covering the physical ranges in that area.

So the conclusion for two phase flow scaling is that for the most two phase parameter groups proposed by Ishii the prototype and our two facilities all are pretty much in the same range, with the exception of the CHF number and the face change we don't worry about.

For the hot leg, then we should only be concerned about bubbly and churn bubbly, and those important things are Froude number, Beta and drift number.

I think this kind of a study will make life much easier.

(Slide.)

Now we want to describe briefly the facility design. In the facility design the pressure vessel we have is about five feet tall and about 20 inches or less than

two feet wide, and we have about two feet wide of the heater section. We have 15 heaters and we have about 200 kilowatt total.

An an important thing I want to call your attention to is we have four vent valves around the circumference and also we plan to insert in the separate effect test, insert some insertion in the downcomer so we can change the resistance in the peripheral direction. This will become a separate effect test to study over a wide range of parameters so that we can cover the physical phenomena without getting surprises.

Then we have the steam generator. We have made the two sections so that we can adjust the heat transfer. The top side is by steam or gas and the lower side is by water to have a better control. Also, we have various tabs where we can adjust the height. This, by the way, is fabricated right now and should be delivered next month by PG&E.

As an example of our study, when we study heat exchange in the steam generator, for example, we went through quite a detailed design parametric study and then we also have a small simple program coming up to find out the right number of tubes, the right number of the flow rate and so forth. So that we can pretty much scope what the exit temperature on the primary side will be if the

secondary flow is changed. An example like this is so we can have a wide range of scoping before we do the study.

MR. TIEN: What is the major difference in the conclusion you arrived at with your modified Ishii scaling, between Ishii's and yours?

MR. HSU: Between Ishii's and ours is this. We only ---

MR. TIEN: You scaled the hot leg phenomena.

MR. HSU: Yes, we concentrated on the hot leg.

MR. TIEN: What is the final result in yours?

MR. HSU: The final result, well, it turned out that the physical size is the same like Ishii's. It is basically U squared over L. In fact, Ishii was saying you got the right answer with the wrong assumption.

(Laughter.)

But I wanted to tell him that I got the right answer with the right assumption because I only concentrated on that particular range of phenomena. It is not covering the whole thing. If I cover the whole thing, I will be just as restrictive as Ishii. We have the same size like Ishii, but then we have the parameter ranges are correct.

MR. TIEN: The operating range.

MR. HSU: Yes.

MR. MICHELSON: What differential pressure did

you design the vent valve for?

MR. HSU: That is one thing we don't want to set as a variable. We will make a vent valve about one and a half or two inches diameter and will put differnt weights on the backs so that they open at a different DP.

Incidentally, I would like to mention one thing about vent valves. The way you think about vent valve openings is in the order of inches of water or foot of water. The Japanese test in the cylindrical core showed that their DP at random in the downcomer could be in the order of inches or foot of water. So I would not be surprised if the vent valves before, that they were not opening at the same time at all. That caused a very interesting and very intriguing phenomena.

Frankly, if I tried to draw the diagram, I just cannot figure out how exactly this responds to the stoppage of flow. I talked about that in the test matrix.

MR. CATTON: The Japanese test was basically symmetric and it had that much difference.

MR. HSU: Well, even if you have symmetric ---

MR. CATTON: CCTF.

MR. HSU: --- you have broken cold leg.

MR. SCHROCK: Excuse me, Y.Y., are these valves going to be instrumented so you know the position as a function of time?

MR. HSU: We will have windows and we will look at it. We will have windows right next to the vent valves and we will keep peering at it.

MR. SCHROCK: Students watching.

MR. HSU: Oh, yes.

(Laughter.)

MR. YOUNG: There will also be instrumentation.

MR. HSU: Yes, we do have instrumentation. We do a Delta P and so forth. If you are interested and we have time we can show the instrumentation.

MR. TIEN: Ishii is not here, but you mentioned that he said you got the right answer but used the wrong approach. What is his objection?

MR. HSU: If you look at Ishii's analysis, he was trying to cover all the scaling with the restriction of the CHF equal to one and the change in phase number equal to one, and these two added a tremendous restriction on his scaling. We relaxed those.

MR. TIEN: So why he objects so much is not that important.

MR. HSU: Well, he did not know that was not important. What he did was he tried to be as general as possible from his analytical point of view. But from our standpoint we were only expertimental on the part we were worried about most.

MR. SCHROCK: Could I ask another question. Your scaling now results in near real time behavior for two-phase phenomena as well as single phase?

MR. HSU: No. Two-phase phenomena, we cannot even figure out how much real time it is, I mean how much you are off from real time. That single-phase one we can analyze, but not two-phase because it is quite complicated. So all we can do is say as long as we are covering the same physical range of important controlling parameters, then we know the physics. The time we really have to ask after we study it more. I cannot even venture to say what the scaling will be. But based upon single-phase which is near one, then two-phase will probably not be too far off.

MR. SCHROCK: Well, it seems remarkable that such different facilities could do that if it were true. Then it also raises the question of maybe we should come back to the idea of geometric similitude.

(Laughter.)

MR. HSU: What I am saying is that you have to study the phenomena itself in the hot leg without worrying about the whole system for that particular part of the problem.

For the flow oscillation, they will still be different, I am sure, because tall and skinny will be

quite different from fat and short for the oscillation between the loops.

Briefly I will talk to the schedule.

(Slide.)

The heat exchangers are in the fabrication stage and we should get them in the next month or so.

The vessel design we are doing now and we are fabricating in the fall, and the heaters will be ordered at that time and should be delivered in time for mounting.

Graduant students will put in the scaffolding and the piping and so forth during the next semester. We are putting in the electrical system. We are bringing the electrical leads first. We are going to put in 200 kilowatts. So there is a lot of electricity to be brought in, and also the rest of the electrical system.

We are ordering some of the instrumentation control, including Apple. We get Apple already by the way. The other peripheral parts are not in yet. Then they will be installed and checked out during this period.

What we are shooting for is that next spring we are going to have a shakedown test. This is just so that we can acknowledge some contribution. The heat exchanger was donated by BG&E, and there are all these things that the University of Maryland contributes, 45K plus about half a professor.

(Slide)

Test matrix. In the text matrix, what we do is if we compare with the MIST priority list and the items they worry about, what we will cover is we pretty much cover all the natural circulation and we will do part of a small break LOCA. We are not prepared to do feed and bleed and also the tube rupture, but after we finish this and if we do find that there is need, our facility is simple enough that we can modify it to accommodate that beyond our present scope.

Now the test matrix we have ---

MR. WARD: Could you go back to your previous slide there.

(Slide.)

MR. WARD: What do you mean by the center column there?

MR. HSU: We took this from the MIST study, not our own.

MR. WARD: Okay, I see.

MR. HSU: I was just trying to compare.

MR. WARD: What if you put another column up there and you made an attempt to evaluate the capability of your test system for modeling the phenomena important to that particular issue?

MR. HSU: Well, you will see when I talk about

the test matrix essentially, you will see what we can do.

As I say, we are covering this part and we can do all this here in the first part because it was designed for it. Then we were told to stretch into the small break. So we can do part of a small break thing, but we don't have a pump. So will have to add that later. We don't have it right now. The break isolation, we have to put new valves into that. We can do the vent valve with no problem. We can change the location of the break or the size of the break fairly easily. The ECC we cannot do very easily unless we add modifications.

So what I am saying is the first part is within our capability. The second part is partially within our capability. Really when you operate a facility like this you have to include feed and bleed capability, but that is for the operation purpose. So if we want to use that to achieve the feed and bleed operation itself to simulate the prototype, then we have to think it over more yet.

In the text matrix we have four parts. The first two are shake-down tests and the component characterization tests. Then the third is separate effect tests.

The first part, shake-down tests, of course everybody knows how this is. We will use air/water and

then steam/water.

The component characterization is the important part which is very interesting because although we estimate the K, we do not know how good they are. So we have to run the tests to determine the K experimentally by plugging up all the holes except the one loop. Then we leave the one-by-two loop to try to check whether the one loop one will give us the right answer, and then a two-by-four loop. So we check them to determine the resistance along the loops.

The vent valve, the vent valve could be opened close to the cold leg or at the far end of the cold leg if we assumed the vent valves opened differently instead of opened all together. So we have to determine the resistance of the flow between the vent valves in the cold leg, whether they are at the far end or close. Then we have a flow rate.

To answer your question about the set point, then we just put a different weight on there and we can get different perceptions. So we run that to characterize the vent valves.

Then we characterize the steam generator to know if the heat transfer is like we had calculated, and also we can see where the thermal center is by adjusting the flow.

(Slide.)

Now then for the separate effect tests, basically all tests will be like this. We will have a baseline case and then we change one variable at a time. This is the typical NRC way of putting the matrix, but in our case we would, because our separate effect, we anticipate doing an ALARA and so we double the matrix. Everything will be like a two base case and twice of those variable runs. Then we fix the variables which are for the vent valve condensation mixing. Of course, then we have a steam enthalpy flux and water enthalpy flux and the gap of the downcomer and the set-point vent valve. These are the variables and we varied them one by one to check whether a surprise came on that.

For the U bend, and the interesting thing about U bend is that you have a velocity component upward, V sub Y and V sub X. So you have to measure both at each location. The variables are J sub G and J sub L, the pipe diameter, radius of curvaturb and non-condensible or steam. Right now we are using the non-condensible, but we are later going to study steam.

MR. CATTON: You are going to measure the velocities?

MR. HSU: We are measuring them. This is separate effect tests.

MR. CATTON: I understand. You are going to get the big circulation and eddies and the whole business.

MR. HSU: We see them already. In fact later if you have time we will have a movie and show you a very nice cyclone going down to the steam generator.

These are the separate effect tests and we want to study more physics and then we will put that into the small computer program so that will become an understanding model and hopefully our model could be plugged into later the system.

The system tests, when we will have to combine the hot leg stoppage due to the bubble on the top and whether we can remove the flow interruption by pressurization or by top venting. Then at the same time what is the interaction. See, remember we talked about the separate effect. We have the U bend and we have the vent valves separately. But what is the interaction between the flow stoppage, the pressurization and the vent valve action. Then what is the result of the multi-loop oscillation. Then if we adjust our steam generator flow rate so that we [illegible] a different heat removal sink, then what is that [illegible] on our system.

Then the variables are power, non-condensible, steam generator flow rate, cooling rate and the top venting. All these we will do one by one to see what is

the combined effect based upon the separate effect results.

MR. TIEN: How does the non-condensible affect your scaling?

MR. HSU: Non-condensible affects scaling, the fact that the bubble does not disappear. So you don't have the subcooling effect.

MR. TIEN: Two-phase scaling does not include the non-condensible.

MR. HSU: That is right.

MR. TIEN: So non-condensible, if it is very important, how would that effect in terms of overall scaling?

MR. HSU: Well, we do this. What we do is if non-condensible then we just see the bubble does not collapse. It is essentially equivalent to having a saturated flow with the subcooling number equal to zero. If you have steam, then the subcooling effect becomes very important in collapsing the bubble.

MR. TIEN: This leads me to another general question. In the scaling, in your case you are limited to a more important phenomena on say a lot leg side. But if you are limited to that, can you actually do some additional thinking, say your scaling will fail really in some sense to anticipate the surprises or the limitations

of your scaling?

MR. HSU: Well, yes.

MR. TIEN: Non-condensible is one and there are many others. Would those things upset the whole thing or affect your scaling laws and so on?

MR. HSU: One thing I know that upset me, and that is if the flow stoppage go so bad and the power so high that you actually would dry out a core, then it would upset the whole thing completely, but we don't anticipate going into that region. If we go into that region, then we have to be more careful in including the CHF number.

MR. TIEN: I am also thinking that we discussed the surprises. Sometimes it perhaps is good to anticipate surprises, and then of course sometimes there will be no suprises. You can say the possibility of surprises.

MR. HSU: I would rather say difficulty with. The one that I anticipate difficulty with is when it comes to multi-loop oscillation. If you tried to draw it equivalent to a circuit diagram it could be very, very complicated, especially if the vent valves opened and closed at different times and also if the vent valves chatters. Those things are the ones I don't know how to handle except by saying we observed the phenomena. Those things I don't think anybody can really scale.

MR. CATTON: But you can appeal to the codes

there. If you can model it and prove that your model is okay, you have closed the loop.

MR. HSU: Well, what we do is we would say if we can observe the phenomena, the physical phenomena, if we can construct the model and use a small, simple model in a separate effect way to understand it, then we feed that into the large computer.

Now I want to show you very quickly a few of the data for the U bend bubble velocity.

(Slide.)

We have a very simple plastic pipe. It is a two 90 degree sweep. So it is not quite exactly a semicircle because we have to join them here. So that would slightly push sideways. Water and air are going this way and they flow down here and the bubble starts here and they start to move like this. Then the water falls and comes down here. The water fall can never be very symmetric. So it starts the secondary flow.

When you do that you start to see this nice cyclone and the cyclone gets tighter and tighter. It is very beautiful down here. That gives me a very interesting thought, that is that in case this happens also in a big candy cane, that means some part of the steam generator could be more efficient than we thought because we have a spiral flow going down. But that is beyond the point.

MR. MICHELSON: The tube sheet breaks that up, doesn't it?

MR. HSU: No. See, you have this plenum and then you have many tubes. Depending upon your vortex, they enter to which one. See, you have a flow going down and you have some place more vorticity than another place. Those ones with more vorticity carries into the same tube and then becomes tightened up.

MR. CATTON: Do any of the bubbles get across?

MR. HSU: Not in ours. The flow rate we try to do will like two feet per second and we cannot carry the bubble through. But you do have a secondary bubble here. Your original bubbles come out here and they just collect here, but then the fall comes down, and when the fall comes down shoots into the pool. Then in turn the gas in this region forms a secondary bubble flow.

MR. CATTON: That might be a scale effect. You have got a five-foot horizontal separation and a three-inch pipe. Shouldn't it be a five-foot separation and a much larger diameter pipe? That would tend to wipe out that cyclone behavior.

MR. HSU: We made two tests. Another way is a smaller, tighter tube with a horizontal section on the top. The curvature is different in other words, but we saw the same fall.

We do plan to make another one with a larger curvature, I mean with a larger sweep.

MR. CATTON: And bigger diameter?

MR. HSU: No, same diameter.

MR. CATTON: Three inches?

MR. HSU: Yes, and then we can see the curvature effect.

MR. CATTON: Don't you have to get the large diameter? The diameter of the hot leg is what, three or four feet. It is almost the same ---

MR. HSU: No. The important thing is that in this part the bubbly flow comes out, the same bubbly flow. So as long as your pipe is larger than this square root of sigma over delta G so you don't have a slug flow, then it doesn't really matter how big the pipe is as long as the pipe is big enough.

MR. CATTON: I understand. You have made a point of this vortex, and I am wondering what would happen if you had the large diameter pipe, would you still form the vortex and I tend to think not.

MR. HSU: I would say probably more so because the reduction of area ---

MR. CATTON: Then it looks like you ought to test it.

MR. HSU: Well, that is the nice thing about

our single test that we can easily do it.

MR. CATTON: I am a strong advocate of those kinds of tests.

MR. TIEN: Following this question, the multi-component, three dimensional and secondary flow, it is very massive and it is a very important region. On the other hand, your overall scaling, the modified Ishii scaling is still based on one dimensional two-phase ---

MR. HSU: That is for the system.

MR. TIEN: So I thinking perhaps you should do a sub problem scaling, but in this case it is not possible because it is so complicated. So maybe it is good to do some experimental scaling and build another say slightly different curvature and diameter and so on. So you try to use experimental scaling to gain some idea about the physics in that very complex problem.

MR. HSU: That is what we intend to do. This pipe, if we change the pipe diameter here, and I want to check one more thing, but if I put a perforated plate here with different tubes going down there and then whether the cyclone is concentrated in one tube or is distributed, but I bet it is concentrated in a few tubes because once they are there, they are there.

MR. TIEN: I think that is the first step in experimental scaling, but still I think you have to put a

lot of thought into the experimental scaling so that if you have two or three slightly geometrically different bends, you still can draw some physics out of it.

MR. HSU: Yes.

MR. CATTON: The large diameter.

MR. HSU: Well, we are going to do it. In fact, one thing we are going to do is connect this and make it a loop by itself, and then that steam would come in here and it would bleed off a little bit of water there and make a circle by itself, but that is down the line.

MR. CATTON: Just make sure you damp out that vortex before you pump it into the other side.

MR. HSU: Now this preliminary data that we have, this is one example about the Beta waves project on the screen, the movie picture, and then the student will take all the coordinates and they use a magic pen and they just get all these bubbles circled and put into the computer right there.

By the way, we borrowed from physical ed. They do have more money than us. That is to check how do you strike the golf ball and so forth.

(Laugther.)

MR. HSU: See, in physical ed, they took the pictures of people striking the ball or anything like this and they analyzed their motion. So we borrowed that and we

analyzed the bubbles, which is very nice and handy.

These are the data range and I am not going to go into more, but I want to show you a few typical data.

(Slide.)

This is a fixed bubble, I mean that mosquito fly on the data points.

(Laughter.)

This is one of the equations used by the code. This is for the slug flow for drift flux. You can see that this is a vertical component. You can see it is everywhere and that means that the equation is not very appropriate.

MR. TIEN: I am very pleased to see this. I expect that because in that region you probably would not be able to get very single value type of data.

MR. HSU: Exactly, and this is another popular drift flux equation and again you cannot predict data. The why is this, because if you follow closely a couple of data points, there are only two bubbles you are following here, and you can see these two bubbles, they move from say the "A" bubble moves from the first frame and then two or three frames later it is here and then down here and so forth. It is all over the place in size, 50 percent in size variation and 50 percent velocity.

The so-called size is a little bit misleading. Actually what happens again is it two dimensional or three

dimensional in fact. The bubble moves around in and out of this channel and deforms, and since we can only take two dimensional pictures, and we assume that is axially symmetric, that caused the difference in the size.

But no matter what, even if it is spherically the same size you see the velocity changes quite a bit and that is inherent. We tried to analyze more and understand what is the liquid flow distribution effects and what is the velocity effects and we haven't got any reasonable information yet.

There is one more important piece of information I want to show you.

(Slide.)

As I say, in the U bend you have an "X" component which we never had in the code at all, and now you measure the VX which is the bubble drift with respect to flow. Here is the zero and this is the negative and the positive. What happens is some bubbles are lagging through the flow and some bubbles are leaving the flow and again over a wide range. The code just didn't have this input at all. So we have to do that.

By the way, this of course is expected because the bubbles should be some places leaving and some places lagging because the flow sweeps this way.

MR. CATTON: You also have the torus components

and that would do some of this, wouldn't it? Your good friend Yow can help you with that.

MR. HSU: There are a lot of those kinds of things. I remember way back in NASA days we observed this torus thing, too.

So that ends my presentation. Thank you.

MR. WARD: Thank you, Mr. Hsu.

Mr. Sursock.

MR. SURSOCK: My name is Jean-Pierre Sursock from EPRI, Nuclear Power Division.

I will be presenting to you today some EPRI related studies to the B&W plant design.

(Slide.)

I had intended to discuss the SRI-1 results and follow that with SRI-11 plans and then discuss some of the separate effect tests that are being conducted as sponsored by EPRI. I don't think time will allow me that. So I will jump immediately to some analyses we are contemplating doing.

MR. WARD: Well, wait a minute. I think that we do have time. We are not on any particular constraint at the end of the day. So unless you have a constraint, just go ahead with what you had planned please.

MR. SURSOCK: Fine.

(Slide.)

The first SRI test facility was built right after the TMI accident in order to analyze the natural circulation mode of heat removal at TMI.

The main objective of the facility was to study two-phase natural circulation and the boiler condenser mode, as well as to study the effect of non-condensible gas on interruption of natural circulation.

(Slide.)

The major results of the study, which were completed a few months after the accident in late '79, in December '79, indicated that the system can operate in stable two-phase natural conditions.

Two modes for removal of heat were identified, the two-phase natural circulation and the boiler condenser mode, which at that time were called hot leg uncovered and hot leg covered.

We found that both regimes could tolerate a very large amount of non-condensible gases and still effectively remove the heat.

I will be showing briefly some of the results that were obtained with that facility which is schmetically shown here.

(Slide.)

It was a linear scaled test facility. The

reactor vessel was represented here with three electric heaters and there were two loops with one cold leg per loop and no pumps in the cold legs. There wasn't also any pressurizer in that facility because we were planning to study two-phase natural circulation only.

There were five side gauges to measure the levels, in the steam generator, in the hot legs and in the reactor vessel and various Delta P cells and thermocouples.

MR. TIEN: Could you comment a little bit on why the non-condensibles would not impact too much on the heat.

MR. SURSOCK: The non-condensibles were injected at the high-point vents.

MR. TIEN: I see, already injected.

MR. SURSOCK: No.

MR. TIEN: In your previous slide both regimes can tolerate substantial concentrations of non-condensible gases.

MR. SURSOCK: Yes.

MR. TIEN: Could you comment on why?

MR. SURSOCK: I will answer that in a minute.

(Slide.)

The two modes of decay heat removal were characterized by the temperature profile on the secondary

side.

In the first mode, which is the boiler condenser mode, I am plotting here the elevation in the Y axis and the temperature on the secondary side on the X axis. The first mode is characterized by a stair shape for the temperature on the secondary side which indicates that there is practically no heat transfer from primary to secondary in the upper part of the steam generator or the lower part of the steam generator.

Most of it occurs by condensation in a very short span in the steam generator and that span happened to be where the level is on the primary side in the tubes.

MR. MICHELSON: Where was the level on the secondary side?

MR. SURSOCK: I am sorry. I forgot to mention that the secondary side was a liquid solid, was subcooled.

The second mode of heat removal was characterized by a much smoother gradient of the temperature and it was associated with the two-phased natural circulation mode where two phases would flow co-currently in the hot leg.

The diffe ence in curves is due to the ratio of primary to secondary flow rate. If the primary to secondary flow rate is less than one, then the curve would be concave, if it is greater than one, it is convex and if

it is equal to one it is essentially a linear shape.

(Slide.)

Coming back to your question, C.L., this is a plot indicating the effects of non-condensible. Again on this plot the elevation is shown on the Y axis and the temperature is shown on the Z axis. In this plot the first curve is the one that was shown on the preceding slide and the non-condensibles were absent in this particular run.

Then the next thing we did was to add some non-condensible in the hot leg. After a while when we reached steady state we took measure of the temperature profile and we found it was shifted upward as such and the amount by which it was shifted was proportional to the volume of non-condensible that was injected.

The level on the primary side was still here, which indicated that the non-condensible gas accumulated right above the level where the condensation would occur. Now the condensation occurs, not at the interface level with the liquid, but above the additional volume that was added due to the non-condensible.

MR. MICHELSON: Question. If the secondary side was liquid solid, why was the condensation occurring predominantly at the interface, the level on the primary side, while it was occurring uniformly along the tube?

MR. SURSOCK: Because at this point we are

essentially reaching T-sat on the primary side and therefore there is no reason for the vapor to condense.

MR. MICHELSON: You mean the secondary side is approacning primary side temperature.

MR. SURSOCK: That is right. It is approaching T-sat on the primary side.

MR. MICHELSON: What I need to see then I guess is the profile temperature on the secondary side.

MR. SURSOCK: Tnat is it.

MR. WARD: That is what that is.

MR. MICHELSON: Is that what that is?

MR. SURSOCK: That is it.

MR. CATTON: So you stratified the secondary side.

MR. MICHELSON: He had to to do that.

MR. TIEN: I think if you interpret your non-condensible distribution from the wall temperature distribution, you may get a distorted picture because the non-condensibles will be concentrated near the interface of the vapor and the film. So I think your data is reasonable. However, your data cannot be interpreted as the interface of the vapor and the gas, the non-condensible gas. I don't know whether I made that clear.

In fact, we just did a study in fact showing

this. If you measure the wall temperature you get like what you have here, but that is very different from the actual vapor gas in other kind of separate zones because a lot of non-condensible gas actually accumulates near the interface of water film and also the vapor. So you have a two-dimensional profile for the non-condensible gas region.

MR. SURSOCK: That is not surprising.

The further addition of non-condensible gas further shifted up the sharp gradient point and the shift was commensurate with the amount of non-condensible gas that was added.

MR. CATTON: Is the location of that shelf transient in that it moves up with time or moves down with time or something?

MR. SURSOCK: During the transient it does.

MR. CATTON: It should slowly move down as you stratify your secondary side?

MR. SURSOCK: Yes. However, these data were taken during steady state.

MR. CATTON: Are you adding water to the secondary side of the steam generator at a slow rate?

MR. SURSOCK: Yes. The secondary side is flowing. There is flow through the secondary side.

MR. CATTON: Okay. So then the location of the

shelf is just a function of heat transferred and when you add the non-condensible you have transferred less heat so the shelf should move up.

MR. SURSOCK: Well, you have transferred the same amount of heat.

MR. CATTON: I understand. On your previous slide what did HLU stand for?

MR. SURSOCK: Hot leg uncovered.

MR. CATTON: Hot leg uncovery?

MR. SURSOCK: Uncovered. The reason was that the boiler condenser mode, what is now called the boiler condenser mode did not really have a name right after the TMI accident, at least not to my knowledge.

MR. CATTON: So you gave it one. Good.

MR. SURSOCK: It was characterized by the fact that in the reactor vessel that mode was observed when in the reactor vessel the level would be dropped below the hot leg nozzle and thus we called it hot leg uncovered.

(Slide.)

Another result that came out of this study is the so-called stability map where we plot here the system pressure on the vertical axis.

MR. CATTON: One more thing. If you increase your flow rate into your steam generator, do you move that shelf up and down?

MR. SURSOCK: No, you don't. If you don't have non-condensible gas, the position of the sharp transient is characterized by the mass inventory in your primary side. That determines the level inside the tubes in the steam generator and it is at that level that you experience that large ---

MR. CATTON: And I can't change that if I change the flow rate into the secondary side?

MR. SURSOCK: No.

MR. MICHELSON: But you changed the cooling of the tubes further up in the condensing area of changes and that changes the slope.

MR. SURSOCK: You may change the slope a little bit, but I don't think it is a major change.

The verical axis represents the system primary pressure and the horizontal axis represents the flow rate on the secondary side.

Now these data points represent actual test data at steady state obtained at various secondary flow rates with the same power and mass inventory on the primary side.

On the right of this curve one would be operating in single phase natural circulation. On the left of this curve one could not reach a stable steady state natural circulation, two-phase natural circulation.

On this curve one would be operating in two-phase natural circulation in a stable condition. So that for an operator who wants to be at a given pressure and in a single-phase mode, he knows what kind of flow rate he would have to have on the secondary side in order to be at a given pressure and away from the two-phase natural circulation mode. Of course, this sort of map would have to be generated for a plant. This was generated for the scale model.

MR. CATTON: So what you need is the pipe diameter effect.

MR. SURSOCK: Yes.

MR. CATTON: It seems to me that as you change the diameter that curve is going to shift.

MR. SURSOCK: I think you are right.

MR. CATTON: And Y.Y. will get that with the University of Maryland experiment.

MR. SURSOCK: I suppose.

(Slide.)

That was basically the major outcome of that first series of tests, and we are now planning a more refined series of tests with the SRI-II facility.

The basic objective of the SRI-II facility is to develop a data base for the qualification of system computer codes.

In addition, we would like this facility to be able to support the MIST and OTIS program in running scoping runs to help determine more accurately the test matrix.

(Slide.)

The basic design requirements for the test facility are listed here. The most important of them is probably the hot leg again.

The hot leg will include high-point vents and to inject non-condensible gas and to vent the steam, but it will also include viewports for flow regimes, for the observation of different flow regimes.

But, most importantly, it will include the possibility to change the size of the candy cane, and by that I mean that at the top of the hot leg we will have a flange, we will have a flange on the top of the steam generator and we will be able to change the configuration of the candy cane by changing the heighth at which the candy canes occur.

By running similar tests, tests which are otherwise equivalent with two different candy canes, we hope to shed some light on the phase separation phenomena that could take place in the candy cane.

The second design requirement concerns the reactor vessel. The power will be up to a hundred

kilowatts in that reactor vessel. It will have an external downcomer and the vent valve will be connecting that downcomer to the upper plenum of the reactor vessel. Again here the vent valve may be variable in order to study the effect of vent valve actuation.

The third aspect is the cold legs. We will have two cold legs per loop. We will have two loops. There will be a primary pump in each cold leg and an HPI system in each cold leg, and of course a break simulation device in one of the cold legs.

The steam generator will be made up of tubes with an actual tube diameter. It will have an auxiliary feed at the top and a tube break capability, namely, a path that would connect the primary to the secondary side which could open to simulate a tube break.

Finally, the pressurizer will actually be set up to control pressure with heaters, spray and relief valves.

MR. SCHROCK: Do you have provisions for injecting the non-condensible other than through that vent valve? Can you put it in with the steam flow at the base of the hot leg?

MR. SURSOCK: No. The only provision we will have is to put the non-condensible at the top of the U bend and at the top of the reactor vessel.

MR. SCHROCK: I would think there might be a difference in the phenomena with that mode of injection as compared to the non-condensible coming from the core region with the two-phased flow.

MR. SURSOCK: You are saying that injecting it at the top of the reactor vessel is not a good approximation?

MR. SCHROCK: At the top of the hot leg. At the top of the reactor vessel still may be a different spacial distribution of the gaseous phase through the upper part of the reactor vessel and therefore into the hot leg.

MR. SURSOCK: I don't think at this stage there is any plan to inject a non-condensible right directly into the core. It could be considered.

(Slide.)

Let me now turn to the scaling criteria for the SRI-II test facility.

We have been through several iterations on this. The first one was to assume pure linear scaling, geometrical scaling, and the reason for that is that at the time we were considering it, namely, last September, there were two different philosophies for scaling. One was the linear scaling and the other one was volume scaling with conservation of elevation.

The latter one appeared to us beyond the scope

of that particular project. As our thoughts evolved we came to a compromise by the beginning of this year between the two types of rationale. At just about that time we learned of Ishii's scaling. So there was a further study of that scaling. We felt that it had more promises than the compromise that we were converging upon and we adopted that scaling for the design of the facility.

Ishii's scaling basically starts from the conservation equations based on the drift flux approximation. We put them in non-dimensional form and then it determines about nine or ten dimensionalist groups which have to be preserved if one is to simulate the phenomena accurately.

The problem we have in preserving all the numbers is not a matter of height, but it is a matter of pressure. The budget and the scope of the project limit our facility to about a hundred psi and therefore we are operating at a rather low pressures.

(Slide.)

With that constraint the dimensionalist group that we can preserve from Ishii's scaling are listed here. We are at the transit time number, the Froude number, the heat source number, the phase change number and friction number, which are the major parameters.

The ones that we cannot preserve because of

the pressure are the drift flux parameters and the density ratio.

The last two, the subcooling over the latent heat and the CHF number, are not of major concern. The reason is that for the CHF we do not really plan to operate extensively with the core uncovered. So the CHF will not have a major effect on the primary heat transfer.

As for the subcooling, it is always possible to get very close to the ideal subcooling by changing the inlet enthalpy on the secondary side. So by adjusting that parameter we could presumably get very close to the subcooling as constrained by the scaling laws.

MR. TIEN: The scaling is very similar to the University of Maryland's approach.

MR. SURSOCK: Yes, it is similar.

MR. CATTON: What are you doing with the vent valves?

MR. SURSOCK: As I said, the vent valves are essentially going to be a variable in our design.

MR. CATTON: Do you have multiple vent valves like the University of Maryland?

MR. SURSOCK: That is right. That is the intent.

MR. CATTON: Okay, good.

MR. SURSOCK: Now the results of this

constraint and dimensionalist number ---

MR. CATTON: We can't tell from your drawing, but you are going to have a similar setup to the University of Maryland with a flapper valve and then you vary its weight and stuff like that?

MR. SURSOCK: Well, the final design has not yet been chosen.

MR. CATTON: But it wil be multiple?

MR. SURSOCK: Yes.

MR. MICHELSON: There will be a flapper type valve?

MR. SURSOCK: Yes.

(Slide.)

The results of the scaling analyses are as follows. The length of the scale is an arbitrary number. In our case we take a length scale of about one-fourth. As a result of that, the time is scaled according to the Ishii rationale as the square root of that particular scale. If you were operating at full pressure, the factor in front of that delta to the power one-half would be exactly one. The fact that you are operating at low pressure changes that but very slightly.

So that the phenomena will occur twice as fast in our test facility and they occur in the real plant, and I am not going to apologize for it.

(Laughter.)

The one bonus of operating at low pressure concerns power because in Isnii's scaling the factor in front of that delta to the power of minus one-half is again one, which for a delta of one-fourth would yield a model power density equal to twice the real plant power density.

The reason why we are in good shape is because of that .1 in front of here which as a result was the fact that we have a hundred kilowatts available to us which will enable us to simulate a plant condition up to 20 percent power.

MR. CATTON: Now you haven't dwelt at all on the U bend itself in the separation process.

MR. SURSOCK: No. As I said, what we intend to do there is to have several U bends.

MR. CATTON: You show two inches. You are going to do two inches and four inches maybe?

MR. SURSOCK: No. I meant the heighth of the U bend versus the radius of curvature will be changed, the diameter of the pipe.

MR. CATTON: I may be wrong, but it seems to me that the thing that is of interest in the U bend is the time it takes the bubble to cross the pipe divided by the time it takes the slug of water to get from one side to

the other.

MR. SURSOCK: Right.

MR. CATTON: The only way you are going to address that is if you vary the hot leg diameter.

MR. SURSOCK: I didn't follow your logic. You said it is the ---

MR. CATTON: I am taking a slug of fluid and I making it travel in the horizontal direction some number of feet and that takes a certain amount of time. You scale time and you can calculate that time, but there is another time that you have to include, and that is the time it takes for the steam bubbles to get out of the water and collect in the top.

MR. SURSOCK: That is right. So by changing ---

MR. CATTON: So there are two time scales, and that second time scale is not scaled.

MR. SURSOCK: What I am saying is that by changing the elevation at which that second phenomenon occurs, and that you do by changing the ---

MR. CATTON: When the slug is rising vertically it is going to be sort of uniformly filled with bubbles. When it turns those bubbles start to come out. There is a time it takes them to come out. That time divided by the transient time is a parameter for your particular U bend. If you are trying to scale the process that takes place in

the U bend, that is the thing you should be focusing on. It is exactly as the steam separator and how much time does it have to separate out the steam.

Am I not making myself clear?

MR. SURSOCK: I think what you are saying is clear, but I am not sure I agree with it. I think one of the important parameters would be the time it takes for a bubble to go all the way up.

MR. CATTON: But you are feeding bubbles at some rate through the bottom. That is almost a steady process. You are boiling at a certain rate in the core and there are certain velocities associated with that. So up the pipe the bubble population is uniform and there is a certain slip between the bubbles and the flow. That is uniform. Once it is established, I don't care if you add another ten feet to the pipe.

MR. SURSOCK: No, I am not sure you have established that when you are getting at the top of ---

MR. CATTON: Well then there are further unknowns which means the scaling needs a little more attention.

MR. SURSOCK: Okay, I agree with that, but I think the major problem is that the slip velocity when it gets to the top of that hot leg has not yet reached its terminal velocity.

MR. CATTON: Well, I don't know. It seems to me that in 70 feet of height those bubbles ---

MR. SURSOCK: Well, we are not talking about 70 feet.

MR. CATTON: I understand that, but if you scaled properly you ---

MR. SURSOCK: But that cannot be scaled

MR. MICHELSON: You are feeding in at a uniform rate at the bottom. The number of bubbles entering the bottom of the verical riser is a fixed number. Now the rate at which they are rising can be variable, but the population density is a constant.

MR. SURSOCK: But it seems to me that the inertia will play a major role in that separation, and if the velocity of the bubble is more or less important, it will affect the separation effect altogether.

MR. MICHELSON: Yes, but the separation isn't occurring until you enter the U bend. Below that the density is constant.

MR. CATTON: And there you are going to generate that double role on the velocity that is going to sweep bubbles around and all kinds of things are going to happen in that U bend. It is a function of radius of curvature to pipe diameter, and it is a function of all kinds of things. There are two time constants.

MR. SURSOCK: Well, certainly the facility is flexible enough, and that was the intention of it.

MR. CATTON: And I think you have a very nice facility. What I am a little worried about is the inflexibility of the users.

MR. TIEN: I suppose the University of Maryland and your SRI that you try not to change the hot leg diameter because that would be too much of a problem. Perhaps you don't need to change the hot leg diameter to study this phenomena. Maybe you can change just the bend diameter and perhaps you can vary the diameter of that.

MR. SURSOCK: I started saying that. The facility is flexible enough so that it will always be possible to change the diameter of the U bend itself just by doing that because we have this flanged hot leg. So there wouldn't be any major problem in doing so.

MR. TIEN: But still a uniform diameter across the U bend, the inverted bend. I was thinking you can vary the diameter, but then you don't have this step change from the hot leg ---

MR. SURSOCK: Well, you don't need to have a step change. You can have a smooth change.

MR. CATTON: If they do that, they need to change the velocity at entry to vary this ratio of ---

MR. TIEN: That is right.

MR. CATTON: You can do it either way, and you also have to worry a little bit about the size of the bubbles and the impact that has. There is no question but that you can do it if you set out with that in mind, but if you have coupled that U bend to the system and the system is going to determine the velocity, then you don't have that degree of freedom.

MR. TIEN: Yes.

MR. HSU: The tests we saw, the bubbles don't separate when you enter the bending part. So that separation occurs before you reach the top, which means that the radius curvature of the bend would seem to be more important than the diameter of the pipe. The radius curvature determines how far in the path it has to go through to separate out. When you are in the up sweep you already start to migrate towards the top.

MR. TIEN: Well, you have a combination of the two effects. So you have to consider both.

(Slide.)

MR. SURSOCK: The text matrix follows closely the MIST test matrix and we have divided that into small break LOCAs, the transition from forced-to-natural circulation and then from single-phase to two-phase natural circulation to the boiler condenser mode of heat removal.

We also have tests under the feed and bleed mode of heat removal and steam generator tube rupture and the proportion would be equal to the MIST test matrix.

(Slide.)

As for the schedule in the milestones, they are represented in this chart.

The design is not yet frozen and we are still adding and subtracting a few items. We hope to complete that in September, late September.

The start of testing will occur in June 1984 and the end of testing will be in February of '85. This is an important date because it occurs before the MIST tests would start and therefore we should be able to analyze the data from SRI-II and feed it into the test matrix of the MIST facility.

MR. WARD: Let's see if I put on this sort of schedule the date for when the MIST design is frozen when is that?

MR. SURSOCK: The MIST design will be frozen in September of this year.

MR. CATTON: I think it is pretty near frozen already.

MR. SURSOCK: This completes the discussion I had on SRI-II and SRI-I. I am preprepared now to discuss a couple of separate effect tests, but in view of the time I

don't know if you want me to skip those and go to the analyses.

MR. WARD: This might just be a convenient time to break for lunch and, if you don't mind, we will come back and pick up the rest of yours right after lunch.

MR. SURSOCK: All right, fine.

(Whereupon, at 1:10 p.m., the meeting recessed, to reconvene at 2:10 p.m. the same day.)

AFTERNOON SESSION

(2:05 p.m.)

MR. WARD: Go ahead.

(Slide.)

MR. SURSOCK: To resume the presentation, I will briefly discuss a couple of separate effect tests that are being sponsored by EPRI. There are a number of separate effect tests that are being sponsored and it is impossible to cover all of them at this point. So I have selected just a couple, but I would like to remind you of the other ones we are also sponsoring.

What I will be presenting today are pressurizer tests and some flow regime tests that were performed at Santa Barbara. There are other separate effect tests that are performed elsewhere. For instance, there was a large once through steam generator test that was performed here at B&W and there are projects that study condensation heat transfer correlation and flow blockage, reflooding and so on.

(Slide)

Let me start with the pressurizer tests. These tests are performed at Dartmouth by Professors Wallis and Richter. The objective of the test is to determine the heat and mass transfer in a pressurizer during typical transients. The idea is to generate a data base for

pressurizer modeling in computer codes.

The basic results to date is that the first series of tests is completed. The first series of tests concerned insurge and outsurge flows in the pressurizer, opening of relief valves and pressurizer spray activation. Pressurizer condensation phenomena were also studied.

MR. WARD: One of the issues with the pressurizer seems to be the surge line connection into the pressurizer, the angle and the character of that connection. Is this modeled or are variations on that modeled in these tests?

MR. SURSOCK: No. The issues that are addressed by these tests concern the stratification in the pressurizer as well as the effectiveness of the spray in controlling the pressurization as well as the effectiveness of the relief valve in controlling the depressurization.

(Slide.)

Basically the issue is the fact that there aren't available in the literature any data against which one could qualify pressurizer models. The only data that is really available are the so-called shipping port tests which are not really complete and which were performed in 1968 or somewhere in that time.

Any any rate, the schematic of the facility is

presented here. You have a test section which represents the pressurizer itself as well as several tanks. The reservoir tanks which represents the primary system will provide the flow for the insurge test and it will serve as a reservoir for the outsurge test. There is a spray tank and there is a holding tank for the relief valve. These tests are performed with Freon at about 25 psi.

(Slide.)

MR. SCHROCK: Is the wall heat transfer in the vapor region studied in these tests?

MR. SURSOCK: Not in that particular test. This is performed in a plexiglass facility with Freon and wall heat transfer is not studied in that series of tests. There is parallel to that another pressurizer which operates with steam/water at about 100 psi which studies this particular effect as well as the heat and mass transfer at the interface between steam and water in the pressurizer. So this other pressurizer is used to get the heat transfer coefficients.

MR. MICHELSON: Is there some particular reason for using Freon?

MR. SURSOCK: The reason is that we wanted to reproduce the density ratio during pressurization and depressurization.

MR. CATTON: You want to reproduce the ---

MR. SURSOCK: The density ratio at high pressure.

MR. CATTON: But the condensation process is what out of tilt with Freon because its thermal diffusivity is so low relative to water.

MR. SURSOCK: That is true.

MR. CATTON: That is why it simulates high pressure for boiling processes nicely.

MR. SURSOCK: I think the idea was essentially to get some data for modeling.

MR. CATTON: Well, one of the arguments that the nuclear industry always makes is that they can't use Freon for modeling because their codes have water properties. What are you going to do about that?

MR. SURSOCK: Just add the Freon properties in the code.

(Laughter.)

MR. CATTON: That is a fine answer.

(Laughter.)

(Slide.)

MR. SURSOCK: This is the type of pattern, recirculation pattern we observed during normal operation when we only have the heaters in the pressurizer. As you can see, we have this natural circulation in the loops which indicates stratification, cold water at the bottom

and hot at the top.

When we operate the spray, then this pattern reverses and instead we have cold water coming down the center and looping around in the opposite direction which indicates a better mixing and considerably less stratification than in the case without spray.

MR. MICHELSON: What effect does the diffuser on the surge line have now on the patterns during the surge?

MR. SURSOCK: In here?

MR. MICHELSON: Yes.

MR. SURSOCK: At this point the surge line is not activated.

MR. MICHELSON: I thought that double arrow meant you were getting surges in and out.

MR. SURSOCK: Not for that pattern.

MR. CATTON: You certainly would, wouldn't you? If you turn on the sprays you are going to decrease the volume. You are sucking fluid in from the surge lines, your flow in the surge line when the sprays are on.

MR. SURSOCK: Probably it would, you are right.

MR. CATTON: The question is what is the rate of flow through the surge line.

MR. SURSOCK: I would estimate it is small in that particular case.

MR. CATTON: When you set up patterns like that that result from density gradients in the fluid, they are very easy to disrupt, very easy. Any flow through that surge line at all is going to change that.

MR. MICHELSON: And the diffuser design will also affect it.

MR. SURSOCK: Well, the important point is that you can separate the effects in that particular instance and then build up your models out of these separate effects.

(Slide.)

The type of data we get in this facility is represented here. We have the temperature of the spray and the flow rate of the spray as a function of time. We observe then the pressure response of the pressurizer here and we intend to use this.

So you can see in that particular case the pressurizer pressure drops when the spray is activated and the rate at which the pressure drops can be used to both model the pressurizer model or qualify an existing model.

MR. SCHROCK: I don't understand that. You had a small spike in the spray line flow that gave sudden momentary drop in pressure, but then when the flow came on later it had a very modest effect at about 240 seconds or something like that. Why is that? It is strange.

MR. SURSOCK: I don't have the answer to that. That is what you are referring to.

MR. SCHROCK: Right. I don't have the answer.

MR. ZUDANS: This could be just a point pressure. It is not the average pressure.

MR. SCHROCK: Well, I was just comparing the effect of increasing flow at two different points in time, and it is strange. Somewhere there is an explanation.

MR. SURSOCK: One would hope.

(Slide.)

There are several tests that are now being conducted or have been completed concerning the insurge and outsurge which we also intend to use to build the pressurizer model and which we feel could have some bearing in this particular program in here.

The other series of tests I would like to present are some flow regime tests that were conducted at Santa Barbara. They concern the flow regime in a U tube essentially, an inverted U tube. The tests were designed to study reflux condensation in a U tube steam generator, but parts of it were redefined to examine the flow regime in the hot leg and candy cane, and let me explain how that can be done.

(Slide.)

This is a schematic of the rest facility

showing a boiler and then what would be the U tube and a receiver tank, and there are two cooling jackets around the tube, one on the ascending part and one on the downflow part.

What we did is just to deactivate the cooling on the ascending part, which then makes that leg essentially adiabatic and corresponding to the hot leg, and the downflow part would be corresponding to the tube in the steam generator. The cooling would then take place only on this side.

By varying the power in here we would get different a flow regime in the ascending part. Then we would determine the powers and the mass inventory for which we could get carryover around the U tube and the regions for which we would have interruption of natural circulation.

So those kinds of results were in an attempt to corroborate the results we obtained on SRI-I where we would get unstable two-phase natural circulation, if you remember that map that I showed you earlier, and where we would get stable two-phase natural circulation and stable single-phase natural circulation.

MR. CATTON: On your pressurizer tests when you turn on the sprays and you have a fairly rapid reduction in pressure, Freon won't necessarily flash on you but

water will and that might change the picture somewhat. I would hope when you do the modeling of the process you somehow incorporate that into the model.

MR. SURSOCK: Well, the actual latent heat of Freon is incorporated in the model.

MR. CATTON: I am talking about the flashing characteristics. Water will take hardly any superheat before it begins to bubble and froth. You can go through a much greater amount of superheat with the Freon as you reduce the pressure and that will certainly change the effectiveness of the sprays.

MR. SURSOCK: The effectiveness of the spray really is not assessed in that particular model. The effectiveness of the spray is assessed in a parallel model that I mentioned earlier which operates with steam and water at about 100 psi.

We had done extensive studies of condensation of steam around the spray as a function of spray angle and spray droplet size.

MR. CATTON: If you flash in the pressurizer you are going to throw lots of two-phase fluid all over the place and that is going to change the characteristics of the spray condensation process and you should think about that a little bit before you attempt to model the Freon results. There is a difference and it may affect the

results. It may reduce the effectiveness of the spray because you are throwing more saturated fluid around it from the pool.

MR. SURSOCK: Okay.

(Slide.)

I would like to conclude with the analysis effort that we intend to implement.

The objective of the analysis effort is to qualify the RETRAN-02 code and modular modeling system code which is for short is called MMS. Both codes were sponsored and developed by EPRI. The idea is to qualify the codes as well as to help in the MIST and OTIS data interpretation.

The two codes will be, first of all, cross-compared and then they will be qualified against a small-scale facility, which is SRI-2, a large-scale facility, which is the MIST and OTIS program and finally against plant data wherever available.

We feel that if the code behaves adequately with the three scales, then that means they have reasonably good physics in terms of correlations, in terms of conservation equations and in terms of numerical schemes.

So if they pass the three tests, then the models are good. If not, we will have to determine what

are the weaknesses and what kind of enhancements are appropriate.

MR. WARD: What is the MMS code?

MR. SURSOCK: The MMS code is a modular code that was recently developed by EPRI for safety and operational transients. It is especially geared to handle small breaks rather than large breaks. Its main characteristics are speed and user friendliness.

MR. WARD: Is it based on RETRAN?

MR. SURSOCK: It is a different concept. It is based on lump volume approximation.

MR. CATTON: It is kind of a building block.

MR. SURSOCK: It is a tinker toy type.

MR. CATTON: You can take a steam generator model and you can couple it to a core or you could even couple that steam generator to a fossile fuel plant, couldn't you?

MR. SURSOCK: Exactly. As a matter of fact, it is developed for a fossile plant as well and the fossile people are using it extensively for the balance of plant model and for the control analysis because it has a large package of control analysis such as root locus analysis and stability analysis.

That concludes my presentation.

MR. TIEN: Have you or EPRI thought about

supporting some study about U bend, just U bend?

MR. SURSOCK: Yes, we have thought of supporting studies of that nature. We are, however, waiting to get some results from SRI-II with the different U bend and the results from the University of Maryland before we ---

MR. TIEN: Maybe you can start now because I think it is good for the scaling really to study the U bend.

MR. CATTON: If you wait for the University of Maryland, that is 1985.

MR. SURSOCK: No, the results they are getting now, the separate effect results.

MR. CATTON: Oh, they will available soon?

MR. SURSOCK: Yes. So we are trying to assess the necessity for those tests. As I said, we will probably get into that after we get those results.

MR. WARD: Very good.

Any questions?

(No response.)

MR. WARD: Mr. Carter is next.

MR. CARTER: My name is Randy Carter from Babock and Wilcox.

(Slide.)

This presentation is a continuation of what we

started this morning prior to the tour. I will go through a few more topics than we did in the morning. We will cover a little bit of the background of the GERDA facility as far as the purpose and a little bit of history about the chronology of how it all happened. In a description of the scaling approach, and I am particularly focusing on the hot leg and the hot leg U bend. I will talk about the overall arrangements and some of the special features, the instrumentation and what we have learned from the GERDA program and how it might be used for some of the other programs.

(Slide.)

We mentioned that the program this morning was aimed specifically at code verification. I would like to point out again it is specifically for the raised loop 205 arrangements and MIST will cover the lowered loop arrangements separately.

(Slide.

The overall project on GERDA really started with a BBR, the German company, and a B&W task force back in the second quarter of 1980. There were some discussions within BBR and B&W during the latter part of 1980 and ultimately the GERDA program started in early 1981.

During the period of 1981 the facility was designed and constructed. Also during that time we went

through a period of what we call design verification where BBR's version of RELAP was used to show that the GERDA facility as designed would exhibit the expected events during a small break LOCA event such as the natural circulation, interruption of natural circulation, boiler condenser mode and refill characteristics that would expect the facility to show us. That was completed towards the latter part of 1982 and was documented in a report to BBR.

In the period of April through October of 1982 the facility went through a characterization period. During this time we debugged the facility. We did some of the tests of calibration of instrumentation in place, volume versus elevation, check out of the HPI systems and, two-phase venting systems.

Then in the last quarter of 1982 and the first quarter of 1983 we did the bulk of the program which we called Phase I. This included both separate effect tests such as natural circulation, steady state boiler condenser modes and also some of the integral tests where we had small break LOCA or leaks open and allowed the system to go through the complete set of events such as again the interruption of natural circulation, steady state boiler condenser and refill all the way back to a filled primary loop condition.

Currently we are now in the process of analyzing the data from the Phase I program and reporting this with it to end roughly at the end of September of 1983.

MR. KADAMBI: Is BBR a utility?

MR. CARTER: It is Brown Bavari Reactor and it is basically a vendor in Germany. Their parent company is BBC, Brown Bavari Corporation. It is a vendor relationship. The actual utility is RWE in Germany.

MR. KADAMBI: What was the question that they asked that required the construction of GERDA?

MR. CARTER: It was basically a licensing question and it became an issue in Germany much before it became any question in this country and pretty much for the BBR plant, Mulhem-Kaerlich, there was an agreement that they would do verification type testing in an integral systems test, and from their standpoint a one-by-one loop was judged to be adequate.

So it was a relationship between BBR, their licensing agency, the Tuft and the RSK that they would experimental verification of small break LOCA behavior.

(Slide.)

In things I want to talk about in scaling here will touch on the criteria we used in specific applications, the methods that we would have used to scale

different parts of the loop, some of the results and I will point out some of the atypicalities that existed in GERDA and why they existed.

The overall criteria that was used for GERDA, the first and foremost, and these are in order of priority, the first that we thought was the most important was to preserve the full elevations in the loop. Most of the transients that are associated with the small break LOCA phenomena are natural circulation driven and we felt it was absolutely necessary to maintain the correct buoyancy forces in the loop.

So to do this we maintained the critical elevations, and I will show you a little bit more specifically later what these were of the Mulhem-Kaerlich plant. MK is the Mulhem-Kaerlich plant which is BBR's plant in Germany.

The second thing we felt was very important was the phenomena and the phenomena here associated particularly with the hot leg itself. The information that we were really interested in has to do with the two-phase flow phenomena, whether you have bubbly flow, how that might lead to the interruption of natural circulation and the continuation of the transient.

The third level or a third scaling criteria was volume. It is desirable if possible to keep the

volumes correct so that you have roughly the same timings that the plant would have. The scale factor that resulted was the ratio of the number of tubes in the Mulheim-Kaerlich steam generators which were 32,026 to the 19 tubes that existed in the single GERDA steam generator which gave us a volume scale factor of 1,686 and that is also the power scale factor for GERDA.

The last thing that we considered was that the overall irrecoverable pressure losses in the loop should be maintained so that the natural circulation characteristics were correct. To do this we used orifices located in non-critical parts of the loop so that we did have the correct overall loss characteristics of the GERDA loop.

(Slide.)

The scaling methods really went in a sequence of four steps.

One is to determine what phenomena you would like to preserve and find what the governing equations might be, convert these desired models into design requirements such as the hot leg diameter that might be required for desired phenomena scaling, compare the various models to see how typical or atypical they might be and then select an optimum model scale.

What I would like to do is to go through a

couple of these steps, particularly for the hot leg sizing that we went through for GERDA.

(Slide.)

There were three major ways of scaling GERDA or three major phenomena that could have been preserved.

One approach is to preserve volumetric scaling or use volumetric scaling which would preserve the superficial vapor velocity and the flow regime in the hot leg according to the some of the flow regime maps.

Another approach is to use a void fraction modeling or basically a bubble rise modeling technique which results in a different hot leg diameter of approximately two inches in inside diameter using the bubble rise modelsl of these people, Wilson, Grenda and Patterson.

The third approach is to use a Froude number scaling which will result in preservation of flow regime maps such as Dukler and Taitel, the generalized coordinates, and also the flooding criteria according to Wallis.

If you look at all these approaches, they are mutually exclusive. You cannot satisfy vapor superficial velocity, bubble rise and Froude number at the same time. So you ultimately make a decision of what is most important to the program.

(Slide.)

In the case of GERDA we felt the most important thing was to preserve the Froude number which provides us flow regimes and flooding according to some of the work done by Dukler and Taitel and Wallis.

The other thing is it provides us with the largest of the three possible scale diameters, a 2.5 inch diameter versus a 1.3 or approximately a 2 inch diameter.

It does a couple of other things for you.

One is it provides the least atypical fluid to volume ratio. In any scaled model as you go from a high pressure, large pipe down to a scaled model high pressure, you typically run into the problem that the fluid surface to volume ratio increases.

The other thing it provided is it provided from those three criteria the least likely whole pipe slugging diameter.

In the closed session tomorrow I will show you some of the videos that have been taken from the GERDA hot leg both at the 35 foot elevation and in the hot leg U bend that confirms some of this scaling criteria.

MR. TIEN: This flooding criteria, did you use actually the Wallis correlation or the Kutatelatz correlation?

MR. CARTER: It was actually Wallis.

MR. TIEN: I think really this is not right because the Wallis correlation calls for the diameter of the pipe inside. However, for large pipe diameter like what you are talking about here, you are really in a regime where the Wallis correlation would not work. It would really go to the Kutatelatz correlation. So then it would be independent of the pipe diameter.

MR. CARTER: I might refer that to Jim Gloudemans that did a lot of the scaling. Can you comment on that, Jim.

MR. GLOUDEMANS: I really think that Wallis had the smaller pipe rather than the larger pipe.

MR. TIEN: Kutatelatz is the larger pipe. This pipe is very large.

MR. CARTER: No, it is three inches in diameter.

MR. TIEN: Yes, very large. Wallis is really for very, very small pipe. So I think even Wallis right now he has his own correlation, but it is still called a modified Wallis correlation. I don't think it is arguable. I have worked on this for many years now also. Everybody now agrees.

MR. CARTER: There are two things that really come out of it though. One is the fact that you are preserving the flow regimes of the generalized system and

at that time we felt that it also was providing a simulation of the flooding criteria. These other two things are sort of spin-offs. They also are beneficial for you as you go through the analysis.

MR. TIEN: I think you can look into that. If you use the Wallis correlation then you have a constant that will be a function of your pipe diameter.

MR. CARTER: Yes. Wallis definitely has a pipe diameter in it.

(Slide.)

Using the criteria, we look this morning briefly at this figure. The overall loop then ends up in a reactor coolant system as a full elevation simulation which is about 95 feet from the lower part of the reactor vessel to the hot leg U bend.

The major components are the reactor vessel which is pretty much a volume scaled system or a volume scaled component ---

MR. CATTON: You mean cross-sectional scale.

MR. CARTER: The reactor vessel?

MR. CATTON: Yes.

MR. CARTER: It is actually a volume scaled component. The volumes in this are pretty much scaled to the plant. The volume scale factor of 1,686 I showed on the previous slide.

MR. CATTON: But the height is the same.

MR. CARTER: The height has been truncated slightly. We do not have a full elevation.

MR. CATTON: I am just being picky. Forget it.

MR. CARTER: Okay.

MR. CATTON: But you didn't scale volume. You scaled a cross-sectional area.

MR. CARTER: Okay. The hot leg diameter was selected based on the phenomena that we talked about. It uses a Froude number scaling which results in a three-inch schedule 160 pipe or about 2.6 inch inside diameter.

The steam generator is prototypical in a sense of the elevation, the diameters and the tube support structures that are included in it. It contains 19 tubes over the full length of the steam generator.

The cold leg piping was also scaled according to the flooding criteria and the pressurizer was volume scaled or a cross-sectional section if you like that, and it is slightly truncated in elevation to give us the correct volume.

MR. CATTON: What is the cross-sectional area of the pressurizer?

MR. CARTER: The pressurizer is also three inches. It is about 2.6 inch and about 42 feet long.

MR. CATTON: How long?

MR. CARTER: Forty-two feet.

MR. CATTON: So when you think about those recirculation patterns that Jean-Pierre showed up there, you just know that they are not going to play a role.

MR. CARTER: During the testing of GERDA really the spray effects were not important. We did not have pressurizer spray at all.

MR. CATTON: So then it really doesn't matter what you do to the pressurizer in this particular case.

MR. CARTER: In this particular case as far as any internal mixing. It basically is providing the accumulation volume and the time as far as lead in saturation.

MR. CATTON: Seeing as how you didn't scale it properly, then it is okay if it doesn't matter.

(Slide.)

Looking at the hot leg U bend in particular, first a sketch.

The hot leg U bend shown for GERDA and for the plant matches first the elevation of the spillover. In GERDA the hot leg U bend diameter was matched to the pipes so that we kept a constant diameter as we went through the vertical section, through the hot leg U bend and into the section leading down to the steam generator.

So what it provides for us is that we do

preserve the hot leg U bend spillover elevation. We also maintain the same hot leg diameter or the 2.6 three-inch ID.

The actual radius of curvature was based to give you the correct volume, the overall power to volume scale factor, the 1,686 number that we talked about previously. So this radius of curvature was selected so the power to volume was correct.

It also preserves the fluid mixture residence time in that the fact that the hot leg U bend length and the actual velocity through the hot leg U bend are reduced by a factor of approximately four.

Finally the thing that the hot leg U bend does for you is that the centrifugal forces in GERDA are lower than they would be in the plant and ultimately the result is that you are at least as likely to have separation voids in the hot leg U bend of GERDA as you would in the plant hot leg U bend.

MR. CATTON: Actually the separation will be much better, won't it?

MR. CARTER: Yes. You are at least as likely to separate in GERDA as you are ---

MR. CATTON: I would say much more likely.

MR. CARTER: I agree.

MR. CATTON: That is three inches and the

actual pipe diameter is 30-some inches?

MR. CARTER: Correct.

MR. CATTON: I would say by a factor of 10 more likely to separate.

MR. CARTER: Exactly. The vertical rise distance is approximatley one/tenth in GERDA as compared to the hot leg in the plant.

MR. CATTON: So you can just about be assured of separation here and it is going to occur much quicker. Is that going to have any impact?

MR. CARTER: The major impact is leading to the interruption of natural circulation. The thing that we have seen and we will talk about some more tomorrow when we have data is the fact that the interruption of natural circulation seems to be more important and is controlled more by the inventory depletion and the volume versus elevation than purely by the separation.

MR. CATTON: Well, it just says that the separation is extremely efficient. That is all.

MR. CARTER: But it also brings into play which is very important as far as the leak characteristics how fast you are depleting from the loop, where the basic loop ends up in the depressurization as far as metal mass, energy storage, energy input and HIP head flow characteristics. So it is not purely just how much the

void will separate, but how much of the inventory is being depleted so that you do get to interruption of natural circulation.

It is just not purely the separation of voids in the hot leg U bend leading to interruption of natural circulation.

(Slide.)

Looking at some of the atypicalities of the GERDA facility, first of all, it is predominantly a verical system and as a result it is predominantly a one dimensional system.

We have seen some results, particularly in the steam generator, that suggest that even in the small diameter that there are some definite two dimensional characteristics.

Other points, the surface to volume ratio are atypical and the metal mass. Both of these points are not exclusively limited to GERDA by any means. But as you go again from a large facility and scale it down to a small high pressure facility, because of the extra metal mass in the walls and the metal energy storage in the walls you get extra surface to volume and also extra metal mass.

In GERDA specifically the hot leg piping is oversized to preserve the Froude number. It results in an increase in volume in the hot leg compared to what would

be in an ideally scaled loop. The hot leg itself is about three times the idea scaled volume and it results in the loop overall being about 20 percent excess volume.

MR. CATTON: What about the steam volume to surface area for condensation when you are trying to collapse the steam bubble? How does that ratio behave?

MR. CARTER: Well, it is the same situation as here in the fact that you have got extra surface area to volume and it couples the fluid temperatures much closer, it simulates heat loss problems and if you don't take care of the heat loss, then you could get condensation, depressurization and refill. I will talk a little bit more about some of the heat loss.

MR. CATTON: I was thinking in terms of the recovery of natural circulation by pressurization. You essentially condense the steam bubble by increasing pressure, right?

MR. CARTER: Because of the larger surface to volume you are going to have a situation that the heat losses are potentially going to be higher than the scaled model, which then could cause you to condense and depressurize. The other end of the spectrum is the metal mass is higher.

MR. CATTON: You have two routes to remove the energy from the steam bubble. One is through the metal

walls to the outside world and the other is through the metal walls to the subcooled water that is below the surface, and athe third is from the steam to the water surface itself.

MR. CARTER: Okay.

MR. CATTON: Now in this skewed scaling all three of those are kind of out of tilt. The question is what is that going to do or does it matter?

MR. CARTER: I am sure it gets into the situation of some of the timings and the metal mass certainly is an important factor.

MR. CATTON: I was referring to the metal mass more as a route for heat transfer to change the rate that you are going to get rid of that steam bubble. It goes both ways. It goes both as a situation of causing you a heat sink and a heat source at different parts of the transients.

MR. CATTON: Here we are with a system almost done and I would like to see the analysis that tells me which of those three routes are important, whether they are important, how do they impact on your test and what does the modeling look like and does it include these effects.

MR. CARTER: From the experience we have it appears that the heat sink route of steam fluid/steam

energy to the pipe wall is particularly extremely important during the refill phases.

MR. CATTON: For this system.

MR. CARTER: For this system, correct, for the GERDA system.

MR. CATTON: Is it for the full-scale system?

MR. CARTER: No, it is not.

MR. CATTON: Then you are going to have to change the models you use in order to account for this other route. If it is a factor of ten, for example, so that it masks the condensation on the water surface, which is probably the important one in the full-scale system, if it totally masks that, you are never going to test that with this system.

MR. CARTER: Unless you do something to take the potential for the heat loss down.

MR. CATTON: That is right, but, you see, it depends on the rate you are trying to do it. If you guard heat it from the outside and you have a rapid pressure increase, it doesn't matter if you guard heat it. It is not going to do you any good. Somehow you have got to interface what you are doing with your models, with what you are doing here and the relative importance of those different paths in order to justify this particular scaling. If you don't do that, then nobody knows.

MR. MORGAN: By picking the largest diameter of the different scaling approaches we have minimized that much more than using volumetric scaling or something else.

MR. CATTON: That is certainly true, but if you haven't minimized it enough, you are going to be spinning your wheels when you try to check out your codes and I think you ought to know that before you run your test.

MR. ZUDANS: What about this guard heating. You can only compensate in the steady state.

MR. CATTON: well, that is different. I had a similar experience with an experiment. I was trying to look at heat transfer across a gap and I had to conducting material in there. It turns out I didn't think I had very much and it just shot the whole damn test down because 90 percent of the heat transfer was through the metal and not through the fluid itself. It just ruined the whole test for me and I am trying to assure myself that you are going to look at that before you generate data to verify a code because you may not have anything for verification.

MR. CARTER: Going back to the earlier point that I commented about early in the 1981 time frame, the actual GERDA facility was analyzed with the RELAP code, BBR's version of the RELAP code, looking to see it the expected characteristics of the small break LOCA event ---

MR. CATTON: Well, right now we know that the

RELAP code does not handle this condensation process properly at all. So if you used RELAP to analyze this, I would really be suspicious of anything you might present.

MR. CARTER: But the point was that the code was trying to show us that, one, we got the same kind of events predicted for the GERDA facility as we got predicted for the MK plant.

MR. CATTON: I will sound like a broken record, but I will repeat that. The RELAP code, RELAP 5 in particular, has demonstrated and admittedly by the people who developed it cannot handle these kinds of condensation processes properly. So if you used the RELAP 5 code to evaluate these systems, you don't know what you are evaluating because the code doesn't work for this kind of problem.

MR. CARTER: In this particular case we were using a BBR version of RELAP 4, which is considerably different than RELAP 5 and I am not sure ---

MR. CATTON: It is probably worse, or it could be worse.

(Laughter.)

MR. SCHROCK: Could you comment about this guard heating thing because this morning you said you would get to that and it seems to me that it is in this slide where it arises.

MR. CARTER: I will talk about guard heating in just a few minutes. I am going to get to it.

MR. TIEN: I would like to come back to Ivan's question. When you talk about atypicalities, I think it is again important to emphasize what phenomena, what physical phenomena you are going encounter and which one will give you trouble. I think you have to itemize really and then you can say whether this metal mass is a problem for certain phenomena. Maybe for other phenomena it doesn't matter at all. I think you have to have a kind of matrix listing.

MR. CATTON: When they talk about bump the pump to clear that steam bubble it doesn't matter.

MR. TIEN: Right, exactly. I think that is very important.

MR. CARTER: We will get to that a little bit later.

(Slide.) Looking at the facility and the schematic framework we talked about this morning the major components of the steam generator, the cold leg, the reactor vessel, the hot leg, the pressurizer, the HPI system, the single-phase leak and the two-phase leak system.

The secondary side is a closed loop with a condenser, feed pump, feedwater heaters and high and low

auxiliary feedwater systems.

As we mentioned all the way through, it is a one-by-one loop, one steam generator and one cold leg. It allows us to test in GERDA roughly one to eight percent power. A full eight percent power is approximately 180 KW with one percent power being about 22 kilowatts.

We have the ability for multiple leak locations. We have done tests with leak locations at the bottom of the steam generator in the cold leg suction piping, in the discharge piping of the cold leg in the bottom of the reactor vessel and also with leak sites at the top of the pressurizer and the top of the hot leg U bend.

(Slide.)

I would like to touch first, before I go on, on the steam generator itself just a little bit.

The steam generator in the GERDA facility is a 19-tube steam generator. It has 19 tubes that are located in a hexagonal array as shown here. The tube diameters are prototypical. They are 5/8th inch in diameter in a 7/8th inch triangular pitch.

The overall length from the upper tube sheet to the lower tube sheet is approximately 52 feet. It is the steam generator we have used for several years before the GERDA project in looking at the overall heat transfer

characteristics in the steam generator.

One of the points we will be making along through here is that the elevational characteristics and the distribution of heat transfer through the steam generator is very important.

It then also provides the capability of having high auxiliary feedwater and low auxiliary feedwater which is an important parameter when you are looking at the natural circulation characteristics and also restart of natural circulation.

MR. MICHELSON: How did that steam generator get steam separation?

MR. CARTER: I am sorry, steam separation?

MR. MICHELSON: Yes, how did you arrange for steam separation?

MR. CARTER: It is a once through steam generator where we come in with the feedwater at approximately in GERDA at around 120 degrees, saturate it, superheat it leaves either as dry saturated steam or superheated steam.

MR. MICHELSON: It is always dry saturated ---

MR. CARTER: It is either dry saturated or superheated steam in the case of the GERDA test program.

(Slide.)

MR. CARTER: The reactor vessel in the GERDA

arrangement is shown here. Basically we had a heated section that was approximately six feet in length. The core heaters were electrically heated core heaters. We did not try to simulate the core per se. There were three heaters of an inch and a half in diameter which provided for us the heat source and we matched the thermal center from the center of the core to the expected thermal center of the steam generator elevation.

Above that we had the simulated upper top plenums, the reactor vessel vent valve, and I will talk a little bit more about that in a second, and then the downcomer section coming back to the lower plenum of the reactor vessel.

The elevation of the lower part of the downcomer was set so that we matched the highest flow hole in the lower distributer plate of the lower plenum.

In GERDA the reactor vessel vent valve was simulated by a restrictor placed at the vent valve downcomer interface. This restrictor was sized so that we got the correct loss coefficient when the vent valve was open. This particular vent valve isolation valve would then be opened based on a sensitive differential pressure between the upper top plenum and the downcomer.

Through the GERDA program we used a number of different set points to see the effect of different

opening and closing Delta Ps on the effect of vent valve flow.

(Slide.)

As I mentioned, the capability existed to have a number of leak locations. Our actual leak sites were controlled by critical flow orifices. Just to give you a feel of the size, approximately a 10 square centimeter or .01 square foot scaled leak had a diameter of about 30 mils in diameter.

Prior to doing the integral systems tests at GERDA, we did separate effect tests looking at the orifices to make sure that we did get the kind of characterization of leaks that we wanted to.

Because of the proprietary nature of the data I have at least taken the scales out, but the main point of the slide is that we have looked at a number of leak sizes over a range of pressures and found that the predicted saturated vapor critical flows and the saturated liquid critical flows experimentally and analytically agreed pretty well once you got to the size leak that you wanted.

(Slide.)

One of the things we wanted to do in GERDA was to minimize heat losses particularly in two main regions of the loop, and these were the hot leg and the

pressurizer. The reason we zeroed in on the hot leg and the pressurizer was that those were the two components that would experience both water and steam conditions during testing.

To do that we used guard heaters. If you look at pipe wall, there was the stainless steel lagging material that we showed to you this morning which basically establishes a half inch layer that we used for a control layer.

Within this layer we used a low density type temperature insulation. It was a Kaowool insulation that minimized the additional density or energy storage that could result if you had a high density insulation.

Within that control layer there was one thermocouple that was placed on the outside diameter of the pipe and another thermocouple approximately half way through that layer. Those are the two thermocouples that were used to control the input of the guard heaters into the system.

On the outside of the lagging material there was a ribbon heater that would be continuously wrapped over the surface of the pipe. Beyond that is additional low density high temperature insulation and additional passive insulation out to the ambient.

If all of your penetrations to the loop

isted inside the guard heaters, the control setpoint for the thermocouples could be zero to establish an adiabatic wall condition. The fact that in the loop we have a number of instrument penetrations coming out of the loop, it is necessary to characterize these guard heater sections. Typically our guard heater sections are 10 to 20 feet in length and the hot leg has eight of these zones to control the heat lossess.

With the fact that you do have the penetrations, you then have to go back and characterize it so that you slightly bias the guard heaters to put back in the heat loss. you have out the appendages.

To show you the way the guard heaters worked I have one one slide that shows some of the results.

(Slide.)

What we have plotted is the normalized temperature along the length, and the length is from the outlet of the reactor vessel to the inlet of steam generator in steady state conditions.

What we saw without the guard heaters on is pretty much a linear decay in temperature due to to the heat loss. With the guard heaters on we basically can maintain a constant temperature from the outlet of the reactor vessel to the inlet of the steam generator.

This becomes particularly important when you

have a voided condition in the hot leg where steam could be present causing additional condensation that would not occur if you did not have any heat losses.

MR. SCHROCK: So this is aimed at steady state?

MR. CARTER: No, it is aimed at the whole transient.

MR. SCHROCK: Have you analyzed the dynamic characteristics of it?

MR. CARTER: Yes we did, and one of the things that we were doing during the program was to take the anticipated depressurization and repressurization rates and look at how the guard heater design I showed on the previous figure would respond to those pressurizations and depressurizations.

MR. SCHROCK: It seems to me with the larger thermal capacity of the metal and the much tighter thermal coupling to the fluid conditions as fluid transient conditions are introduced into a given section of piping, that the impact on the thermal hydraulics of the pipe can be very profound before your thermocouples regulating the guard heaters will even sense there is a transient present.

MR. CARTER: That was not true even in the case of up to the largest break we had in GERDA which was about 40 square centimeters except for the core which is open a

very short time period. The characteristics that we had, as I remember, and I am quoting a little out of context, but the over and undershoots were small in comparison to the total energy input into the pipe. The guard heaters did track the transients reasonably well.

MR. SCHROCK: I think that is incredible to believe that because ---

MR. CATTON: How thick is the pipe wall?

MR. CARTER: The pipe wall is about a quarter to three/eighths of an inch.

MR. CATTON: That is pretty thin.

MR. SCHROCK: It is twice the thermal capacity of the of the real machine in metal, and the thermocoupling is in much great ratio than a factor of two. Therefore, fluid with a different temperature approaching a given section of pipe is going to be maintained at that temperature as it goes through that section of pipe for a time which is considerable before the penetration through the pipe wall is going to be felt by the thermocouples regulating the guard heater.

The thermal resistance between your guard heater and the surface where you want to regulate heat flux to maintain protoptypical conditions is very large. That thermal resistance is a very large capacity, large in comparison to the capacity rate of the flowing fluid.

MR. CARTER: I guess the only thing I can offer is to pursue the analysis that we did do and see if we can't provide that through a vehicle somehow. Right now that is still part of the GERDA program.

MR. CATTON: It is a matter of relative time constants, thermal diffusivity of the pipe wall and the rate of change of the temperature or whatever within the system.

MR. SCHROCK: I think for overall steady state conditions the idea is very workable, but I think it is unbelievable for the transient.

MR. TAYLOR: Randy, at what rate are you talking about these temperatures changing?

MR. CARTER: You are talking about primary fluid temperatures?

MR. TAYLOR: Yes.

MR. SCHROCK: Then we are talking steady state. I am not arguing with steady state. What you are saying is the whole transient that we are discussing is so slow that it is a sequence of steady states and there is no difficulty with that.

MR. TAYLOR: That is what I wanted him to comment on.

MR. CARTER: The temperature changes, probably the most rapid one is the time when you go to saturation

as you first have the initiation. It is probably on the order of a few degrees per minute, and those exactly we can see tomorrow in one of our replays where you can see the rate of change of temperatures. It is reasonably slow and even for the 40 square centimeters it was reasonably slow.

MR. CATTON: What about circumstances where you are trying to collapse the steam bubble during a repressurization? How fast is that transient?

MR. CARTER: Well, you are still at saturation temperature.

MR. CATTON: You are suddenly increasing the pressure so you saturation temperature is rising fast.

MR. CARTER: At that point the core power is very, very far down the curve. So the rate of repressurization ---

MR. CATTON: Somehow we are talking about different things. You have got a steam bubble and you are trying to get rid of it.

MR. CARTER: The steam bubble in the ---

MR. CATTON: --- in the top of the candy cane.

MR. CARTER: Okay.

MR. CATTON: And you are going to get rid of it by pressurization. So you are going to increase the pressure of your system.

MR. CARTER: In this case in GERDA the only time it would repressurize is because it wanted to repressurize.

MR. CATTON: Then I have completely misunderstood. I thought one of the experiments that you were trying to run involved an assessment of recovery of natural circulation through repressurization.

MR. CARTER: Recovery of natural circulation. The system was allowed to go through, first, it would be forced circulation. The leak is open, the pumps are tripped and it reaches saturation. The system will then go into the loss of natural circulation. You will basically get into intermittent natural circulation. The volumes deplete and depending on the power the pressure will reach some sort of a constant point while the inventory depletes and HPI is being injected according to its head flow.

Eventually you reach a point where the inventory is depleted enough that the boiler condenser mode will onset and the primary pressure will decrease. Now the primary inventory will begin to increase because of the increased HPI flow. At some point you will get into some slight repressurization, but it is really then dependent on the coupling of the primary to secondary steam generator heat transfer and the amount of core power

that you have at that point in the transient.

MR. CATTON: So you never get into circumstances where you repressurize it at any greater rate.

MR. CARTER: No.

MR. CATTON: In other words, maybe you have got a steam bubble in the candy cane for the same reason there was one at TMI and there there was no leak.

MR. CARTER: Well, in this case we could still have a leak, but the rate of repressurization is controlled by the rate of refill.

MR. CATTON: Well, that is right, but in other words, you are always going to fill it relatively slowly so that the time constant is long.

MR. CARTER: Well, the rate of refill is controlled by the HPI heat flow characteristics.

MR. CATTON: I understand that. I am just asking a simply question. If you will never repressurize fast, then I think the guard heating is probably all right.

MR. MICHELSON: You can repressurize fast though to isolate the leak.

MR. CATTON: He says you can't.

MR. MICHELSON: Well, if you have a leak and you isolate it, for instance, like if you close a PORV,

you are going to repressurize very quickly. So it is a practical case. It isn't a hypothetical case.

MR. CATTON: Under those circumstances your guard heaters may not do the job.

MR. CARTER: Additional analysis is probably worthwhile.

MR. ZUDANS: What controls the guard heat input, the two thermocouples that you had there?

MR. CARTER: Within each zone in the hot leg, and those zones are about 10 to 20 feet long, and within that there are the control thermocouples that direct the controllers as far as the amount ---

MR. ZUDANS: And one is located in the metal ---

MR. CARTER: One is on the OD of the pipe and the other is in the insulation.

MR. ZUDANS: Well then the insulation piece of information could never come very fast. It would be delayed because it is insulation. So you wouldn't feel that difference. If you base one of your points in the metal and the other one is in insulation, there is a certain period required for heat transfer. So you couldn't respond to any fast transient syndrome.

MR. CARTER: Well, the transient we exposed it to was the depressurization rate associated with ---

MR. ZUDANS: It was slow enough that you could believe it.

MR. CARTER: --- opening a 40 centimeter break and we felt it was justifiable for the kind of control we needed. I agree that there is some point at which the rate of depressurization, particularly for the larger leaks, where the response either due to heat pressurization and repressurization is not going to be adequate.

MR. ZUDANS: When you heated up the system in your steady state you wouldn't have any input in those guard heaters I assume.

MR. CARTER: In the steady state? Oh, yes, you would because you would like to maintain basically a zero heat loss.

MR. ZUDANS: You would lose the heat through this outside fiberglass?

MR. CARTER: The plant because of the very large pipes looks almost adiabatic and that is the thing we were trying to accomplish with the guard heaters is to reduce the amount of heat loss so that it is closer to what the plant is doing.

MR. TIEN: Why do you use two thermocouples instead of a surface heat sensor?

MR. CARTER: You could have used a heat flux meter.

MR. TIEN: That would make things much easier without many ambiguities.

MR. CARTER: I agree you could use a heat flux sensor.

(Slide.)

To continue with the overall heat loss characteristics of the loop, I mentioned that one of the things that we wanted to be able to do is to minimize the amount of heat loss in the loops so that the tested power is not small compared to the heat loss, or to say it another way, that the heat loss is not large compared to the tested power.

The only thing I can offer right now, and we can talk about it more tomorrow in the closed session, is the fact that we did look at the heat loss characteristics over a wide range of temperatures with the various combinations of the heaters on, steam generator full of water and steam generator empty of water, and the amount of heat loss is small in comparison to the total powers that we tested. If you would like, we can talk about that in more detail in the closed session tomorrow.

(Slide.)

The instrumentation we talked about this morning, and I don't think that it is really necessary to go through that again.

(Slide.)

I would like to summarize a few things that we have learned from GERDA and that can be used as we go on into the MIST project in particular.

One is that GERDA was designed for verification of small break LOCA predictions. We have seen both during our design verification phase before GERDA was built and during the testing that we do get the expected events following a small break LOCA initiation. We do see the natural circulation, the interruption of natural circulation, boiler condenser mode, refill and the return to natural circulation.

The facility was designed to basically preserve the plant typical elevations that we felt were critical for natural circulation driven events. We preserve the phenomena, in particular the hot leg phenomena that we felt was important, and in this case the Froude number scaling.

Overall pressure losses were maintained and volumes were maintained so that we did get characteristic natural circulation flows and event timings that were not out of line.

The tests that we have performed during phase one have confirmed that we do get the perdicted small break LOCA phenomena that we got during the design

verification phases and we feel that GERDA is certainly adequate to give us some useful data for small break LOCA verification.

(Slide.)

Some of the things that we have learned from GERDA that are very important for us as we go on into the MIST project is that heat losses are extremely important, that not only must we be very critical about our guard heaters over not only the hot leg and the pressurizer, but other parts of the loop and considerations of some of the more rapid transients may be necessary to ensure that the guard heaters will be adequate for those tests also.

But heat losses in other components are very important and can change the events as far as how the resulting transient will go on.

Another thing that we picked up and will be reflected in some of the discussion on OTIS is the location of instrumentation, and I will point this out a little bit more in the OTIS presentation.

Another point is the reactor vessel vent valve. In GERDA we used the vent valve that was either full open or full closed. In the MIST facility we will be considering a vent valve that is a slightly different operation to give us an improved simulation of that, and John Klingenfus will talk about the details of that a

little bit later.

The other thing we saw in the GERDA facility is that as you get to the larger leaks, and the best I can probably put it is somewhere in the neighborhood of the 20 square centimeter range, the two-by-four parts are very important. You start to see the effects of HPI flow splitting and going either upstream or downstream that are probably atypical and there is some question at that point for the larger small breaks that the two-by-four arrangement is very important.

Those are all the comments I have for GERDA. If you have got any questions I will be glad to answer them.

MR. MICHELSON: How much pressure noise did you notice on the instrument used to control the reactor vessel vent valve?

MR. CARTER: That instrument was critically damped. The way we take the data is we basically go out and snapshot. We take the data. We sleep for five seconds and go back and look at the data again.

MR. MICHELSON: What I am really concerned about is that you use that different pressure up there to control the vent valve as to whether it is open or closed. Did you damp the control circuits also?

MR. CARTER: Right. It did not pick up the ---

MR. MICHELSON: So it wasn't in synchronism with the two Delta P existing at the time.

MR. CARTER: Well, it was in true synchronization, but the fact that this vent valve ---

MR. MICHELSON: Well, if it is damp it can't be.

MR. CARTER: Let me make a point. The reactor vessel vent valve in GERDA was not designed to be responding to very, very quick pressure changes. The actual valve itself had time constants on the order of five to ten seconds. So we damped the instrument also so that it would not be trying to respond to peaks which would have made the thing just basically trying to open and close all the time.

MR. MICHELSON: But in reality it might open at a time when the differential pressure no longer really existed because you are out of phase with the pressure.

MR. CARTER: Well, in this case though the instrument signal response time was much faster than the valve.

MR. MICHELSON: Right, but the entire response time, instrument plus the valve you said might have been on the order of several seconds.

MR. CARTER: Right. It may have tried to open and ---

MR. MICHELSON: The pressure may be totally different several seconds later.

MR. CARTER: Right. It may begin to open and then it begins closing.

MR. MICHELSON: Yes, and out of synchronism with perhaps the true pressure fluctuations that would normally be seen.

MR. CARTER: Right. This is definitely one of the things that will be looked at in more detail for the MIST facility is the RVVV simulation.

MR. MICHELSON: I think what you would really like is a valve controlled by the two Delta P.

MR. WARD: Go ahead with OTIS then.

(Slide.)

MR. CARTER: For the OTIS presentation I will basically go through what we will be doing to the GERDA facility to set it up. This will include some of the hardware changes and some of the controller setpoint changes and I will briefly go through the outline of the test program for the OTIS program, the OTIS project.

(Slide.)

OTIS stands for the once through integral system. Its purpose is to do some additional code verification. Now we are looking at a raised loop arrangement, but we are changing the setpoints and leak

locations to be more consistent with the domestic plants and using this in combination with the GERDA data to have a very comprehensive raised loop arrangement data.

We start with GERDA as a reference point, and just as a reference I will leave this figure up here so we can look at some of the changes that we will make.

(Slide.)

First, just to go through the changes and I will explain each one of them.

One of the things that we will be doing is having the capability to have a reactor vessel upper head vent. In GERDA we have a vent location there, but we only use that for warm-up and venting of any gases out of the loop. It is not used during testing as a vent site.

The second thing we will be doing is to add a restrictor in the upper plenum so that we have a simulation of the resistance between the top of the core and the upper head of the reactor vessel when the vent is open.

Two other areas that we will be getting into have to do with the surge line on the pressurizer and the reactor vessel upper plenum. From GERDA we saw that the surge line typicaly would cool down during some of the tests. We want to minimize cooling of the surge line fluid.

Also now with the fact that we have an upper head vent, we want to try to minimize the heat losses in the region of the upper part of the reactor vessel during the OTIS test.

Another one is the cold leg flow measurement. I mentioned that during GERDA we saw some of the indications of flow. At times we got voiding in the cold leg region where the cold leg orifice was located. We are going to relocate that to a region where we always saw single-phase flow.

Another one is a branch leak system. This one is more operational than anything else. OTIS has a number of different leak sizes with a few number of tests and this will allow us to be able to continue testing without having to shut down and reinstall orifices.

The last one is the OTSG string thermocouples and pitot tubes. During the GERDA program we initially started out with string thermocouples that were located on the ID of individual steam generator tubes.

This is basically one long sheath that is about 30 feet in length and it has a number of junctions in it to look at the temperature along the length of the tube. These were used in GERDA. They were then taken out during some of the non-condensible gas tests. For OTIS will reinstall those or very similar thermocouples to give

us primary fluid temperatures through the steam generator.

(Slide.)

Just briefly going through mechanically the changes, one of them is associated with the upper head vent. We now will be able to take the vent from the top of the top of the reactor vessel head, take it to our single-phase leak system so that we can meter the amount of water/steam that is removed.

The restrictor will be located in the upper head of the reactor vessel between the reactor vessel vent valve location and the upper head of the reactor vessel. The preliminary number as far as the size of the opening is approximately 13 percent open to give us the desired restriction.

The similar arrangement for guard heaters will be used on the upper top plenum. There will be two zones of guard heaters, one between the hot leg reactor vessel nozzle and the restrictor location, from the restrictor location at the top of the reactor vessel. These will be from GERDA testing and the restrictor location will provide a sort of demarcation between the characteristics and we felt we needed two zones there.

MR. ZUDANS: There are no guard heaters anywhere below that.

MR. CARTER: Correct, the reactor vessel.

(Slide.)

During the GERDA testing we saw that the vent valve would emit steam into the region and at times would void the cold leg spillover in the cold leg discharge piping and part of the downcomer. At times this steam void would move back into the cold leg suction piping and would make the cold leg flow measurement invalid during those periods.

What we have done or propose to do for OTIS is to relocate this at the outlet of the steam generator so that we have a continuous measurement flow through the whole test.

(Slide.)

The last one is just pointing out the thermocouple locations. The string TCs are the instruments noted by the circles with plus signs. Those are two individual string thermocouples that would be located in two individual tubes and would provide a temperature profile from the inlet of the primary steam generator down to approximately the 25 or 30-foot elevation.

(Slide.)

In addition to the hardware changes to make some of the OTIS tests be more consistent with the domestic arrangements, the two major setpoint changes we will change are the auxiliary feedwater and the high

pressure injection.

The parameters that will be varied have to do with the level in the steam generator after a simulated trip, the rate of increase in the level on the secondary side of the steam generator and the mode of level control that will be used. This is whether we will have a constant level of control or whether we will have a high low-level control in the steam generator.

For HPI we will use domestic head flow capacities and we will vary this both for the high multiple pumps and single pumps and also looking at the low shut-off head pumps and the high shut-off head pumps.

MR. CATTON: Somehow I missed your methods of measuring level on that previous diagram, if you can kind of point to it.

MR. CARTER: The measurements of level?

MR. CATTON: Right, inventory.

MR. CARTER: On this particular figure?

MR. CATTON: Yes, or do you have another figure?

MR. CARTER: There is another figure that shows levels. These are just the point measurements in GERDA. There is an accompanying figure that we could get if you would like that show all the differential and level instruments.

MR. CATTON: I would like to see that.

MR. CARTER: Sure, no problem. We can get that.

MR. TIEN: I see in your guard heating you still have the control thermocouples there. I don't think you can use the two thermocouples that way. You really should have use the surface sensor because when you try to feed back the signals, the thermocouple in the insulation just will not give you the right feedback to change your guard heating.

MR. CARTER: I understand your comment and all I can say is I do believe that it will work and the anaslysis supports and the test results I think support it. As long as you don't have a very rapid transient, I think it will provide you with ---

MR. TIEN: But I see no advantage really. Why not just use a surface heat sensor which is very simple and very cheap.

MR. CARTER: I concurred with that. You could use a surface indicator.

(Slide.)

The OTIS test program, there are a total of 13 planned tests in OTIS.

One of the tests will be a benchmark test where we will go back and repeat a test that we performed in GERDA to show that OTIS and GERDA do perform similarly

and that we do have characteristics that can be continued.

One of the tests will be associated with use of the reactor vessel high-point vent.

There will be three tests associated with leak configuration. This has to do with whether the leak is left open during the complete transient or whether the leak is isolated.

Leak locations, there will be at least two tests associated with different leak locations in the facility.

MR. MICHELSON: Will there be possibilities of more than one leak at a time?

MR. CARTER: In the OTIS test the only possibility is if you repressurize and have the PORV opening at the same time. In MIST, and I will show you that a little bit later, there are some combination leaks like HPVs at the hot leg U bend and reactor vessel upper head open at the same time.

MR. MICHELSON: I was thinking of reactor coolant pump seals and simulating those leaks if you lose your pump seals.

MR. CARTER: No, that is not in this program.

MR. MICHELSON: Isn't that a practical consideration? It has happened a few times already as in a small break LOCA and it is postulated that you may

actually get a real small break LOCA accompanied later by axial failures. I just wondered to what extent you are going to look at the disruption of all of all of the circulatory arrangements.

MR. CARTER: At this point we don't plant to have multiple leak sites open at a given time. There would be a single leak site opened.

MR. MICHELSON: Is there some philosophical basis for believing that that isn't necessary?

MR. CARTER: I am not really sure.

MR. CATTON: You have a lot of conductivity probes.

MR. CARTER: Right.

MR. CATTON: Are they going to be used for level?

MR. CARTER: They indicate phase at the point.

MR. CATTON: Now one of the things they point out to us every time we have been in a LOFT test is now you can't rely on those.

MR. CARTER: We had good experience with them. We had some difficulties early in the program associated with aging effects in the way that we wanted to condition the circuit, but after we want back to basically an analogue circuit and treated each probe individually, we got some very good results that are consistent with

some of the phenomena we saw in the loop and they definitely show us some characteristics around the vent valve and the hot legs.

MR. CATTON: Oh, there was no question but that these things would occasionally indicate that there was water and that there wasn't water. What we were told is that you couldn't rely on them. Do you have a different kind of conductivity probe than they have in LOFT?

MR. CARTER: It is very similar.

MR. CATTON: Have you discussed the use of these with them and they blessed it?

MR. CARTER: Right, we have. Well, we didn't ask them to bless it, but we did utilize some of the experience that they had and we had good experience with the conductivity probe I admit that after we went through a change in the conditioning circuitry.

MR. CATTON: Ralph, are the people at Idaho reviewing the instrumentation with these things in mind?

MR. LANDRY: They already are reviewing the instrumentation.

MR. CATTON: Okay.

MR. LANDRY: We have had pretty good luck with the conductivity probes on LOFT except when they have just failed and physically gone out. When they have operated we have been pleased with their operation and in fact Bud

Goodrich was to the point of being able to tell the range of the quality of the mixture going by it from the voltage that you are seeing on the conductiveity probe. That is someone that has designed the units and has worked virtually his whole career with them. It is more of an art than a science.

MR. EBERSOLE: I believe that.

MR. LANDRY: Well, they are not the kind of things that I would put in anything but a test facility.

MR. EBERSOLE: How do you know you have good results when that is the only kind of measurement you have got? I don't see anything else to back it up.

MR. CARTER: In addition, there is the other figure that has the differential level.

MR. EBERSOLE: The DPs?

MR. CARTER: Right.

MR. EBERSOLE: And so they cross check?

MR. CARTER: Right, they cross check. Well, they give you two different things, too. When you have got a quiescent system you can get the cross check, but the level will give you the collapse levels and the conductivity will give you a froth height. In quiescent, yes, we can cross check.

MR. ZUDANS: Would you put my mind to peace. We have GERDA, OITS and MIST.

MR. CARTER: Right.

MR. ZUDANS: At the present where are we?

MR. CARTER: At the present we are with the GERDA facility.

MR. ZUDANS: OTIS is just in planning?

MR. CARTER: Right. The testing program on GERDA has been completed. OTIS is upcoming and the rough schedule on that is to begin modification of GERDA for OTIS in the October 1983 time frame with testing to be performed early in 1984.

MR. ZUDANS: And then MIST would follow that?

MR. CARTER: MIST would follow OTIS which would be the complete new facility with the two-by-four arrangement.

MR. ZUDANS: Completely new and none of this will be used?

MR. CARTER: No, we will use some of the components, but I am saying the arrangement as far as one-by-one versus two-by-four would be different. We would utilize some of the GERDA components.

MR. LANDRY: If I could back up to Carl Michelson's question about looking at the concurrent multiple leaks, one of the criteria that we used in designing OTIS, if you will, was that we wanted to get as much information as we could on the raised loop

configuration before we tore GERDA apart to build MIST.

We were not planning on doing extensive modifications and we were not intending to spend any extensive amount of money on that facility. We felt that we could utilize some time that was available and we could utilize an existing facility with some very minor modifications to round out the data which now exists from the GERDA program.

We felt that once we go into the MIST program, which is going to be a lowered loop plant, it would be prohibitively expensive to go back and tear that facility apart and build the raised loop configuration which GERDA is now in.

So that is why as long as we have the facility we want to spend a little bit of money and get a little bit more data.

MR. MICHELSON: I think my real question was in any of the three cases where you are looking a multi-phase, GERDA did not look at that sort of thing. OTIS will not. Will MIST look at that? If MIST doesn't either, then I have to ask what is your philosophical basis for believing that you don't need to look at it at all?

MR. LANDRY: We have plans for five additional tests which we have not specified at this time.

MR. MICHELSON: So this is another one you might think about then.

MR. LANDRY: Yes. We are trying to get our minds thinking along those five additional tests and make up our list of things we would like to look at and then start to weigh them. If the facility is capable of multi-leaks, we may very well try to impose a multi-leak on one the tests already.

MR. MICHELSON: I assume it is capable of more than one leak, or at least the connections are there where you could open up two locations, and let-down capacities I don't know.

MR. LANDRY: I am sure we could in some way open multi-leaks.

MR. TAYLOR: Could I ask a question to further develop your question, Carl. What did you have in mind when you were talking about multi-leaks? I judge you are not talking about multi steam generator tube ruptures.

MR. MICHELSON: No, that would be a different case.

MR. TAYLOR: What kinds of things did you have in mind?

MR. MICHELSON: This is a case wherein you have seal ruptures, two seal ruptures or a seal rupture in combination with another failure, the seal rupture coming

of course from the degrading of the seal with time because you have lost cooling or whatever. That is the question. I wasn't considering two primary pressure boundary leaks.

MR. TAYLOR: I just wondered whether there was anything else on your mind aside from pump seals.

MR. MICHELSON: Well, valve seals of course would be another possibility. Pumps seals is the most likely of any great size and there, depending on who you talk to, you can get up to 150 to 200 gallons a minute.

MR. CARTER: Within the defined test program at this point there are two secondary characteristic tests. These are aimed primarily at looking at the effects of different auxiliary feedwater control techniques at the different plants.

HPI capacity, there we will be looking at the difference of single versus multiple HPI pumps, a single HPI cool-down test and a single composite test that would be dictated pretty much by using some of the operator type guidelines for a small break LOCA.

Right now currently we have 13 tests defined within the OTIS program.

MR. TAYLOR: As was brought up a little earlier and again an interesting test, and I guess you are just going to add it to your list, and that is a case where you start out with a break of some certain size, small break,

and then going one way or another you are able to isolate it. It might have been a let-down line break and you were able to isolate the let-down line. Is that going to be in one of those?

MR. CARTER: Right. That is the leak configuration where we would have a leak open and at some point in the test the leak would be isolated.

MR. MICHELSON: And you look for now the repressurization and recovery.

MR. CARTER: Correct.

MR. LANDRY: We also have that in the MIST program. We have a break isolation test included also.

MR. EBERSOLE: Is the seal cooling system subject to single void failure?

MR. MICHELSON: Sure.

MR. EBERSOLE: Is it single-point failure?

MR. LANDRY: I think all we may be talking about is something like Robinson had like just blowing the seal.

MR. EBERSOLE: No, I am talking about loss of seal cooling.

MR. MICHELSON: Well, you can break the plate and do it that way.

MR. TAYLOR: If you consider the loss of off-site power to be a single failure ---

MR. EBERSOLE: Well, what about loss of seal water pressure?

MR. TAYLOR: It won't be a problem because you still have cooling water.

MR. MICHELSON: I think in the case where you break the seal water line itself then you have got the blowdown of the line, depending on the arrangement.

MR. TAYLOR: But that is not a big high leak if you still have cooling water to the seals. It is a few gpm at most unless you have loss of all services to the seals involving both the injection water and the cooling water.

MR. MICHELSON: I think you would have to perform a test to show what the degraded condition would be in matter of minutes.

MR. EBERSOLE: Does the injection water and the cooling water converge back to a single source of input?

MR. TAYLOR: No. It is a separate loop. It is component cooling water for the seal cavity and injection water for the seal itself, high pressure injection. At least that is the case on our plants.

MR. EBERSOLE: Is yours a three-stage seal?

MR. TAYLOR: Yes.

MR. WARD: Okay, thank you very much.

Mr. Taylor is next I believe.

MR. TAYLOR: I am going to help you, Mr.

Chairman, to pick up ten minutes on your agenda.

MR. WARD: Okay.

MR. TAYLOR: I think all we want to do here before Randy continued was to go back and try to put in perspective the MIST facility in terms of where we are, and actually Mr. Zudans question got at it a little bit.

The programs that have been talked about up until now have been either past or just recently completed tests or near-term tests relative to MIST which goes on out to 1988.

When we first talked about having the ACRS subcommittee come out to the Research Center, and I think Paul Boehnert and I talked about it back in January or February, one is always faced with a dilemma as to whether or not you wait until you have answers to a lot of questions about a new facility or whether you go ahead and inform the regulatory agencies and the Advisory Committee early and then you may have a number of questions that can't be answered.

But anyway we felt that it was inappropriate to have the committee here until at least after the contract was signed, which was just two weeks ago. So now as soon after the contract was signed as possible the meeting was arranged, and actually it was set up a little bit ahead of the finalization of the contract.

So really as we go into this longer term future activity, I think the committee can rest assured that their questions that have been asked today will be considerd very seriously and we appreciate them.

Our intention right now at the next point in the agenda is to go into this longer-term discussion, and even though it is very early and even though, as Randy Carter said, the data that has come off of GERDA is still being analyzed, I think it is appropriate to get some of the committee's concerns out on the table so that we can wrestle with them as the specifications for the MIST facility gets finalized.

You have to recognize of course that you have to have a certain level of finality before you can enter into a contract like this. So in some respects the design, as Dr. Catton mentioned, is quite far along, but in terms of instrumentation and in terms perhaps of vent valve configuration and things like that, there is still room for some change.

We do have a pretty good agreement between the staff, EPRI, the owners and B&W with regard to what the overall configuration of the loop is going to consist of, but at the same time we want to say that we do welcome the questions that the committee asks and they will be given good consideration.

So even though it is very early in the MIST program and the preliminary specification right now for the facility is just now available, as somebody said this morning, the final specification for the facility will be out around the 1st of October and sometime after that procurement of equipment will begin and so on.

Our purpose during the last part of the agenda for today is to go into this longer term thing. Since we knew, as you mentioned in your opening comments this morning, that scaling is a major issue, we want to again talk about scaling and the approach that was used in the MIST reference design, and Randy Carter is going to do that.

Then, because there have been a number of questions about vent valves and the downcomer modeling, John Klingenfus is going to talk about that in his presentation. Then Bob Jones who is from our Emergency Core Cooling System and Safety Analysis Unit in Lynchburg is going to talk about the computer code assessment program. Then Tom Hollowell on my right from Consumers Power is going to talk about some of the key milestones as we go down into the future in the MIST program and that will end up the session for today.

I think particularly at the point when Tom gives his comments it would be interesting I think, at

least to me and I think to others, to have some further feedback from the subcommittee as to whether or not when you see certain milestones on there and certain places where the subcommittee would like to interact further, we would like to know about that if you have any thoughts about it.

I have no further comments other than those, and I would just like Randy Carter to go ahead and continue.

MR. WARD: Okay, fine.

Does anybody have any comment or question for Mr. Taylor on what he talked about?

MR. ZUDANS: Can we have a short break?

MR. WARD: Mr. Zudans wants a short break.

(Laughter.)

MR. WARD: I am sure you won't mind, Mr. Carter.

MR. CARTER: No.

MR. WARD: Okay, ten minutes.

(Whereupon, a short recess was taken.)

MR. WARD: Okay, Mr. Carter, go ahead, if you will, please.

(Slide.)

MR. CARTER: In this presentation we will talk about some of the early work we have done on the MIST

facility. We will go through some of the design features, including a description of some of the scaling ideas and scaling criteria, some of conceptual arrangements of the hardware that we have at this point in time, talk briefly about the instrumentation and go into the test program and, if you like, we can go into the details of the test matrix to show some of the parametric effects that we will be considering.

The material I will go over is general in nature and I will talk about some of the details of the hot leg components, the reactor vessel core, some of the emergency core cooling systems and then John Klingfus will go into some of the more detailed discussions about the scaling of the downcomer and the reactor vessel vent valve.

(Slide.)

MIST is the final piece of what we call the integral system program that has been gone over by a number of us this morning. It is the multi-loop integral systems test. It now will provide the data for the lowered loop arrangement, the 177 fuel assembly arrangements both in separate effect and integral effect data for code verification.

(Slide.)

One of the things I would like to try to do is

to go through some of what we feel are the more important events in a small break LOCA and explain what we think some of the related phenomena or key characteristics that have to be considered are for the MIST facility.

The components that we feel are important are the initiation event, saturation, intermittent circulation, steam generator heat removal or boiler condenser mode and the primary refill.

In the initiation event some of the important characteristics are thermal center elevation and flow coastdown. Those two are very much tied together in the sense that they control the rate at which energy is depleted in the loop and set up a lot of the remaining part of the transient as you go through the overall small break LOCA event.

Steam generator initialization and the transient characteristics, the initialization of the steam generator as far as its distribution of heat transfer througout the elevation, are very important as far as setting up how rapidly the system will begin cooling down and the amount of heat transfer that will take place. This has to do with particularly the water level elevation in the steam generator and the distribution of how the heat transfer is taken out.

Also, as you get into the transient the

characteristics such as the feed control, the level control in the steam generator and their influence on the rate of energy removal from the system are very important.

Component irrecoverable Delta P, here we are looking at the capability of maintaining the correct natural circulation resistance in the loop, and this is very important in the beginning again because of the fact that if you have the wrong resistance and you start the initial part of the transient, the rate at which you remove energy from the system will change the subsequent events in the small break LOCA event.

Fluid transit times, if you could preserve those it is desirable, but in some of the scaling criteria that we will go through that is not possible in all cases.

The next event, the saturation, some of the characteristics that are important there are the fluid level versus bounding elevations. For example, the elevation of where the pressurizer ties into the loop typcially during a saturation mode, the pressurizer will deplete first, you will see saturation occuring in various parts of the loop and eventually moving up into the hot leg U bend portion of the loop.

Hot leg voiding and the characteristics associated with the hot leg U bend are very important for the saturation period.

Power to K is very important in the sense that if you don't have the right power to K curve, for example, if you had a very high power to K, saturation would occur earlier at a different pressure and would hold up at a different pressure so that repressurization and the cooldown characteristics would be very different than desired.

Leak and HPI characteristics are tied in to some extent with the power to K. Based on the power to K that you simulate, it will end up dominating the pressure that you will level out at and the initial part of the loop characteristics as far as how rapidly the inventory will begin depleting and how rapidly the inventory is made back up into the system is controlled by these characteristics.

Also, the leak and HPI characteristics are important as far as the core cooling during the early parts of the transient and reaching saturation.

RVVV performance is important during the saturation phase from the standpoint of the quantity of fluid, whether it is water or steam, that will be going through the vent valve and heating up the fluid in the lower part of the vessel and the interaction with the core temperature and enthalpy rise.

A very important parameter that comes into the

modeling has to do with the heat losses, the metal thermal capacity and the metal/fluid coupling during the early parts of the transient.

If you have a very high excess metal capacity, you have to carefully control the initialization conditions of the metal temperature so that you don't change the initiation and reach of saturation characteristics dramatically.

Intermittent circulation, the hot leg U bend characteristics are very important in the sense of how you have the voiding taking place, whether you have the correct sizing so that you do not get a slug characteristic in training the fluid in going over the hot leg U bend.

Reactor vessel vent valve characteristics are important during the intermittent circulation from two perspectives. One is how they remove the steam from the core and whether this steam would go through the vent valve to the downcomer or up the hot leg U bend that could restart or intermittently spill over.

In addition, the vent valve characteristics are important from the standpoint of voiding into the cold leg, heating up of the fluid in the cold leg which could cause a voiding collapse and movement of the levels up and down into the hot legs in the steam generator which could

lead to intermittent circulation.

That one I have sort of already tied to the last one as far as the downcomer cold leg voiding and condensation in the bounding elevations.

The other one is the steam generator conditions. Depending on how the steam generator heat transfer is controlled, whether you have a high aux feed or low aux feed and coupling of the primary to secondary, the rate at which you remove heat will be very important for intermittent circulation.

In the boiler condenser mode the primary fluid volume versus elevation is key from the standpoint of when will you get to the onset of the boiler condenser mode, the resulting power characteristics that occur at that point and also the resulting pressure and depressurization that occur at that point.

Steam generator performance, again the characteristics of high injection versus low injection, level control and pressure control are very important during this time period as far as removing via the boiler condenser mode of heat removal.

Leak/HPI characteristics, as you go through the boiler condenser mode the depletion rate is important to define when you get there and whether you stay into the boiler condenser mode.

Also the HPI head flow characteristics are important from the standpoint of how much fluid is being added back into the loop to give you either a constant boiler condenser mode or an oscillatory boiler condenser mode.

During refill the boundary elevations, particularly the elevation of the hot leg U bend returning to natural circulation, the volume versus elevation as far as timing associated with power dissipation and getting back to the refill condition.

High point vent valve performance, as we have seen in GERDA, is a key parameter in the rate of refill and whether you can remove the trapped steam bubble in the top of the hot leg U bend.

Heat loss, particularly in a scaled model is very key during refill. If you have excessive heat loss in critical areas that you might have steam you can cause a condensation and depressurization which will allow the system to refill very rapidly.

Finally, associated with these things the HPI/leak characteristics are tied to what the pressure is doing, whether the inventory is being depleted or refilled to ultimately get back to a solid water system.

We have looked at these and talked about a number of these things in some detail and to try to put

them in some sort of a priority level is very, very difficult within a given category. A lot of them are very much interrelated and we didn't feel at this point we could put them in any type of ultimate priority level.

MR. CATTON: Where are differences in the loops? Where does this fall in here? You do have intermittent circulation.

MR. CARTER: Right.

MR. CATTON: If you do have intermittent circulation, I would think that on the other side you would list asymmetric loop behavior and I don't see asymmetric loop behavior anywhere.

MR. CARTER: Well, that can come into the vent valve characertistics and the steam generator conditions and possibly cause an asymmetric performance.

MR. CATTON: I would feel more comfortable if you called it out separately because when you are thinking about that it may lead you to a different conclusion with respect to your vent valves.

MR. CARTER: All right. The only thing that we were doing here is in a sense we felt this was the driver and the asymmetric performance was more of a result of the way the steam generator was operated or the way the RVVV might be operated.

MR. CATTON: Well, that is certainly true.

MR. CARTER: That really could show up there.

MR. CATTON: But your present ideas with respect to your vent valves may wash out that effect.

MR. CARTER: It all depends on the type of loop-to-loop oscillations you might be looking for.

MR. EBERSOLE: I have a comment. Last week we were talking about the unresolved safety issue, the station blackout. In turns out that if you look carefully at the individual plants across the country and begin to measure the probability of this accident against the reliability of the grid and the reliability of the individual diesel unit installations, you get a tremendous spread. I think there is a variability in the order of a hundred, which means there are a few plants at the bottom end of the spectrum where this challenge begins to look real bad and there is going to be some action taken about this very shortly.

But if any of these are B&W plants, you might compound your table up there by saying at this point in time I have no AC power, and what is going to happen?

MR. CARTER: I will have to defer on that one, but I think some of the tests that we consider also include the loss of off-site power.

MR. EBERSOLE: I don't mean off-site. I mean station blackout.

MR. CARTER: Oh, station blackout.

MR. EBERSOLE: Now if the seals fail, then the primary is going down, you still have steam pressure for aux feedwater, but if the primary side of is blowing down, then in essence the heat goes the other way. I don't know what happens to the attempt of the primary loop to go to lower pressure and temperature in the absence of any augmented boration. Life gets very messy indeed.

You may run out in fact of the evaporative capacity of the feedwater pumps because that was stipulated on the basis that you are only going to cope with decay energy.

But, anyway, just add a little parenthetic addition up there no AC power and I think life will get very interesting.

MR. CATTON: That could be anywhere on that chart.

MR. EBERSOLE: That is right.

MR. TAYLOR: That is MIST 2.

(Laughter.)

MR. EBERSOLE: You had better look at the blackout statistics first.

MR. HOLLOWELL: I think you are right that station blackout is a serious consideration.

MR. EBERSOLE: I don't know how the seals stand

up. I don't even know whether they are uniform or whether there are some of them that go faster than others.

MR. HOLLOWELL: We have looked at seal leakage even up through the highest rates and you still have on the order of two or three hours before you run into a problem.

MR. EBERSOLE: Is that across the whole spectrum of designs of seals?

MR. HOLLOWELL: That is for the B&W type seal.

MR. EBERSOLE: Are they all alike?

MR. CARTER: They are nearly the same.

MR. MICHELSON: Well, in two or three hours of course you have lost a fair amount of inventory, depending on the assumptions on seal leakage. Have you actually done a calculation in which you assume a certain seal leakage which if found within the three hours you still have natural circulation?

MR. HOLLOWELL: Right, as long as you have aux feedwater.

MR. MICHELSON: Well, yes, but you have got to make up the inventory on the primary side or eventually you are going to end up with a depleted inventory and no water up in the U bend and no natural circulation and no necessarily in a boiling condensing mode yet and so forth, and without any AC power which will address the problem.

MR. HOLLOWELL: The seal leakage, it is the large, it could be 150 gallons a minute, but it is not ---

MR. MICHELSON: Well, I asked this same question not too long ago in another subcommittee meeting and the calculations apparently have never really been done, or at least they were promised them and it never came to show what the inventory is at the end of three hours in the case of station blackout with seal leakage.

MR. EBERSOLE: The foreign reactors are adding little auxiliary diesels to keep the seals clear on the thesis that this is diversity, non-electric.

MR. MICHELSON: It may be necessary besides. Could you answer my question. Do you have a calculation on the seal leakage and the inventory after three hours.

MR. HOLLOWELL: Yes, we do have it. It is a major part of our PRA. It is will be available whenever our PRA is available.

MR. CATTON: I didn't know PRAs did calculations.

MR. MICHELSON: I didn't know either.

MR. HOLLOWELL: Well station blackouts.

MR. CATTON: The PRA doesn't calculate seal leakage. Somebody has to give it to them.

MR. HOLLOWAY: Oh, yes, we used an assumption on seal leakage.

MR. MICHELSON: And then you have to calculate the primary side inventory to find out whether or not you even have natural circulation for three hours.

MR. HOLLOWELL: That is right.

MR. MICHELSON: And that was all done. Where can I read about this and which PRA will it be in?

MR. HOLLOWELL: Well, sometime between now and the end of the year when the PRA is available.

MR. CATTON: Which plant?

MR. HOLLOWELL: Midland.

MR. CARTER: From these criteria we saw that as you go through a number of these the elevations continue to pop out as being a very critical parameter for the natural circulation events leading into initiation and finally finishing with refill.

Also, some of the very specific phenomena ranging from the hot leg, the hot leg U bend and some of the details of the reactor vessel vent valve are very important. Volumes seem to be coming in a little bit lower. Basically we feel that at this point in time the overall criteria similar to what we had for GERDA is still the criteria to use.

Basically the full elevation in the sense of key elevation such as the hot leg U bend spillover, core thermal centers and steam generator thermal centers are

very important because of the natural circulation characteristics.

Phenomena, and there are a number of them, and basically you are going get into some of the phenomena for each component, and we are going to get into a couple of those in the reactor vessel vent valve and downcomer a little bit later, but in the hot leg is has to do with the voiding and entrainment in the hot leg U bend and flow regime transition. Basically you can do that type of phenomena discussion for every single component.

The third level is the power and the volume scale. If you take the perfect scale, that should be a 38 which results in an overall scale factor of 817.

Finally, the preservation of loop irrecoverable losses are important.

(Slide.)

MR. WARD: Do you think you said something wrong?

MR. CARTER: I was wondering if I made everybody leave.

(Laughter.)

(At this point in the meeting because of the lateness of the hour and other commitments some members departed from the meeting.)

MR. CARTER: We can always change the scale

factor if it is that bad.

(Laughter.)

(Slide.)

One of the initial layouts of the loop, as shown in this schematic, and I will talk through it a little bit, starting with the reactor vessel section, the reactor vessel in MIST will be full length. The only exception will be possibly a trucation of the upper part of the reactor vessel in the non-flow region to minimize some of the volume.

The core itself, and I will show you some specific pictures of the core, will be a full-length core. It will have a 45 fuel element simulation with the correct diameters and fuel pin pitches.

The lower plenum of the reactor vessel will use similar as GERDA did the highest flow hole in the lower plenum distributor plate.

From the reactor vessel there will be two hot legs. At this point they are a three-inch diameter similar to what was in GERDA. The hot legs are shorter now in the MIST facility since it is a lower loop. The hot leg itself is only about 35 to 40 feet versus about the 65 to 70 feet in the raised loop arrangement.

The hot leg U bend is scaled with pretty much the same radius of curvature as was done in GERDA. So we

have the same scaling criteria in the hot leg U bend.

The steam generators are both 19 tube steam generators. They are full length to preserve the tube diameter and tube pitch and characteristics in the steam generators.

The cold leg piping is phenomenologically scaled or Froude number scaled which results in approximately a two-inch schedule 80 pipe. One of the things that we are trying to do in the MIST facility wherever possible is use the smallest pipe thickness possible, where typically for this type of apparatus in the past you would use probably a schedule 160. We made some calculations that show we can get down to schedule 80 which will help minimize the metal capacity problems that you might have in a scaled loop.

The loop will have four scaled reactor coolant pumps. The reactor coolant pumps have been a point of a lot of discussion so far as to whether they should be a very high speed specific scale pump or whether we should strive more importantly for minimizing leakage. At the Semiscale facility they have had considerable difficulties with leakage from their high-speed pump. And also to minimize heat losses associated with the pumps. Those discussions are still going on at this point.

The cold leg spillover sections back into the

downcomer will also have the much exaggerated inclination to them as GERDA did because again we will try to minimize the horizontal scale to cut out as much excess volume as possible.

In the downcomer it is probably easier to look at the planned view showing the cold legs coming into the downcomer and the vent valve arrangement. There will be additional discussion on that. John Klingenfus will get into that in just a little bit.

(Slide.)

Another consideration in MIST that is slightly different than what we had in GERDA is the pressurizer. In GERDA pretty much we had a volume scale pressurizer that was three inches in diameter and about 42 feet long. In MIST we are considering more of a phenomena scale pressurizer because of a desire to do venting transients and spray transients. It looks like at this point the pressurizer will be about six inches in diameter and about 10 to 15 feet long.

(Slide.)

Just to go through some of the key things that we feel are going to be in the MIST facility and to show you some of the specifics, we have hit on a two-by-four scale factor and 19-tube steam generators.

We will use full loop guard heating. From

GERDA we feel that particularly during some of the transients, at a later part of the transients during refill and boiler condenser mode the heat loss characteristics are extremely important and we need to minimize those as much as possible.

Currently the planned power for the loop will be 10 percent power.

The core heaters, and I will show you a little bit about that will be full length.

(Slide.)

We will have a total of 45 fuel rods simulated by electrical heaters. They will be the .43 inch diameter on the plant typical pitch. Within that array there will be 45 rods and four unheated guide tube regions.

One of the things that we are evaluating right now is the fact that we desire to make it into a square bundle. We probably are going to be going into a circular pressure vessel and we want to have a filler piece that minimizes the volume and also minimizes the excess metal capacity that could be stored in that wall section. There are a couple of designs that are being considered for that right now.

In the core heater itself the planned heat flux profile is shown in the next figure. What is planned is a peaked heat flux profile with a peaked average point

of about 1.25 over the active heat length of 144 inches which gives you at 100 percent power 316 watts per square inch.

The heaters themselves are going to be designed and capable of a hundred percent power. As used for the MIST program they will only operate during the first part at about 10 percent power maximum.

MR. ZUDANS: When you described the pressurizer you said a very large diameter. I didn't quite understand or maybe I misunderstood.

MR. CARTER: We changed the approach or the consideration on the pressurizer a little bit from GERDO to MIST. In GERDA we have basically a volume scale pressurizer and it resulted in a three-inch, 43-foot long pressurizer.

In the MIST facility we feel that the venting exercise of opening the PORV and also spray which will be part of the MIST program, it is important to consider such things as entrainment and how to pressurize and we have gone back pretty much to a Froude number scale pressurizer which results in a six-inch diameter by approximately a 10 to 15-foot long pressurizer.

MR. ZUDANS: But will that not change the other functions the pressurizer has to perform in such a way that it wouldn't be anything like a representation like we

expect?

MR. CARTER: Well, some of the key things we need to worry about is certainly during the early parts of the transient when you go through the initiation of the leak to saturation you have got to maintain those bounded elevations and you have got to maintain the correct fluid volume in the pressurizer so that as you deplete and saturate that is correct.

There is a lot of discussion about that topic and we have been discussing it with EG&G. They had once a large diameter short pressurizer and their later facilities have a skinny tall pressurizer. We are trying to understand why they switched from first the larger diameter to the smaller diameter and we are wanting to go from a smaller diameter to a larger diameter, and we haven't really resolved and completed all those discussions at this point.

MR. CATTON: It is 15 feet high?

MR. CARTER: That is approximately the number I remember. It is just over 10 or 12 feet.

MR. CATTON: In you are interested in entrainment and sprays and condensation and so forth, I would think that you would interact more strongly with EPRI, particularly their program that is going on at Dartmouth.

MR. CARTER: Well, Jean-Pierre Sursock is certainly working with us on the PMG.

MR. CATTON: Well he in the diagram that he put up on the board showed that, depending on whether you had sprays on or sprays off or heaters on or heaters off that you have got certain circulation patterns within the pressurizer.

Now Froude number scaling is not going to take care of that for you. If that part is important, you are going to have to do something else.

MR. CARTER: Is that also during the venting exercise that you are talking about?

MR. CATTON: I am not sure what part of it, but I think that you ought to find out and, if it is important, you have got to consider aspect ratio and you are not doing that now and you can't do that with the kind of scaling you are doing. So you may just want to give up that part of the testing.

MR. CARTER: Yes. I agree at this point we have sort of gone back and forth of whether it should be the almost aspect ratio type or whether it should be the volume or whether it should be Froude number scaling.

MR. CATTON: Well, it shouldn't be either. If you have that kind of recirculation pattern that Jean-Pierre showed us, then it is neither one of those

kinds of scaling. You have got to look at other mechanisms within the volume, and I would think that the place to go to do that would be to Dartmouth.

MR. CAPTER: Okay.

MR. MICHELSON: How did you scale the surge line?

MR. CARTER: Right now the surge line is a I believe an inertia or momentum scale. I would have to defer to Chuck.

MR. MORGAN: It is Froude number scaled. It has got the same loop seal arrangement. The elevations are preserved from the hot leg down into the entrance into the pressurizer, and that was because with an open PORV we wanted to preserve the flooding characteristics.

MR. CATTON: What is the diameter of the surge line?

MR. CARTER: I am not sure at this point. This is really new at this point.

MR. CATTON: Again there, see, if the diameter of your surge line is getting anywhere near the diameter of your pressurizer you are going to change the fluid mechanics characteristics of the whole thing.

MR. CARTER: I think it certainly would be 20 to 30 percent of the diameter anyway, if that is significant.

MR. CATTON: Well, I don't know. That is something you need to look at.

MR. MICHELSON: Are you simulating the diffuser in the pressurizer?

MR. CARTER: There will be a mockup of the cap on top of the surge line diffuser.

MR. CATTON: Again, that takes up almost the whole pre surizer diameter and it is going to be quite different.

MR. CARTER: Oh, it would not be the full size. It would be scaled down, but there will be some simulation of that diffuser.

MR. CATTON: Well, I think you need to talk to the people at Dartmouth.

MR. CARTER: I understand and I don't disagree.

MR. EBERSOLE: Is there anything novel about that heater rod design up there that you are showing us, or is it just pretty much standard?

MR. CARTER: Well, there are two designs really that are being considered right now. One is the design that as been put out by Rama. It is basically the circular core winding and the heater where they varied the pitch to get the desired heat flux. There is another one made by a company in Europe where they use basically six individually heaters with a variable diameter to their

heater arrangement.

Right now we haven't had to decide on one or the other. Each one has some advantages, particularly the fact that we want to first operate at 10 percent power and then go at 100 percent power later. But there are two potential designs that are being looked at right now.

MR. MORGAN: Randy, the surge line is three-quarter inch 160 which is about .6 inches in ID.

MR. CARTER: Versus about 5.5 inch pressurizer, if that is the way we go right now.

MR. CATTON: So it is one/tenth of the pressurizer diameter.

MR. CARTER: Right.

MR. CATTON: And the actual system is probably a ten-inch line.

MR. MORGAN: It would be roughly in the same proportion. The pressurizer diameter on these pressurizers---

MR. TAYLOR: 177 fuel assemblies, 84 inches and the surge line is about 10 inches.

MR. CATTON: The jet characteristics, or whatever it is that is coming in might be quite different.

MR. WARD: Well, there is a diffuser in there, isn't there?

MR. MICHELSON: Yes. They are going to simulate

the diffuser.

MR. SCHROCK: Is there a scaling problem with the heaters in the pressurizer?

MR. CARTER: There doesn't appear to be. The one question we have got in the pressurizer will be because of the small diameter and what is the resistance we want to have in there as a result of the heaters and that has not been finalized.

One of the things that we would probably do just for facility operational purposes is to oversize the heaters and use some banks during the test and some banks during maneuvering the facility.

We did in GERDA just scale the heater capacity almost with just a little margin, and what happens is you have just a lag ---

MR. SCHROCK: I wasn't thinking of the heater capacity so much as its influence on the fluid mechanics.

MR. CARTER: Right. We will be looking at the resistance particularly again in the case of relieving a transient, the resistance it would impose on the fluid. That is ongoing.

With respect to the ECCS systems, where in GERDA we had only the high-pressure injection system, in the MIST facility we will have high pressure injection, low-pressure injection and also a core flood system.

The arrangement for the high-pressure injection system will be such that we can go to all four cold legs. Just for reference, I understand to some people an accumulator means something else, but this is only the accumulator on our high-pressure injection pump. In one design it might use a positive displacement pump. This would be to eliminate pulsations.

The arrangement of the HPI system would be to monitor loop pressure and based on the pump discharge pressure to control the amount of flow to get the head flow characteristic that we want.

From the pump the connections at the cold legs would be scaled so they have a typical plant resistance. So if there is the thermal hydraulic driven case that you have to have HPI flow preferentially to one or more locations, it should be scaled so that you can get that.

MR. MICHELSON: Do you know approximately the pressure frequency of the positive displacement pump that you might use?

MR. CARTER: No, I don't, not right now. It would change, too, because the one we looked at is a variable speed. So it would vary.

MR. MICHELSON: It is a real noise generator for the whole system even after you put in a surge tank.

MR. CARTER: If you have to go to the

high-speed, that is a real question.

(Slide.)

The low pressure injection system and the core flood system would be arranged so that the LPI in concept is very similar to the HPI based on system pressure.

The head flow would be simulated to inject into the core flood nozzle on the downcomer part of the reactor vessel.

The core flood system would be a vertically oriented cylinder. As it stands right now, it looks like it will be about a six-inch diameter by a 25-foot long tank that would simulate both of the core flood tanks in the 177 plants.

This would be actuated based on a pressure signal from the loop which would open an isolation valve, and in addition there would be a check valve downstream of that going into the core flood nozzles.

MR. MICHELSON: If you had the 600 pound pressurizer ---

MR. CARTER: The core flood?

MR. MICHELSON: Pardon me, core flood, are you intending to leave that tank open and inject the nitrogen as well in some tests or is it always isolated?

MR. CARTER: As it stands right now from reading the documents we have we felt that the nitrogen

system was isolated. So we would maintain 600 psi, isolate the nitrogen and then if the system would deplete, it would deplete the amount of nitrogen existing in the core flood prior to isolation.

MR. MICHELSON: But you would not ever inject the nitrogen into your loops then. There are some arguments. People say if you get the pressure low enough, then core flood tanks will dump the nitrogen in, but that is okay.

MR. CATTON: He is going to do that.

MR. MICHELSON: No, he said he is going to isolate it. .

MR. CARTER: No, no. The only place I am talking about isolating is the nitrogen supply.

MR. MICHELSON: Oh, you are going to leave the injection valve open?

MR. CARTER: No. Once be go below 600 psi it stays open.

MR. MICHELSON: All right time.

MR. CARTER: The only thing that would happen is that if it goes above 600 psi it would recede. I misunderstood your question.

MR. TAYLOR: Carl, when the nitrogen is fully expanded before it goes out the line at the bottom of the core flood tank, the pressure is down to 90 psi. So it is

more than a small break, short-term concern.

MR. MICHELSON: For this loop design to be done.

MR. TAYLOR: No, if I am talking about the big plant. I don't know what the characteristic here is. If the core flood tank here is simulated ---

MR. MICHELSON: That is wondered here, what pressure does it get down to before it injects.

MR. TAYLOR: I don't know.

MR. CARTER: Well, I am not sure. The thing we have looked at so far is to have the correct initial water volume and the correct initial gas volume. Now we haven't really looked at how low in pressure we have to go down to to get the gas to expand in the loop.

Now one thing that we will be doing though was a consideration of the fact that the actual core flood tanks are larger than what ours are and the potential that we would have is our gas pretty much stratified at the top.

There will be a small pump that will actually circulate the water and spray it back through the gas dome so that this should be saturated with the nitrogen overpressure. So that if you do begin injecting, this would be saturated with the nitrogen at whatever pressure you are at.

MR. MICHELSON: That would strip out into the loop.

MR. CARTER: Right, it would strip out into the loop, exactly.

MR. MICHELSON: But you don't think you are really ever going to inject the gas bubble into the loop, right?

MR. CARTER: We really don't know at this point.

A couple of other features that we haven't touched on. We will have the non-condensible gas addition capabilities similar to what we have in GERDA. We will be able to add either nitrogen or helium or mixtures of nitrogen and helium at various points in the loop.

We will use a gas detection approach similar to what we used in GERDA which basically takes a sample and looks for the partial pressure of the non-condensible gases.

Controlled leaks will be via the critical leak orifices. The only difference now is the scale factor is different and they change slightly.

We had mentioned before that one of the steam generators will be a new steam generator.

MR. WARD: Randy, before you leave that, the heater rods are built for 100 percent scaled power. The

initial test matrix I guess just calls for 10 percent.

MR. CARTER: Right.

MR. WARD: Are you going to have the capability in the system as a whole for 100 percent power?

MR. CARTER: No. One of the things that we got into, and that was a tradeoff back within the TAG group that probably the most single expensive component to be able to go to 100 percent power we felt were the core heaters. But we will be utilizing a lot of the system from GERDA as far as the balance of the secondary system as far as condensers, piping and steamlines. So we didn't have to totally replace those.

We will still be staying at a level that can only handle roughly the 10 percent power. So if we did need to go to 100 percent scaled power, a good part of the secondary part of the system like the condensers, the steam valves and the feedwater lines would have to be replaced. The steam generators and the actual core heaters would be capable, but a lot of the balancing and peripheral equipment would have to be replaced.

MR. WARD: Of the issues that the TAG group has identified that need to be studied experimentally, do any of those call for a test at 100 percent power?

MR. CARTER: The only difficulty it brings in is the initialization of the loop. There is a question in

starting from 10 percent of power of how do you set up the loop to simulate a trip from 100 percent power and catch it against the K curve.

In GERDA we have gone through some of that problem already of matching power to flow ratios and trying to establish the desired metal temperatures and you will have to do the same kind of thing in MIST. It is not impossible and it is not easy, but you still, even after that problem, have the associated problems with metal capacities that are still going to be different anyway.

Right now that is the only visible problem that we can see as far as the issues that have been defined so far.

(Slide.)

The instrumentation I really didn't plan to go into in large detail, but just to give you an impression of the quantity and type of instrumentation that is planned at this point.

As is currently defined, there will be approximately 700 individual measurements. The figure that you have in front of you is only the point measurements. If you would like, I can also pick up the one that shows the level measurements so that you have a complete picture.

One of the things that has been enhanced to

some extent is the measurements in the region of the cold leg downcomer as compared to GERDA. This is primarily based on the voiding conditions that we saw in the cold leg discharge in the GERDA test. It doesn't show up on this figure, but if I provide you with the Delta P ones or the level indications, there is a very large increase in the density of level information as far as narrow range differential pressures in the hot leg and also in the secondary side of the steam generator looking for the void distribution in the secondary side of the steam generator.

Another fairly significant conceptual change in the instrumentation is the new steam generator compared to the old steam generator. There is considerably more instrumentation and the instrumentation is oriented both to give you the distribution of temperatures and the distribution of heat transfer and the changes in heat transfer regimes, as well as trying to look at locally primary metal and secondary temperatures to calculate heat transfer characteristics.

There are still some discussions going on right now, as Ralph indicated before he left, with EG&G in reviewing the instrumentation both in quantity and locations and the desirability for some of the special instrumentation such as the gamma densitometers and that type of thing.

(Slide.)

The test program is really divided again into two basic parts, the characterization being one part and the remaining tests up here being the second part.

The characterization tests will include the debugging, basically a mechanical checkout of the components and some of the separate effect tests like natural circulation and steady state boiler condenser mode. Probably at this point we have identified a non-condensible gas tolerance test or a threshold test. There are approximately 28 of those that are defined right now in the program.

Then in the major part of the program are the mode transition, small break LOCA, OTSG tube rupture, feed and fleed and roughly tests that are undefined at this point.

What I thought I would do is to go through the test matrices as they are laid out right now for each of the mode transitions, small break LOCA on down to feed and bleed and let you see the kind of parameters at least that we are considering.

(Slide.)

These I had copied after the comments this morning and we can provide copies of these a little bit later.

In the mode transition test what we are looking at is basically starting from a forced circulation system with the pumps on at a power such that we initialize the temperatures and power flow ratio to get the desired initial conditions.

We trip the pumps, we open the leak and let this continue until we reach a steady state boiler condenser mode.

The parameters that we will be looking at are power both at what a nominal power is, which will be using ANS power, a high power with the 1.2 and the 1.08 factor added to them, steam generator level, both with balanced level, unbalanced and a third where we have a balanced level.

This has to do with the two steam generators being either together as far as levels unbalanced and the rate of feed up is the balanced level criteria.

ECCS will be a parameter using both the best estimate model and evaluation model. Vents will consist of none in the reference test, the high leg U bend vent and the high point vent which is the reactor vessel high point vent.

MR. SCHROCK: Excuse me, your footnote on the ANS times 1.2 suggests you are using the old standard. Why is that?

MR. CARTER: I have to defer on that. Do you remember the discussion, Jim?

MR. GOULDEMANS: That is true. It is based on the old standard, but I think it will be updated.

MR. SCHROCK: I am sorry, I couldn't hear him.

MR. CARTER: His comment was that it is the old standard. This was done several months ago and it may need to be updated to reflect the new standards.

There was a discussion, and at this point I am a bit remiss of exactly why we picked 1.2, but ---

MR. JONES: I think the discussion just centers around providing some information relative just to describe licensing rules that we use today which is the 1.2 ANS standard as a measure of the conservatism in some of today's licensing standards. I think that is part of where it came from because that also shows up in some of the other tests.

MR. SCHROCK: But that is very misleading because, first of all, these tests are not going to provide any data directly applicable to any licensing question. Furthermore, it seems clear that we are headed towards uniform use of the new standard, which is much better information. So why not put it into new facility design rather than using old information.

MR. JONES: Well, the six guys that should be

defending it left.

(Laughter.)

MR. CARTER: We basically understand the comment through.

The major part of the test matrix is really the small break LOCA portion and we will sort of have to feed through it. It is a very large table and we will work our way through it.

(Slide.)

The parameters are nine in number ranging from leak size, leak location either at the cold leg discharge, the cold leg suction, the top of the pressurizer, the ECCS with best estimate evaluation model, reactor coolant pump either off, bumbed, long run, or stopped, and or stopped at this point still has not been really defined. It has to do with when do you turn the pumps off and leave them off. Isolation of the leak, either none or at the stall flow condition as currently defined. Reactor vessel vent valve using either the nominal resistance, two times the resistance and a variation in the Delta P required to open the vent valve. Auxiliary feedwater, either constant level, the band control with which you allow it to steam down or feed up to high level and cut off the feedwater and let it steam down again. Asymmetric, being asymmetric to the two different steam generators.

Non-condensible gases, either none or threshold test where we basically continue to inject non-condensible gases until the primary pressure increases to maintain a sufficient Delta T for the heat transfer until you reach approximately 23 or 24 hundred psi.

Vents, there will either be none, the hot leg U bend high point vent, the upper head vent on the reactor vessel, the high point and upper head, this being the high point vent on the hot leg and upper head on the reactor vessel, and then independently the high point vents on the two hot legs.

So those are the parameters. Then as you go through ---

MR. MICHELSON: Question. You are indicating there the possibility of a long run on the reactor coolant pump during the test. How are you simulating the heat inputs and so forth on the reactor coolant pumps? How did you handle that problem?

MR. CARTER: Right now we are looking at that. We are not totally sure whether we have got a heat loss or a heat addition problem.

MR. MICHELSON: Somehow you have to compensate for that in the model.

MR. CARTER: Correct. That is currently being looked at at this point in time. Right now as it stands

there is only one test with a long run, but it has to be considered and even in some of the others during initialization characteristics also.

As you look through the matrix there are sort of categories that you can look at. There is a leak size effect, reactor coolant pump effects, leak isolation, auxiliary feedwater effects, reactor vessel vent valve effects, non-condensible gases, leak location effects and the independent vent on the hot leg effect.

MR. EBERSOLE: What is the basis for the vent size?

MR. CARTER: I am not sure at this point. It is undefined.

MR. CATTON: I would hope in part of this matrix you would make a strong attempt to have a test that corresponds to one of the ones that is in the University of Maryland and also in the SRI-II so that if there are differences we can clearly pinpoint the reasons.

MR. CARTER: Yes, I think that is a very valid point, particularly since it looks like the scaling discussions are working towards that. There are probably still going to be some differences between the various facilities and if we want to identify how those affect it, I think it is a very valid point.

Mike is still here and he heard that. Good.

MR. CATTON: I don't who should address for whom, but somehow they have got to do that.

MR. CARTER: I think it is a good point though.

Within the feed and bleed test the major parameters are the ECCS model, both best estimate and evaluation. They delay time as far as the initiation of the ECCS, either a PORV lift or 20 minutes after scram and the reactor coolant pump, either off or on.

(Slide.)

The final test that is planned, group test or the steam generator tube rupture test, there the parameters are the number of tubes that are ruptured, whether the reactor coolant pumps are on or off, the level control in the secondary side of the steam generator, nominal being the constant level control, full and isolated steam generator. Also whether we have a concurrent or sequential steamline break and the aux feed, I believe in this case it is at the top or at the bottom of the steam generator, and we would only have one of those tests.

That is the way the matrix is laid out at this point. A lot of discussions still have to go on, but that is the basic format of the overall MIST program at this point.

Any questions or comments?

(No response.)

MR. WARD: Okay. Thank you, Randy.

We have been asked to invert the order of the next two speakers, not the speakers themselves.

(Laughter.)

Mr. Jones.

MR. WILSON: A question first.

MR. WARD: Yes.

MR. WILSON: On these running starts because of your power, your only 10 percent power capability, and things you have got to do to commence it, the running starts, do you know at this time what parameters are going to be running parameters, that you are going to have to bring them to some level and let them decay and they have all got to collapse to the start position, do you know what parameters are involved at this point in time?

MR. CARTER: The ones that we might vary?

MR. WILSON: Yes.

MR. CARTER: In GERDA, and we have probably used some of the same approaches, it was a combination of power flow and secondary side conditions of the steam generator.

MR. WILSON: Did that include levels? Did you have these changing levels?

MR. CARTER: I think the primary variable we

changed on the secondary side was mainly the secondary pressure. Secondary pressure is one of the variables we would change to get the desired metal temperatures on the primary side. We did not have to use levels in the GERDA program. It was mainly flow and secondary side pressures.

MR. WILSON: The reason I asked that question was that in another experimental facility we had experience with this running start technique that involved delay of levels and it was actually system mass, or call it residual mass, that is a very difficult problem when you get to code verification and code assessment. I know levels, decaying levels, I mean it really gives you fits in the code assessment arena in trying to initialize your simulation, your code simulation for what really went on in the experiment.

So I was asking you from the experimental viewpoint what your parameters were going to be. I am waiting until your code verification speakers gets up there and I would like to address the question to him if he has had any experience alonf these lines with GERDA and what that experience was.

MR. CARTER: There is no question that the initialization is something we have to work at because of the low power. I am really talking about it from the standpoint of initializing the loop so at some point in

time in the decay power curve we hit a "matched point." Now the simulation then, I am not going to bother to talk about that because that is another story when you take it to the code benchmark.

MR. WILSON: I guess what I am conveying to you is that it is a double problem. It gives you guys problems in trying to set the experiment up the way you preconceived that it ought to be. I know in other instances where level was one of the parameters of concern and it gives the code assessment arena great problems.

MR. JONES: I am Bob Jones from B&W.

(Slide.)

What I would like to do is walk you through the computer code assessment program that will be going on during the whole IST program.

This has several phases, one of them being the development of the RELAP 5 code or modifications to the RELAP 5 code, which is being covered as part of B&W's contribution to the IST program.

The B&W owners have contributed a million dollars of code benchmarks as part of the IST program.

Then there are a couple of specific analytical tasks that are talked about in the IST proposal or contract which will be shared by all the participants.

Then I would like to just lay out kind of a preliminary overview of all the code assessment efforts that are going to be going on via the NRC, EPRI and the B&W Owners' Group.

MR. CATTON: What went into the decision to usc RELAP 5? The reason I ask that is because if it turns out that you have a problem that requires a multi-dimensional annulus, you are in deep water with RELAP 5. You are not going to know whether you are until I guess next year sometime when the University of Maryland and the SRI-II facilities are run and that is going to be kind of far downstream, isn't it?

MR. JONES: The main reason we have chosen RELAP 5 for our efforts is that is the code we intend to us in the future for best estimate and licensee simulations.

MR. CATTON: It may not handle this problem of the vent valves and you are not going to know until next year.

MR. JONES: Right, and there I think part of the code development effort which will be going on by the NRC which will be looking at TRAC, the TRAC code, that will be shown on the ultimate summary slide of all the analytic efforts. They will be going forward with that via research.

MR. CATTON: I guess I would just think that the path that you have chosen is high risk. I mean it is high risk with your customer's money.

MR. SCHROCK: It is high risk in any case.

MR. CATTON: Yes, but at least TRAC can handle the multi-dimensional annulus.

MR. SCHROCK: But there are a lot of other modeling features that they need here that are not well developed in TRAC.

MR. WARD: Are they better developed in RELAP 5, do you think?

MR. SCHROCK: I don't think so. The vent valve question particularly, I don't think it is very well developed.

MR. CATTON: But at least TRAC today actually has set up for a plant and could address the question, but they have not been commissioned to do so as yet. We have a MIST facility that has a single downcomer and essentially eliminates the problem. You are going to test it against RELAP 5 which can't handle the problem anyway, and I just think that is a high risk way to go.

I would think that you would seriously address the question as to whether or not the vent valve question is real first and not wait a year.

MR. SCHROCK: RELAP 5 can do parallel channel

as one dimensional problems and it may be that that turns out to be as good a calculation as you will get.

MR. CATTON: Well, Virgil, we already know that that is not the case from calculations that were done on Mcguire. You get nonsensical answers when you try because of the UV term in the momentum equation has to be there and you can't separate it into parallel channels.

MR. WARD: Let's see, are you referring to the story we heard a couple of months ago? Was that Mcguire?

MR. CATTON: I think this precedes you being a member. It was back when they were looking at the upper head injection.

MR. WARD: Oh, a long time back.

MR. CATTON: They actually tried the method that Virgil is recommending and it didn't work.

MR. SCHROCK: I wasn't recommending it.

MR. CATTON: You were suggesting it.

MR. SCHROCK: It is useable.

MR. CATTON: It is useable, but it gives bizarre results. They get velocities that go circumferentially that are just out of sight and it sort of drips into the lower plenum. It doesn't work. I don't think you have to have dimensions across annulus but around it and it has to be done properly.

Now if they can show straight away that this

business with the vent valve is not a problem, then the MIST facility is good and RELAP 5 is fine.

MR. JONES: I think our initial reaction to that is that for small break LOCA concerns it is not going to be a problem with the vent valve. At least that is our going in position.

The University of Maryland test of course is going to help to either confirm or kill that assessment to some extent.

MR. CATTON: Yes, and it may be a year downstream. I am just wondering what contingency plans you have in mind for that eventuality? It may not happen, but I would think that you should at least consider it and have mapped out in your own mind what you would do.

MR. JONES: Part of what I am going to be explaining in the main talk is going to be about what the B&W Owners are doing and B&W is doing and what is presently covered within the IST contract. There are other efforts. EPRI talked about them briefly today and the NRC touched on them earlier. They will all show up on one slide. So we will have a little bit of a feel I think across the board of several codes and ideas as to how good MIST will be and some idea of plant dynamics.

MR. CATTON: I would suggest that you think in terms of a two dimensional annulus to be stuck into the

RELAP method of calculation.

That comment, by the way, was for Brian Sheron wherever he is.

MR. WARD: Have you got it, Frank?

MR. MORGAN: We have talked to Los Alamos on some of the calculations they have done with a six segment downcomer and they were on the overcooling transient rather than the small break, but their results show that the vent valves operated pretty much together.

MR. CATTON: They didn't, at least I don't believe, set out to look at situations that I have heard were of interest here where you deliberately tried to make your loops different.

MR. JONES: Well, an overcooling transient would make the loops different if it is one side of the generator.

MR. CATTON: That is right.

MR. JONES: I think that is what Chuck said they were looking at.

MR. MORGAN: If you overcool one generator it is. Unfortunately, we don't have the output. We have requested it to look at it.

MR. CATTON: Okay.

(Slide.)

MR. JONES: To kind of put it in perspective,

you have heard several times today, and this is one of the reasons I am here, what is the whole purpose of the integral system test program.

One of its purposes of course is to provide data on a facility which is representative of a B&W MMS, but its major purpose is to provide data to be used for the verification of the analytical model's codes that are used to predict transient MMS behavior. This is part of the reason why we have chosen RELAP 5 because that is our code for the future, if you wish, or at least where we wish to go.

(Slide.)

Now as part of that effort and part of B&W's contribution to the program, we are doing some development in RELAP 5 ourselves right now. It has been an ongoing task for roughly a year now.

We have run into over the last year several problems in the overall RELAP 5 model that we need to take care of and we are planning to take care of as part of our contribution to the program.

First off, one of the things that we have in fact completed, and the documentation is cleaned up before we even release the special version in-house, is the development and installation of the three region nonequilibrium pressurizer model.

The RELAP 5 code has problems. Although it is touted to be a nonequilibrium code, it has difficulty on the pressurizer insurges and we have developed a special model for pressurizer insurges, or actually four pressurizers which we have installed.

In looking at RELAP 5 and looking at the small break LOCA transient behavior, one of the regions you go through during a small break LOCA is after you go through the boiler condenser and initiate a loop refill, you will be compressing the steam bubble in the candy cane during your attempt to refill the system.

The present RELAP 5 formulation would not be adequate to handle that because is forces one of the phases to be at saturation. The least massive phase is at saturation. The way that works is if I am refilling with subcooled liquid and I get a droplet of water in another node and it is subcooled water, that would be the lesat massive phase. It would automatically be heated by taking energy out of the steam, which is essentially an artificial condensation term, and it continues to do that.

The model we are putting in will be basically an isotropic type formulation.

MR. SCHROCK: You know that they are now going to a six equation model?

MR. JONES: Yes, I have heard that in talking

with Ralph Landry. There may be some modifications to this effort as a result of that.

MR. SCHROCK: It has caused problems in other areas, too, and they have known that for some time.

MR. JONES: One of the other models that we have looked at is the interface drag and mass transfer models, basically two-phase flow simulations.

We have done some benchmarks of the present RELAP 5 code, I think it is Mod 1, Cycle 19 or Version 19, and we have benchmarked that code to some GE level swell experiments and we get some really funny void distributions and we are not able to predice the swell level that well in those experiments. We are planning to upgrade those models. The details at this time are not worked out, but that is part of the development effort we will be going through.

Finally, we are upgrading the steam generator model in the code to take care of such things as the aux feedwater spray on the B&W plants, which RELAP 5 does not have provisions for today and the local wetting effects similar to what is in the present CRAFT model.

We are also adding a non-condensible heat transfer model for degradation of steam generator condensation heat transfer based on some experiiments we have run at Alliance on some condensation heat transfers

in the presence of non-condensible gases.

We are also going to change part of the condensation logic to be consistent with the B&W plant behavior, which is at the overlap of levels. When the primary level drops below the secondary level, we would do the heat transfer based on that wetted surface or exposed surface for heat transfer.

Right now the schedule on that is to complete the development of the task by April of '84.

MR. SCHROCK: Excuse me. Could I ask on this, does this mean there is going to be a B&W proprietary RELAP 5?

MR. JONES: Yes, in a sense.

MR. SCHROCK: That may be counterproductive. In fact, you would be better off picking up the more up-to-date RELAP 5 version and not installing essentially equivalent but "different" models to accomplish the same purpose and end up having something that is going to be much more difficult for the NRC and EPRI participants in this to deal with in the evaluation phase.

MR. JONES: Well, I think this is one of the things ---

MR. TURNER: The code for development, the RELAP 5 version we are upgrading, is part of our contribution to this IST program. When we complete what we

have planned, what Bob is talking about, in April of '84, that code will be released on a proprietary basis to the participants in the program, that is the NRC, EPRI and the owners. Then when we go through more code verification with the MIST data, the plan now is to release that code version generally about mid-1986.

MR. ZUDANS: And you will still call it a proprietary version of RELAP?

MR. TURNER: No, sir.

MR. JONES: Not in '86. This is the next slide I had which is we were going to turn it over to the participants in April of '84 and release it to the public in '86.

MR. ZUDANS: You start out with RELAP 5. You do something with it and you end up with something that is proprietary and it will be called another name. It is another code to learn. I think it is kind of ridiculous.

MR. CATTON: Well, but it is business.

MR. ZUDANS: Business, business, you start out with RELAP 5. Is this the latest RELAP 5?

MR. CATTON: No. The last RELAP 5 we saw calculations from had terrible difficulties with the B&W system.

MR. SCHROCK: That is not the latest one.

MR. CATTON: That wasn't the latest one?

MR. SCHROCK: No.

(Laughter.)

MR. CATTON: Well, the one being used by Idaho had terrible difficulty.

MR. ZUDANS: I think I will have to give up.

(Laughter.)

MR. TIEN: Could you mention a little bit about B&W's work on the condensible gas and condensation for your steam generator heat transfer model.

MR. JONES: I will tell you what little bit I can. We ran a typical steam generator tube where we injected a steam and gas mixture into a plenum and we basically just maintained a constant level. The test section had a subcooled fluid around it or a constant temperature fluid around the tube and we were measuring heat fluxes. The facility would then go through some pressure transients and likewise.

The interpretation of that data and how we have applied it ---

MR. TIEN: Do you have any analytical modeling along with your experimental ---

MR. JONES: Yes.

MR. MORGAN: There will be two papers on the heat transfer ---

MR. TIEN: This coming one?

MR. MORGAN: Yes, in a couple of weeks.

MR. CATTON: Next week, isn't it?

MR. MORGAN: Next week, yes.

MR. TIEN: We just completed a paper on this on analytical models. I can send you a copy. It is a very high level kind of analysis for the reflux condensation also and non-condensible gas.

MR. JONES: That work, let's see, Chuck is going to be presenting it next week, right?

MR. MORGAN: Yes.

MR. TIEN: Basically what we find is where you have non-condensible gas your non-condensible gas will accumulated at the interface. So any analysis for the vapor region, vapor gas region, if you use a one dimensional you are completely wrong. So it has to be a two dimensional analysis in the vapor gas region. All the existing analysis on one dimensional, from the very beginning the assumption is not right. We used that assumption before, but now we use a two dimensional ayalysis and we find all the one dimensional analysis are totally wrong.

MR. MORGAN: I don't think this is the place to get into that, but we have gotten reasonably good results. We use a one and a half dimensional analysis.

(Laughter.)

MR. JONES: Dr. Schrock, as far as your comments on RELAP 5 Version 2, as I said, I just recently talked with Ralph Landry and I think that may have some impact on how some of the monies that are in the MIST program may be spent, but I think that is going be further discussions with the PMG, et cetera. We just started talking about that, and I mean today.

(Slide.)

I would like to just basically talk about the Owners Group code assessment program. This is very preliminary. We have been talking about this for a while.

One of the things that we want to be careful of in putting this together is how does this relate to other code assessment efforts that are underway and what is the best way to spend this money. For example, should we use RELAP 5 Version 2. That might be a way to spend this money.

So this is kind of preliminary of what we have been discussing to date.

Basically what we were talking to was taking the upgraded version of the RELAP 5 code and setting it up for the OTIS facility and to benchmark the code to several of the tests that will be performed as part of the OTIS facility, the steady state boiler condenser mode test, one of the small break LOCA tests and the composite test which

is basically a transition between various cooling modes.

You start with a break with no feedwater and then after about an hour you reinitiate feedwater and you see how the system transits between the various possible decay heat removal modes and then the refill portion of a small break LOCA transient.

This effort if it goes forward in this manner will provide some data that would be helpful in assessing how good RELAP 5 is up front before it is used in some of these other code assessment areas. This is part of why it was scheduled in this manner.

As I said, it is preliminary. So don't take it as a promise that that is exactly what we will be doing, but that is at least where we are today.

Now as far as the work that is in IST contract today, there are two analysis efforts that are scheduled to be performed. I will show you the schedule for them and how they fit in within some of the major time scales of the MIST facility.

(Slide.)

The first one is to to perform a design verification analysis. This will basically be a mockup of the MIST facility after the facility specification is issued in about October and then to run it through at least one case from each of the major test categories, the

mode transition, small break LOCA, steam generator tube rupture, feed and bleed series and to determine whether the MIST facility experiences the phenomena that we see in our normal licensing type calculations and hopefully they do.

Based on what we have seen in GERDA to date, that it does step through the various, especially the small break LOCA phenomena, we feel that probably it will come out acceptable.

Obviously if the facility does not experience the desired phenomena, we would have to step back and look at where we are.

Also as part of that effort you will be able to glean some information as to atypicalities. For example, one of the comments earlier today was what is the effect of the additional metal mass in the high portions of the system during the refill from the small break LOCA. You will be able to tell how much energy is being calculated to be deposited into that mass and can by inference, I would say, figure how atypical that is to what you would expect from a small break LOCA transient.

Personally I don't feel that the volume issue is that important or the metal mass as long as you know that the facility has that and you know what it means to your analyses, because the whole purpose of the facility

again is to benchmark the codes.

MR. CATTON: Well, you have to worry about separating where this energy is going. You have got three modes and if you don't separte the three properly, when you go to the big system you are not going to know where you are at. You have got to do that. If you can separate the three properly, then you are absolutely right. I am not sure you can. We wil see.

MR. JONES: We may not be able to. I have my own personal feelings as to what is probably going to be the dominant force, but that is a personal judgment, for what it is worth.

MR. CATTON: You need to be sure that the system is instrumented well enough to separate those three paths for the heat transfer to take place, too. If it isn't intrumented enough and you are not sure of the code, you can interpret it any way you want and we are going to be open for discussion for the next ten years.

MR. JONES: I think that is part of the instrumentation question. From what I have seen of the instrumentation and where it is located and what we have, I think it should be reasonable. I am not sure how much instrumentation you can hang on a system like this either to get the information you need.

MR. CATTON: I understand that. I would hope

that at one of our future meetings we would address this and be more than just reasonably certain.

MR. TIEN: You are not really in the sense benchmarking the code. Perhaps you are trying to benchmark the models you are going to introduce more, right, and refine them somewhat better.

MR. JONES: Well, the refinements to the RELAP 5 that we are adding would be individually verified as best as possible. The compression model, the loop compression model really doesn't have anything to be benchmarked against except an isotropic type solution and to see where it lies. I think MIST is one of the places and GERDA are some of the places we will get those types of benchmarks.

The OTIS benchmarks that at least is in the preliminary code assessment planned for the B&W Owners Group, we will be looking at the refill phase and we will take a look at that portion of the model modification.

The other models such as the steam generator, they are going to be very similar to what we have in the present CRAFT code which has been verified and utilized, some plant data has been verified versus some plant transients.

The two-phased models, the interphase drag and mass transfer model, we have just got to do a better job

on that GE level swell test. That will be rerun after those changes are made.

MR. TIEN: I worry perhaps more about those international models which will be separately verified, and I am not sure how much really verified. I would like to see how you benchmark a code which has been already used many, many years. I think you really try to benchmark some models.

MR. JONES: As I said, most of the new models are going to be benchmarked pretty much separately and the purpose of this is to look at them as a whole. Really developing models out of an integral systems test is very difficult to do, if not impossible. Separate effects is the general way you want to develop the code models.

(Slide.)

Later on in the program after the facility is fully defined it will be constructed and the test plans will be further defined of how will they run these various transients in detail.

We will then be doing pretest analyses which will be used to, No. 1, provide a checkout of the code right up front in more or less a blink fashion and also later on when the data starts to come out they will be compared against the actual data to see how well the code did and also to help us understand what the facility went

through.

MR. MICHELSON: On the feed and bleed tests, there is sufficient capacity in most B&W plants to have appreciable bleed through the letdown system as a mode of heat removal?

MR. JONES: I am not sure. These feed and bleed are through the PORV safety type ---

MR. MICHELSON: Yes, that is strictly the PORV. You are not contemplating considering bleed through letdown line.

MR. JONES: No.

(Slide.)

Again, as I said, I just wanted to show you the time scale for these items.

The facility specification is due to be issued on 10/1 and the PMG approval and the consultants' report I think on 11/1.

We will then go into construction of the RELAP 5 model and the design verification analysis. They will be done in about January of 1985.

In about mid-'84 the test planning and procedures would be developed for the actual MIST facility and MIST construction, which isn't shown here, would be starting in about July of '84.

The test plans would be completed around 6/85

and we would be picking up the pretest analyses a little earlier than that running to about May of '86.

The actual testing on the MIST facility starts in September of '85 and runs to September of '86 with roughly the first four or five months being the characterization debug or shakedown tests for the facility. So that these pretest analyses will be basically done pretty much before the facility is up and producing the big test.

Then the final data reports will be developed running out until about March of 1987.

MR. SCHROCK: How do you line up the scale on that? Where is the reference point for a date?

MR. JONES: 1/1/83, 4/1, 7/1, 10/1 and then 1/1 again. They are by the beginning of quarters. The long lines are the end of the years.

MR. MICHELSON: The facility specification is ending in September of this year, is that correct?

MR. JONES: The end of September, yes.

(Slide.)

Now this is a composite test analytical schedule. It is kind of rough. I got this out of the NRC and EPRI representative yesterday and they both kind of cringed when I put it on the slide because I was committing them to some dates, but it is a pretty rough

assessment of where things are likely to happen in the near future.

You can see the data from GERDA. The final data report is due out like October 1st. The OTIS span for test data and then the MIST span shown up there, those begining triangles are were testing starts and they end where the final data reports come out.

The RELAP 5 development which we talked about completing in 4/84, the Owners Group plan will run, assuming it stays as it is right now, will run about 10/83 to about the end of '84 with hopefully some money being left over to do some possible post test analysis.

MR. CATTON: What does R-5 mean?

MR. JONES: RELAP 5. The R-5s are RELAP 5 codes.

MR. CATTON: Do you intend to do any calculations for University of Maryland or for SRI-II with RELAP 5?

MR. JONES: They will be done here by the NRC.

MR. CATTON: But that is not the same R-5 that you are doing.

MR. JONES: I am not sure which R-5 they will use. They may use the new version.

MR. CATTON: It seems to me that if you are going to prove your code you have got to use it against

the three facilities because of the skewed scaling right from the outset. If you don't do it against the three facilities, then I am not sure what it means.

MR. TIEN: I think that is according to how you benchmark your code. I think if you just check your own tests and you can adjust all the constants in your models and that would not really be much. You have to go to another facility ---

MR. CATTON: That is right, and some of the models that they will be using are different than the ones that will be used by NRC or by EPRI.

MR. JONES: Yes.

MR. CATTON: So you really need to test your models against the several facilities.

MR. JONES: I hear your comment, and all I can say now is it isn't planned.

(Laughter.)

MR. SCHROCK: He is not promising.

MR. JONES: I am not promising. I think that is something that we did discuss.

MR. CATTON: If you don't do that, we will be arguing about this for years.

MR. JONES: Yes, I hear you.

(Laughter.)

MR. JONES: I think a lot of this, especially

the comments of Version of RELAP coming out, some of how these things are being attacked and which codes will the NRC be using here for some of their efforts, certainly as we said, RELAP 5 wil_ be released to the NRC and EPRI in April of '84. So they could take their version of RELAP 5 which exists which may be Version 2 at that time for verification purposes, and our version of RELAP 5 and do it under their money. I think how this effort is integrated is unknown at this time to some extent.

MR. CATTON: If they take your code as developed by you and test it against those other programs, that is still not quite the same because it is different people and different modalization and different time constants and different all sorts of things.

MR. JONES: Yes.

MR. CATTON: Code verification is proof of the user as well as the code.

MR. JONES: The two items I just discussed at the design verification efforts shown on the slide there.

The NRC is planning to do an extensive amount of analytics with TRAC and RELAP 5. They will be setting up a plant deck for a lowered loop with TRAC and RELAP 5, or at least that is their current plans or thoughts, and we will be doing the University of Maryland test and then a series of calculations in GERDA, OTIS and MIST.

EPRI is going to be benchmarking the MMS and RETRAN codes as Jean-Pierre Sursock talked about today. They will be doing both OTIS and MIST along with the SRI-II facility and they will be also developing a plant deck in a later time frame starting about 1985.

In summary then, there is quite an extensive analytic program planned for this or at least under consideration at this time.

Certainly your comments are greatly appreciated. How they get resolved between each of the participants at this time via the PMG is certainly not my decision, but I think your comments are of help.

MR. WARD: Okay. Thank you, Mr. Jones.

Mr. Klingenfus is next.

MR. KLINGENFUS: I am John Klingenfus. I am from B&W in Lunchburg, Virginia.

(Slide.)

I am here today to discuss with you the MIST reactor vessel vent valve and downcoming scaling and reference design as it exists at this time.

The way I would like to proceed along these lines is to, first of all, go into a general downcoming reactor vessel vent valve description of the actual physical orientation in the plant. Then I would like to get into the downcomer scaling concepts, following by the

reactor vessel vent valve concepts and then a conclusion.

I don't know, but somewhere along the way today, and I guess a little bird told me, but I got the impression that you might be interested in the reactor vessel vent valve. I will see what I can do to attempt to address your concerns as I go along and reach issues which I have heard you address today and I have seen in other comments that you have presented in the past.

The way I would like to proceed along the MIST downcomer scaling is, first of all, like I said, I would like to give you an idea of what the actual downcomer is in the plant and then go over the design criteria as it relates to adequate simulation of small break LOCA behavior of the entire RCS.

Next I will present the scaling approach used for the downcomer followed by component descriptions and throughout the description I will try to point out any atypicalities and limitations involved with our scaling.

(Slide.)

The actual downcomer in a plant is an annulus that eight or nine inches wide. It extends from the top of the upper plenum to the bottom of the thermal shield and down into the uppermost flow hold in the lower flow distributor. It is approximately a 14-feet diameter annulus in which many and diverse phenomena can occur

during small break LOCA transients.

The actual design criteria that were used, we tried to consider as many of these phenomena in which the criteria, and I will be calling those out ---

MR. MICHELSON: Before you leave the slide you just had on I have a question. It may be a minor point, but maybe there is something I have always misunderstood. The vent valves there are shown as being on different centerlines as you go around. I thought they were all at the same centerline.

MR. KLINGENFUS: Were you taking these to be reactor vessel vent valves?

MR. MICHELSON: Yes.

MR. KLINGENFUS: No, they are not reactor vessel vent valves.

MR. MICHELSON: Oh, they are not.

MR. KLINGENFUS: That is a cross-section of the upper plenum assembly. Those are holes in the inner plenum assembly.

MR. MICHELSON: Wait a minute, holes in the ---

MR. KLINGENFUS: The reactor vessel vent valves themselves are in the core barrel wall. This is an inner wall.

MR. MICHELSON: Okay. I see now.

(Slide.)

MR. KLINGENFUS: For your reference in order to give you the complete picture of the orientation, this is the asimuthal cross-section here. You see the cold legs in the typical plant separated by 60 degrees on the off loop. In the actual for the loopp they are separated by 120 degrees.

Also shown here is you have the locations of the center of your reactor vessel vent valves. There are eight of them in the typical plant, two in each quadrant.

(Slide.)

The actual downcomer design criteria are presented here. Let me back up due to some of the comments today and sort of try to prioritize the actual criteria that are presented here.

For any small break LOCA, the overall RCS simulation is what we are concerned with. The reactor vessel vent valve and downcomer are naturally going to impact any small break LOCA since they provide coupling both with the overall loop circulation from the cold leg down into the lower plenum, plus an inner recirculation loop in the reactor vessel through the reactor vessel vent valves into the downcomer and back into the lower plenum.

Because of the coupling concern here, naturally we must try to come up with typical flow resistances within those paths in order that we can get

adequate simulation of the overall and the inner loop resistances and flow rates.

But going back to our overall concept, first of all, we must preserve the full bounding elevations. That would be from the reactor vessel vent valve to the uppermost hole in the lower flow distributor.

Next, we want to try to preserve phenomena in the downcomer itself. One phenomena definitely of concern to us is loop-to-loop coupling and asymmetries associated with the different loops. That will be one of our next priorities on the list.

Next, we want to try to account for steam condensation which takes place in the downcomer, the steam coming through the reactor vessel vent valve, the fluid coming from the cold leg and the HPI fluid.

Our next criteria will probably be to use exact power to volume scaling in the lower downcomer region, at least at or above the top of the core. The reason why we want to do this is to maintain the correct volumes and liquid levels in the downcomer and reactor vessel during two-phase conditions that might occur within the core region.

We also do not want to forget that the downcomer near the inlet annuluses acts as a mixing chamber, if you will, between the reactor vessel vent

valve, the cold leg fluids, HPI, core flood nozzle and LPI. All these fluids are mixing in the upper downcomer region. We want to try to consider those where possible.

Last of all, we want to try to preserve our Delta Ps in order that we approximate the plant axial and tangential flow resistances.

I think that probably covers the top five or so here and the priority that we have.

A couple of other comments that we want to also consider here is to try to develop a downcomer that will preserve overall plant symmetry and not cause asymmetry just due to the orientation of the downcomer with respect to the cold legs and links of piping associated.

Also, we want to try to minimize the atypical metal to water volumes in surface areas which is inherent in any small break model.

(Slide.)

The scaling approach we used is highlighted here for the downcomer.

First of all, we decided to separate the downcomer into two separate regions. The upper region is an upper mixing chamber in which we will try to preserve the characteristic phenomena in that region. Like I said, power to volume scale in the lower downcomer we want to

hold the exact volume and levels consistent with two-phase conditions in the reactor vessel itself.

Our No. 1 priority is to maintain the bounding elevations between the reactor vessel vent valve spillover point and the top hold in the flow distributor.

In the upper mixing chamber we have utilized an upper annular downcomer concept. This allows us quite a bit of flexibility in modeling loop-to-loop coupling in that region.

The upper downcomer, since we are talking now about a very small model with the fluid being in very close proximity to the fluid within different quadrants of the downcomer, we will use baffles to try to simulate the tangential flow resistance within the downcomer, the flow resistance between the cold legs for any cold leg driven asymmetries.

(Slide.)

Using the upper annular downcomer concept we have a sketch here of what the MIST facility might look like. This is just a sketch. I think you saw a picture that Randy had before that was in a little more detail. This is just to give you an idea of what the configuration will look like.

There will be one pipe coming off of the upper head of the reactor vessel and going through a vent valve,

which I will get into in a few minutes, and what the plan for it is right now, and one pipe then going into the upper downcomer.

While I am here, the lower plenum will have a pipe going from the bottom of the downcomer over, splitting and coming into another region of the lower plenum in the reactor vessel itself.

(Slide.)

The top of the external annual downcomer you saw and let me give you some details about it here.

The cold legs in the actual plant are oriented on 60 degrees off the loop condition and 120 degrees for the loop. In MIST we h.ve shown them as being 45 degrees in either direction.

In order to compensate for the additional flow losses, we will compensate for it by increasing or decreasing the baffle open area to account for the decreased flow resistances.

Also show here are the two core flooding nozzles which come in. This would be one loop down here and one loop up there. They come in at the center of the upper downcomer.

MR. SCHROCK: Where are the baffles that you have referred to?

MR. KLINGENFUS: That is what I am going to be

showing you right here.

(Slide.)

Taking a cross-section, and I think it might be easier to see this is I use both projectors, you have a cross section through the downcoming in an axial direction here and a cross-section then through the reactor vessel vent valve entrance into the downcomer itself.

The upper downcomer extends from, the pipe will be coming in from the reactor vessel vent valve spillover location and then it enters into the upper downcomer and the upper downcomer itself is approximately four and a half feet from the top to the bottom.

The annular concept presents us with a voided region on the inside of the inner pipe. The inner pipe will be capped at the top and at the bottom and no flow will enter in there. It will be a welded pipe.

MR. CATTON: How did you decide on the location? When I looked at your azimuthal cross-section, some of those vent valves line up a lot closer with the cold legs. As a matter of fact, I might have thought you might have overlapped them a little bit.

MR. KLINGENFUS: Granted. In the plant they do. One of the things that we have done a lot of work on is the actual mixing which occurs in the downcomer for pressurized thermal shock. There was a report that has

recently been sent to the NRC that describes that work that we did with the way we addressed the issue of mixing and the orientation of the vent valves. In that report it really doesn't make that much difference on the actual mixing that occurs.

The main issue there is that hot fluid originates in the upper downcomer itself. The buoyancy effects are significant enough that you get a pretty good mixing and pretty good coupling between the reactor vessel fluid and the cold leg in HPI fluid that is coming in.

I am not sure exactly what the title of that report was.

MR. CATTON: I have seen it.

MR. KLINGENFUS: Have you seen it?

MR. CATTON: Yes.

MR. KLINGENFUS: Okay.

MR. CATTON: It is just that here you are going to have two phase and all sorts of other things, and I am not sure you can rely on observations of buoyancy driven effects.

MR. KLINGENFUS: Well, the buoyance driven effects are enhanced by a two-phased system. There you have got steam/water rather than the mixing of single phase.

MR. CATTON: But if I have flow coming in one

of those legs and out one of the other ones, what is going to happen to the vent valves? It might be different if they are lined up with the flow than if they are not. It is just something to think about. It is getting late

MR. KLINGENFUS: Okay. I am going to attempt to address that as we go on here.

Shown over here are the elevations consistent with what we expect to see in the plant. The actual top of the downcomer in the plant is approximately two feet above the actual location of the top of the downcomer or actually the reactor vessel vent valve pipe in MIST.

We have discarded these upper two feet in order to try to minimize the excess volume in the upper downcomer. The upper downcomer is Froude number scaled.

The Froude number scaling does several things for us. It preserves the area ratios of all the inlet nozzels to the tangential flow area within the upper downcomer. That is included, and I will add there are several slides that are included in there that I will not be showing just to give you some more of the details in order to give you a more overall complete picture.

The upper two feet, like I said, are discarded in order to help the overall power to volume scale factor in the downcomer itself.

Also show here is the level at which the core

flood nozzles come in and the cold legs coming in here. The fluid then enters a single pipe going down to the lower plenum.

MR. CATTON: That comment I made earlier, I was looking at your drawing incorrectly. I was looking at the picture with the pink lines as being the open and that is really the metal.

MR. KLINGENFUS: Oh, no, that is the metal.

MR. CATTON: So your reactor vent valve is actually lined up with the cold legs.

MR. KLINGENFUS: It is on the same centerline with the cold legs, yes.

The actual holes for the reactor vessel vent valves are shown here. They are Froude number scaled, which we will get into when we talk about the reactor vessel vent valve pipe itself. There are four of them, one in each quadrant. The baffles themselves are shown here.

MR. WARD: I don't understand the vent valve opening. Where is the vent valve?

MR. KLINGENFUS: The vent valve itself, and there is a picture that I had here.

(Slide.)

The vent valve itself is right here. I am essentially just showing from here into the upper downcomer.

MR. WARD: So there is one vent valve in the pipe.

MR. KLINGENFUS: Well, the actual hardware, we are still investigating that. I will get into that in a minute. It will be actuating on the actual plant vent valve operational characteristics. I will get into that in a minute.

Right now I am not discussing the actual vent valve itself, the hardware for it, but I will address that in a minute.

MR. SCHROCK: Where does the water enter and pass through the vent valve?

MR. KLINGENFUS: I am sorry, excuse me, I forget to explain that.

The water for the vent valve is coming through this pipe after it has passed through the controller valves. It takes a 90 degree bend, enters into an upper chamber and then exits via these four holes in the inner pipe. So you will have a hole for each quadrant. Each quadrant is separated by a baffle in order to simulate the actual tangential flow resistance in the downcomer annulus.

MR. WARD: So these four quadrants give you some handle on simulating possible assymetries.

MR. KLINGENFUS: That is right. That is the

only way ---

MR. WARD: But you still only have one vent valve.

MR. MICHELSON: Only one supply.

MR. KLINGENFUS: Right, there is only one supply. There is one supply coming off the upper head and there is a single pipe coming into the upper downcomer. Now there are four holes and the preferential flow will be in the direction of the maximum Delta P naturally.

What we will try to do to get a handle on that is probably put some thermocouples in order to get a handle whether we are getting flow and what the magnitude of the flow could be into each quadrant.

The baffles, like I was saying, they simulate the flow resistance for your loop-to-loop coupling. Because the annulus itself is approximately 1.4 inches wide, it is oversized with respect to the actual scaled flow area. So what that does is lead us to flow baffles that are fairly restrictive so far as the total flow area in a tangential direction is concerned. The baffles are roughly two percent area. This flow loss is the form of form losses where in the plant you actually have a real long resistance in the downcomer itself.

MR. MICHELSON: If there were differential pressures between the various cold legs, those four holes

are just destroying the effect of that differential pressure and it essentially couples all the cold legs together.

MR. KLINGENFUS: If the differential pressure is existing between the cold legs themselves, you have a mechanism for flow moving around the annulus.

You have got essentially three feet or two and a half feet above the cold legs themselves. The flow is going to be relieved if it is from cold leg cold leg in this region right in here. See the holes in that region.

MR. MICHELSON: Maybe if you would just trace the normal flow, that would help.

MR. KLINGENFUS: Okay. The normal flow coming in the cold leg from the loop down into the inner recirculation loop, the vent valve, comes in, out the vent valve down through the quadrants and then down into ---

MR. MICHELSON: If there is a differential pressure between two cold legs the flow is straight across your diagram. It doesn't have to come down. It can go straight across. Where are the holes? May I misunderstood where your holes were.

MR. KLINGENFUS: Well, the approximate location of the holes are shown here.

MR. CATTON: No, no, those other holes.

MR. MICHELSON: Those big vent valve holes.

MR. KLINGENFUS: The vent valve holes are up here.

MR. MICHELSON: Okay. Then I will take it back.

MR. CATTON: That is a delicate balance.

MR. WARD: The flow can still come in and go up the annulus and down the middle.

MR. MICHELSON: Yes, it can.

MR. KLINGENFUS: But yet that flow resistance is going to be greater than the flow resistance through here. You have got quite a long flow there.

Like I was saying, the actual upper downcomer itself is Froude number scaled. That gives us slightly excessive volume up in that region. It does do several positive things for us.

During two-phase forced circulation it does approximately preserve our flow losses. It also preserves the flow regime that we would have in that region.

Another thing that the Froude number scaling does is it gives us in the upper downcomer itself a metal to water volume that is almost identical to that of the plant. The reason for that being that all the metal mass with the reactor vessel and core barrel and thermal shield and the actual downcomer in the plant.

Now once you get down in to the lower downcomer, the single pipe, you do have the excessive

metal volume to fluid volume.

One thing overall is you do have increased surface area of the metal to water volume. For a scale model there is nothing that you can do to minimize that. Well, we have minimized it with the Froude scaling, but you have got to live with some atypicality in that area.

MR. SCHROCK: What does Froude scaling mean in this regard? Are you talking about the normal plant operating conditions or what?

MR. KLINGENFUS: Froude scaling, essentially what it does is it preserves the area ratio of all of the nozzles within this upper downcomer region. The cold leg is Froude scaled, the core flood nozzles are Froude scaled and the reactor vessel vent valve holes are Froude scaled. It preserves typical velocities for scale mass flow rates coming into that mixing chamber, if you will.

We are trying to come up with a two-dimensional model here of actual three-dimensional phenomena that occur in the plant. In order to try to model those with this scale facility, you have all sorts of atypicalities and we are not trying to say that we are modeling the mixing in there properly.

The best handle that we felt we could get on it was by preserving the area ratios and thus getting identical or essentially scaled velocities similar to that

at the plant even though they are roughly one-fourth of the plant because of the Froude scaling.

The Froude number that we are talking about was the same discussion that we have been into before. I don't have a slide on it.

MR. CATTON: Just tell me what it is.

MR. KLINGENFUS: Chuck, do you have that on one of your slides?

MR. CATTON: You can just tell me.

MR. KLINGENFUS: It is essentially the J sub G. The Froude scaling doesn't mean that much in the actual downcomer itself because of the conditions that go on there. You really don't have any two-phase flow going through there, but it preserves that area ratio and the subsequent mixing.

MR. CATTON: To me conservation of mass conserves area ratios. I thought Froude number was essentially U squared over G Delta Row, or Row U squared over G Delta Row. There is no area or dimension or anything in it.

MR. SCHROCK: There is a D.

MR. CATTON: Where is the D, in the denominator?

MR. TIEN: Yes, that is it.

MR. SCHROCK: What about the holes in the

baffles, is there some kin ,f similar rationale for that?

MR. KLINGENFUS: The holes in the baffles are trying to approximate the tangential flow resistance around the downcomer. Because the downcomer is oversized, you have a full length flow area and an annulus that is one/sixth that in the plant. That flow area has a very large scale to it. That requires us to use a very large loss coefficient between the actual cold legs. That is for similar conditions and exact scaled flow rates, and we would expect to come very close to the same Delta P between the cold legs with this concept.

Agreed, it is approximate, and with a small scaled facility like this we are just trying to preserve as much coupling and have it as typical as possible with this small a scale model.

(Slide.)

That essentially concludes our details of our downcomer. There are some more slides given there just for your information and I will be gald to answer any questions. I think they are really getting into the details of the numbers themselves and I don't know if we really want to get into that right now.

MR. MICHELSON: I would like to go back and refresh my memory on the plenum of assembly of the reactor vessel, and that gets back to that first slide you showed

again. The reactor vessel, the cross-section where I asked the reason for the two sized holes.

MR. KLINGENFUS: That is coming up next.

MR. MICHELSON: Okay.

MR. KLINGENFUS: Next I will go into the MIST reactor vessel vent valve simulation.

I will show you the full sized hardware, its orientation in the plant with respect to that cross-section that you were interested in and I will give you the operation of the full sized reactor vessel vent valve, our design requirements as they relate in this MIST design and I will try to talk about the atypicalities and limitations as well as the concerns that you have addressed to previous speakers.

(Slide.)

Again, the reactor vessel vent vale itself, there are eight of them in the typical plant located in the core barrel wall. Its centerline is approximately two feet above the centerline of the cold leg.

MR. MICHELSON: Now the holes in the plenum are apparently positioned in front of the vent valves or are they spaced over?

MR. KLINGENFUS: I have looked at that, but I am not sure. Chuck.

MR. MORGAN: Some of them line up and some of

them don't.

MR. MICHELSON: Well, there are eight holes and eight vent valves. Are the holes not symmetrical?

MR. KLINGENFUS: There are different sized holes and some of them are raised on a different centerline. I am not sure which holes. I assume they would probably the larger ones -- well, I won't say that.

MR. MICHELSON: It looks like there are a lot of effects then. When you talk about a valve that opens at a tenth of a psi differential, you can start talking about momentum effects against the valve and so forth if the hole is lined up with the valve versus the valve being hidden behind the boundary.

MR. KLINGENFUS: We are talking about very, very low velocities and very, very small Delta Ps.

MR. ZUDANS: Those holes don't open to the valves.

MR. MICHELSON: Yes, they do.

MR. ZUDANS: They do.

MR. MORGAN: They open to an annulus and the valve is on the other side of the annulus.

MR. MICHELSON: But in some cases apparently the hole is lined up with the valve and in some cases it isn't. and I would think that that could be a significant effect on which valves are opening.

MR. CATTON: A tenth of a psi shuts the valve.

MR. MICHELSON: I am not familiar with the rationale of why the holes are there in that arrangement.

MR. MORGAN: The holes are there for steady state operation to keep the hot legs from shortcircuiting flow essentially from the peripheral bundles of the core. In other words, this is an attempt to make the flow flow up, turn around and come down. Rather than having a very low pressure spot, you might be pulling 10 percent or 15 percent more flow from the bundles that are right underneath the hot leg if you didn't have something like that.

MR. MICHELSON: That is not real clear from the drawing, but I guess some of the flow goes up through and comes out the same series of strainers on the left.

MR. MORGAN: It goes out through those holes. There is an annulus there and it goes down into the hot leg and out.

MR. MICHELSON: All right.

MR. KLINGENFUS: There is also a series of holes down by the hot leg itself.

MR. MICHELSON: That normal flow effect now disappears when we are talking about vent valve operation, but there is a new flow that is established when these vent valves open. I understood during natural circulation

nearly all these vent valves opened more or less.

MR. KLINGENFUS: Right.

MR. MORGAN: That is right. The vent valves ought to open in natural circulation.

MR. MICHELSON: Then why are they all open?

MR. KLINGENFUS: Why are they all open?

MR. MICHELSON: Yes.

MR. KLINGENFUS: The flow resistance around the annulus is very, very small. I agree that you can come up with cases in which you can look at cold leg or steam generator driven oscillations or related to the leak or HPI flows and condensations in the cold leg in which you could establish diffenential pressures around the downcomer. Because of the minimal flow resistance in the downcomer, this differential pressure propagates around the downcomer fairly quickly and all of the vent valves within a second or two are going to either be open or, if you have a case at which you really only have a very, very small differential pressure, one vent valve may crack, but the flow would only be for a very, very minimal crack and really will not impact the overall RCS.

MR. ZUDANS: Could you show in this picture which space that the vent valve will connect to which space.

MR. KLINGENFUS: Okay. The vent valve connects

to an annulus that is between the upper plenum assembly and the core barrel wall. Fluid enters this annulus through two ways, either through these holes in the upper plenum or it can come up into the upper head and then into the annulus. Whenever you experience a differential pressure from the upper head to the downcomer, the flow will come out and down into the annulus.

MR. ZUDANS: The vent valves open to a totally different space.

MR. KLINGENFUS: Yes. They go back up into the actual reactor vessel wall.

MR. ZUDANS: Then those big holes have nothing to do with the them because they do not connect with that space.

MR. MICHELSON: Yes, they do.

MR. KLINGENFUS: They do connect with this annulus here, not the downcomer.

MR. ZUDANS: The vent valves connect with the annulus that you just showed, but the big holes will never connect to that annulus.

MR. KLINGENFUS: Right.

MR. MICHELSON: Not directly.

MR. ZUDANS: Then only through the vent valves. The way the story was in the beginning, I thought on, those big holes connected with it.

MR. WARD: His point is if there are significant velocities coming of those big holes in the plenum barrel, or whatever you call it, they might cause the other fluctuations ---

MR. KLINGENFUS: That might be the case in a large break but not in your small break where you are experiencing such small differential pressures.

MR. MICHELSON: But even in the small breaks throughout the scenario those vent valves remain open?

MR. KLINGENFUS: For most small break natural circulation transients, yes. You can have cases probably with very, very decay heats or were at a ---

MR. MICHELSON: But generally they are open.

MR. KLINGENFUS: Yes.

MR. MORGAN: I will go through a short derivation tomorrow that shows that they generally are open unless there is very little heating in the core.

MR. KLINGENFUS: It is just simply an elevation head. Because the flow losses are so small within the downcomer and up through the core, it is simply a density difference in the cold void in the downcomer and the warmer fluid that has been heated by the core in the upper plenum.

The actual vent valve itself, to give you a few of the details of it, it is a 14-inch diameter valve.

The actual flow area is shown right here. It is located in the core barrel wall that we just saw.

It opens on differential pressures and will open up and its flow open orientation is 21 degrees from its original closed position. At any differential pressure, positive differential pressure from the downcomer annulus to the upper plenum region of the reactor vessel, the downcomer will be closed. Any zero Delta P will be closed also. There is a significant closing force exerted upon the reactor vent valve to keep it closed.

The actual vent valve itself opens on a very small differential pressure and I have some characteristic curves that are included in your handout. I think I have got a summary here on the next page.

MR. WARD: Why don't you remind us why they are there. Why are they there?

MR. KLINGENFUS: The vent valves?

MR. WARD: Yes.

MR. KLINGENFUS: The vent valves originally were designed for the case of a large break in the cold legs. They were to provide a path for venting steam that was being generated in the core to move to the break location itself once circulation over the ∩ bend had been interrupted by steam accumulation in that region. That was

the primary purpose of the vent valves.

MR. MICHELSON: Their operation now is really undesirable for small breaks.

MR. KLINGENFUS: No, it isn't.

MR. MICHELSON: Why not?

MR. KLINGENFUS: I believe the thing you are alluding to was that they were designed I agree for a large break. The actual design characteristics were spelled out for a large break. The actual testing of prototype vent valves and scale model vent valves show that they open on a much, much smaller Delta P than the actual criteria calls for.

The actual opening Delta P of a vent valve, consistenly it opens on an eighth of a psi and is full open on .26 psi. That is a pretty small differential pressure.

MR. ZUDANS: Then normally when you inlet is intact and functions, the pressure ---

MR. KLINGENFUS: You have a differential pressure from the pumps that holds it shut.

MR. ZUDANS: If you had a break in this, then this drain out and reduce the pressure, and if the pressure gets as low as the pressure in the plenum, then it would open up.

MR. KLINGENFUS: Right.

MR. MICHELSON: That is why it generally is open for the small break, but that just bypasses the hot water that is circulating back into the annulus. It doesn't take any heat out of it.

MR. MORGAN: If you didn't have a relief path there, you could build up pressure in the upper plenum and force the water level in the core down low.

MR. KLINGENFUS: It provides a circulation, a flow through the care.

MR. MICHELSON: But from the viewpoint of heat removal, it is not doing you any good, but from another viewpoint of a level control it is.

MR. MORGAN: Well, it is because it allows a mixture of HPI water to keep coming in. You have got a recirculation path in there.

MR. MICHELSON: But that doesn't take heat out.

MR. MORGAN: It doesn't take heat out directly, no, but it provides cooling for the core because it provides flow through the core all the time.

MR. ZUDANS: It makes it easier for water to shoot down straight.

MR. MORGAN: Right.

MR. ZUDANS: Finally I understand.

MR. MICHELSON: Althought it is not there for that purpose.

MR. MORGAN: Fortuitously it works wonders. It helps thermal shock.

MR. WARD: Let me ask you, if you have a small break in the cold leg, in order for HIP flow to go through the core, these have to open; is that right?

MR. MORGAN: These opening will help the circulation. I don't if they have to open, but their opening will increase the circulation through the core.

MR. MICHELSON: Let me ask why in the MIST do you really worry modulating that valve? Since you concede that it is always going to be open, why didn't you just put an orifice plate of some size in there and let it always be open?

MR. KLINGENFUS: The reason why we want to do that is because during the range of small break LOCA transients the Delta Ps experienced across there are small and they are within the range in a lot of cases of the just open differential pressure and the full open differential pressure. What that does is it gives us scaled flow rates coming through the vent valve.

MR. MICHELSON: I thought you said it would just open and close and that you couldn't modulate ---

MR. KLINGENFUS: That is the way it was in GERDA. We have an update that I haven't gotten into yet here. We are getting a little ahead of ourselves.

MR. MICHELSON: I am up with you.

MR. KLINGENFUS: Okay.

The actual prototype reactor vent valve operation, like I said, it opens on differential pressure. The volumetric flow rate is simply a function of that differential pressure and the local fluid conditions.

MR. EBERSOLE: Tell me, you could have synthesized that, couldn't you, in some sort of a driven valve without actually having the physical response of it as you have it here?

MR. KLINGENFUS: You mean a controller?

MR. EBERSOLE: Yes.

MR. KLINGENFUS: That is the type valve we have and I am going to get into in just a moment.

MR. EBERSOLE: Okay.

(Laughter.)

MR. KLINGENFUS: The actual loss coefficient through the vent valve is a function of the valve open area which then relates back to only a function of the differential pressure.

So where the flow through the reactor vessel vent valve is only a function of the local fluid condition and the density difference across that core barrel wall between the upper head and the annulus.

(Slide.)

(6:00 p.m.)

MR. KLINGENFUS: Based on these prototype characteristics, we have specified that the reactor vessel vent valve should be located at the spillover elevation of the prototype. This preserves our bounding elevation.

The actual vertical dimensions of the vent valve itself is not maintained exactly. It is a 14-inch valve. We will only be getting a Froude scaling there of about two and a half inches total height. Now this will impact ever so slightly the timing at which you might see steam going into the downcomer annulus itself.

The impact should be very minimal just due to the short distance as well as the way the characteristic vent valve operates. The majority of the open area is at the bottom of the valve and that is where most of the fluid flow is going to be through that area.

The simulated vent valve should produce volumetrically scaled flows for a given set of conditions and Delta P across it. The vent valve opening and closing Delta P setpoints, the just opening and full open setpoints as well as the actual flow resistance from the prototype, we want to try to be able to keep those as variables that we can use in different tests to do parametric studies to find out the impact of increasing the resistance or the setpoints at which they open and

close. Those setpoints will not be varied in individual tests. They will be held constant throughout the test.

One of the problems that Randy alluded to in GERDA, and this was something else we learned from GERDA, was that the reactor vessel vent valve needs to be fast acting for loop-to-loop asymmetries. The reactor vessel vent valve needs to react to Delta Ps that may occur due to any oscillations.

The design that we are looking at now has valves that will be controlled and be operating in probably the one to two second range.

The piping on either side of the reactor vessel vent valve is Froude number scaled to minimize excessive flow losses and any slugging in that pipeline. Additionally, it preserves the area or velocity ratios of all the fluids entering the upper downcomer region.

The reactor vessel vent valve also needs to be compatible with the reactor vessel upper head and the upper external annular downcomer components. Because of our orientation that we have, the reactor vessel vent valve in MIST must contain some length of piping associated with it because of the separation between the two.

Also the 90 degree bend into the upper plenum of the reactor vessel is somewhat atypical, but should not

impact the actual performance of the vent valves as it relates to the overall RCS performance.

MR. WARD: I find it difficult to understand. Your fourth bullet up there says it has to be fast acting.

MR. KLINGENFUS: Yes, because ---

MR. WARD: Well, wait a minute and let me finish asking the question. It has to be fast acting in order to provide good simulation of loop-to-loop oscillations. But given only one vent valve, isn't that going to be incomplete? I mean you are never going to be simulating modeling experimentally the full story on loop-to-loop oscillations with only one vent valve.

MR. KLINGENFUS: Okay. You are right. I said that incorrectly.

Given changes in differential pressures from the upper head to the downcomer itself, it may be impacted by what goes on in the one cold leg as opposed to the other. Let's say we got the case in which one loop is stagnant and the other loop is circulating. In that case it would be driven.

What goes on in the downcomer is essentially driven by what would go on in one loop, and in that respect it would be a loop-to-loop asymmetry. But it is essentially the overall differential pressure that we are concerned about from the upper head to the downcomer

itself.

The actual hardware that we are proposing now will probably consist of several small valves which will approximate the opening characteristics of the eight full-sized reactor vessel vent valves in the plant.

The smaller valves allow us to go with a faster acting cost effective valve that will be able to approximate the intermediate operation of the reactor vessel vent valves. Each valve will probably be opened as the differential pressure increases to give you a larger area which will produce a volumetric scaled flow once we know the flow characteristics of the actual hardware that we get. That is still under investigation. That is the way it exists right now.

MR. MICHELSON: Could you bear with me for a moment and answer a question on the small break LOCA situation wherein you are in the boiling condensing mode of the scenario and the water levels have dropped down perhaps even into the reactor vessel. Now this means that there is steam leaving the upper plenum, going out to the hot leg, condensing in the steam generator and cooler water returning through the cold legs. At the same time, however, the vent valves apparently are open and there is steam passing directly through the vent valves into the cold water that is returning, or over the interface

somehow the cold water is returning, and that condensation is going on there and heating that water a little bit as it comes back through the core. Now is that going to be simulated here, and is that in the models, the calculational models?

MR. KLINGENFUS: The actual condensation that occurs in the steam coming through the reactor vessel vent valve, there have been tests that have been done to determine the condensation of that steam on the cooler HPI. That data is proprietary. It was done by BBR.

That data did enter into the actual sizing of the upper downcomer and I think that is essentially all we can say about it.

MR. MICHELSON: There is a condensation phenomenon occuring there and that is in your calculations?

MR. KLINGENFUS: Consideration was included.

MR. MORGAN: It was included in the GERDA tests and we will talk about that tomorrow, too.

MR. MICHELSON: Unfortunately, I will not be here.

In your loop design for the MIST how is that condensation taken into account? Will steam actually be passing through the vent valve in this design and it will be condensing as it comes into that chamber that you

designed with the baffle plates and so forth?

MR. KLINGENFUS: Right.

MR. MICHELSON: Is that a hydraulically smooth process? Since you are bringing steam into a relatively colder water interface, sometimes that goes rather dramatically.

MR. KLINGENFUS: There is no way that we could simulate that hydraulically similar to what is in the plant. Your surface areas are not the same.

MR. MICHELSON: But if you get fast condensation intermittently, that begins to create oscillations and hydraulic disturbances that may change your answers somewhat.

MR. KLINGENFUS: They should exist in the plant also if there is steam coming in with cold water ---

MR. MICHELSON: Of course, we haven't had this kind of an accident necessarily and watched it.

MR. KLINGENFUS: If it exists in the plant it should also exist here because you should have similar conditions.

MR. MICHELSON: Well, I don't know that we have ever looked for it in a plant because we haven't had an oppportunity to look for it except perhaps at TMI and they were not looking for that sort of thing.

Okay, I realize how it works at least I think.

MR. KLINGENFUS: That essentially concludes the discussion that I had on the reactor vessel vent valve and the downcomer configuration.

I have got some conclusions here.

(Slide.)

The reactor vessel vent valve and downcomer in MIST preserve the bounding elevations, our No. 1 priority for our MIST scaling.

The external annular downcomer maintains characteristic prototype geometry similar to that in the plant which can also preserve cold leg to cold leg coupling and approximates the overall major phenomena which may take place in the downcomer, at least that aspect that impacts the overall RCS response to a small break LOCA.

Granted in a scale model facility, there is no way that we can model all the multi-dimensional effects and the downcomer is definitely three-dimensional effect. The only way that you could determine the multi-dimensional effects is in order to have different separate effects tests.

We are not trying to use any of the data for any mixing associated with different tests. We are just trying to preserve the overall major effects and coupling of the inner recirculation path and the overall loop

circulation paths.

Like I said before, the orientation of the reactor vessel vent valve is somewhat atypical, but it still should produce volumetrically scaled flows for similar conditions in the plant.

The downcomer and reactor vessel vent valve are not identical to the plant and they cannot, like we said, model all the phenomena, but they should be able produce effects related to the overall RCS interaction and behavior during small break LOCA transients.

MR. ZUDANS: In the beginning you said that the facility would be designed to go up to 10 percent of total power, right?

MR. KLINGENFUS: That is the way the tests are.

MR. ZUDANS: How many of these tests that are listed in your matrix could you do on the actual facility?

MR. KLINGENFUS: I am sorry, I don't understand your question.

MR. ZUDANS: There are a number of reactor systems that exist which you attempt to model with this facility. The question is how many of the tests in your matrix for this facility could be done on the actual facility, one of your plants?

MR. MORGAN: I don't think you could really do any because the actual plants don't have fine enough

instrumentation.

MR. ZUDANS: Is that the only reason or is it a physical limitation?

MR. HOLLOWELL: There are no physical limitations, but you have to remember you would be running an experiment on a core that had decay heat. You have to have the decay heat in the core. So then you have to allow the water levels to drop down near accident levels.

MR. ZUDANS: Well, I didn't say all. I say how many of them you could do?

MR. HOLLOWELL: Well, we will be writing supplements of natural circulation tests. Some natural circulation tests have been run and we plan other natural circulation tests on Midland.

MR. ZUDANS: If you look in the time scale between now and maybe, what, '86, before you are really finished with this one and you do all kinds of testing on real plants, then I am wondering how many of these real questions that you want to solve with this facility, not that you shouldn't do it, could be done on a real facility which would make this facility so much more valuable because you could benchmark it properly? You can't do it?

MR. MICHELSON: I think your answer is essentially none because you don't want to go beyond normal natural circulatory arrangements on a billion

dollar nuclear plant.

MR. ZUDANS: I didn't say you had to do all of them, but I am sure some you could do.

MR. MICHELSON: The natural circulation has been done very well in plants that have lost off-site power. We haven't always gotten all the information that was needed, but those are good tests from full power to natural circulation.

MR. ZUDANS: There are so many things that you have to compromise, not that they are not good, that it becomes a major effort to understand what you get in a facility like this and how to translate it into conclusions to the real facility.

MR. MICHELSON: It is the only place where you can lower the levels way down and watch steam bypassing through vent valves and mixing with cold water. You wouldn't ever do that in a real plant.

MR. ZUDANS: Well, I am sure, but if you could have tests that you had to do on a real plant and somehow benchmark them to this facility and get a better translation of your results, it wouldn't be a bad idea.

MR. EBERSOLE: A new core that has got no decay energy in it, you can turn it off like that.

MR. ZUDANS: Yes.

MR. EBERSOLE: So it doesn't have a long-term

hazard potential to itself I mean.

MR. ZUDANS: And you have all the fluid dynamics you want. It is all sitting there.

MR. EBERSOLE: If you could just lock it at no more than "X" percent power and then trip it.

MR. ZUDANS: Well, I had to say it because that is what I normally say. I think some day you will find a way to use the actual plants.

MR. MORGAN: Well, there have been many people who have suggested that that is a good use for Midland.

(Laughter.)

MR. HOLLOWELL: We do plan some natural circulation tests at Midland, but they are primarily to show that we can establish a natural circulation mode and get a cooldown rate.

MR. EBERSOLE: It is very safe if you keep the core covered and if you don't have any decay energy in it you can switch it off like a light.

MR. MICHELSON: Are you willing to give a billion dollar plant up for that purpose?

(Laughter.)

MR. EBERSOLE: If I wanted to know how it worked bad enough.

(Laughter.)

MR. MICHELSON: You would have to be pretty

desperate.

MR. ZUDANS: Well, I certainly understand that you can't just do it, but there might be some of the particular aspects that you could check out without endangering the plant.

MR. MICHELSON: Well, I think the staff suggested that they use operational experience to date in that regard such as ANO 1 and Oconee and a couple of others.

MR. ZUDANS: There is a lot of it, too.

MR. MICHELSON: You can learn some but not a lot.

MR. WARD: Mr. Schrock has a question.

MR. SCHROCK: Well, I wanted to give my reaction to the design of the downcomer, first acknowledging that it is certainly a near impossible problem to scale this. I think you have got a design that excessively complicated. I don't think it even preserves very well the hydraulic characteristics for single-phase flow in terms of the operation of the vent valves. I mean it fails to acknowledge that one valve may be opened while the others are closed and so forth. So it is not going too well in simulating the loop-to-loop interactions.

For two-phase flow I think it is bound to be way off the mark. I think that there must be severe

distortions in the phenomena that occur in the real plant.

I wonder if in the evolution of this design it was ever cons.dered to have three parallel downcomers each of them interacting with a single vent valve to the upper plenum of the core and then joined together at the bottom? It would be so much simply hydraulically and it would behave in a way, in my mind at least, that has some better chance of approximating what happens in the real plant.

I just am concerned that this one is not going to do that and that it is going to produce some funny things, but those funny things aren't going to relate to loop-to-loop interactions in the full-scale plant.

That is only a comment, and the question, was that ever considered to use four parallel downcomers and each one of those having a vent valve interaction with the upper plenum with interconnection vertically along the way?

MR. KLINGENFUS: Different configurations were considered. A configuration similar to what you are describing, we had considered two downcomers connected.

You are talking now about very small pipes which to try to preserve any coupling between the actual loop as well as the flow through resistance is as much of a problem with that idea as with the actual concept that

evolved.

With four you are going to even smaller pipes. Even Froude number scaled they are very, very small diameter pipes. That excessive volume that you would have, if you went with a reasonable size pipe ---

MR. SCHROCK: How do they compare with cold leg pipe sizes? They carry the same fluid.

MR. KLINGENFUS: I am not sure exactly what the ratio of the cold leg area to the downcomer area is. I believe that they definitely would be smaller than the cold leg pipe itself to some extent.

MR. MORGAN: One of the considerations I think that was paramount here was you would have to have interconnection between the pipes and several different axial elevations. Then it gets to be just, or if not more complicated, hydraulically than what we have.

I think from what we have seen, the oscillations that occur are driven by the flow from the cold legs to the downcomer annulus. They are not driven by the vent valve operation or anything like that. They are driven by condensation on fluid coming from the cold legs.

If you had four isolated downcomers or two isolated downcomers and if you had cold flow coming from one leg, in the actual plant that condensation and resulting pressure transients are going to be propagated

very quickly around the entire annulus in the plant.

It wasn't clear to us that if we had separate downcomers that we could really propagate this in the same fashion that it would occur in a plant, and I think that is probably the driving reason why we ended up with an annular downcomer concept.

MR. KLINGENFUS: And additional complication due to the connections and instrumentation needed to determine what is going on.

One thing that I would like to add to what Chuck said. The interactions he said were driven in the cold leg. There could also be steam generator or pump or leak driven asymmetries in the case where you might be starting one pump in a loop or a leak in one cold leg or one steam generator working and the other one not.

Those are the predominant reasons for the oscillations in the plant. They are not driven by the reactor vessel vent valve like you said. The reactor vessel vent valve itself simply responds to those changes.

MR. SCHROCK: I didn't say they were driven by them, but they respond to conditions locally and in this design they cannot do that. In fact, you can have flow backward through those orifices that could not occur through the vent valves.

MR. KLINGENFUS: Through the orifices, yes, but

it cannot go through the actual control valve because it will close down if the Delta P reverses. It actually will open and close on that differential pressure.

MR. MICHELSON: Why was it that you didn't go to a check valve for this purpose?

MR. KLINGENFUS: The problem with a check valve is trying to determine the actual position for given differential pressures and trying to know what the actual characteristics of that check valve are.

MR. MICHELSON: Yes, but it sure responds faster to the differential pressure.

MR. KLINGENFUS: It responds faster, but you have other conditions that put uncertainties into your actual modeling and it may drive uncertainties in the actual response of the plant if that vent valve ---

MR. MICHELSON: You must admit that there are uncertainties when you delay your valve action several seconds.

MR. KLINGENFUS: We are talking one to two seconds now.

MR. MICHELSON: That is true. You said it would be faster.

MR. KLINGENFUS: Much quicker than what we were before. That was one of the reasons for the change in valves.

MR. CARTER: Another consideration is the fact that we had the external downcomer. We looked at the check valve initially and the fact that the thermal expansion of the downcomer reverses the reactor vessel is different. It only takes a very small elevation change and you are changing the characteristics of that flapper check valve. We couldn't see a very clear way of how to prevent the two from being slighlty different, and in different parts of the test actually we changed the characteristics of the flapper valve in there.

MR. MICHELSON: Yes, but I suspect that you will find that your differential pressure measurement is not all that great either for control and that could also vary during the experiment.

MR. WARD: One more question and then we should get to our last speaker.

MR. ZUDANS: Clearly you have something else in mind since you are essentially saying that it is very difficult to have it modeled in such a way that it represents the real thing. So what is it that you plan to derive, a better analytical method that you can then use on the real thing, or what is the key argument in your own mind, because clearly it is not going to be the real thing?

MR. KLINGENFUS: I don't think that we are

trying to model a phenomena that take place in the downcomer with respect to ---

MR. ZUDANS: Well, there are many other things. The downcomer is only one item.

MR. KLINGENFUS: We are trying to preserve phenomena in this facility, in this one-dimensional facility such that we obtain chacteristic phenomena as defined by the points of interest earlier with Brian Sheron and Mary Ellen as they were trying to define the key points of interest in small break LOCA transients.

MR. ZUDANS: I see.

MR. KLINGENFUS: We want to try to simulate those as close as we can. Any type of three-dimensional analysis would have to be separate effects. There have been some done.

There is one other thing that I would like to point out that may have raised a question in your mind earlier when Y.Y. was talking about large differential pressures around the downcomer annulus.

I believe that was a large break test that he was talking about in the cold leg. There you have definitely inertial driven flows. They are not there in a small break LOCA.

MR. ZUDANS: So you expect that the bulk of the key questions that you want to ask of this model, that the

answers will be applicable to the real thing.

MR. KLINGENFUS: Yes, so far as the overall RCS operation. Yes, we do.

MR. MICHELSON: I had better get one minor point clarified then. It would appear that if it became a question later of the vent valve operation and this timing and so forth, that it wouldn't be too difficult for at least one test to put a check valve, for instance, in place of your pressure control valve to see if there are some strange things happening in responding to fast differential pressures.

MR. KLINGENFUS: It would be one of the easier things to change. Now still you are talking about a pretty long time frame there.

MR. MICHELSON: Oh, I don't think we are talking about a very long time frame to put a check valve in or a control valve.

MR. KLINGENFUS: Well, it has to be designed to the flow characteristics of the valve and you have to design some type of proximity probes and get that in a sealed system. You have got a lot of engineering questions raised there also.

MR. WARD: Okay. Mr. Hollowell.

MR. HOLLOWELL: My name is Tom Hollowell and I am from Consumers Power Company.

(Slide.)

I am representing the B&W Owners Group on the PMG and I have been involved in the TAG activities from the start.

I wanted to just briefly summarize what the PMG is about, what the purpose is and what the duties are.

There are four members, as Ralph Landry said this morning, myself, Mike Young from NRC, Chuck Morgan from B&W and Jean-Pierre Sursock from EPRI.

The purpose is to provide representative management from all four representatives on a panel which will oversee the functioning of the project.

The duties include monitoring the technical program details and directing B&W's efforts on the overall job and monitoring and controlling schedules, controlling the costs within major tasks. The program has been divided into major task areas, each one having a budget within itself. To provide feedback to the organization being represented, and I think that is pretty clear, and to obtain organizational approval for major program changes.

Most of the program deviations that will be encountered will be decided within the PMG, but occasionally if we have a major change, we would have to go back and get approval from our sponsoring organizations.

So that is the functioning of the PMG. We will meet about once a quarter. That is what they told us anyway and we have already scheduled two meetings.

(Laughter.)

(Slide.)

These are the major milestones and you heard these dates, and in some cases you have heard different dates for the same milestone. But this is the official schedule of milestone dates from the contract here.

You can basically see that it is divided into two parts, the OTIS program and the MIST program.

The GERDA data is already available and you will see some of that tomorrow

The GERDA facility itself will be available to us for modifications on October 1st of this year. That is when it will be turned over to us to modify for OTIS. Those modifications for the OTIS program will be completed on February 1st of next year. The testing will take about two months and be finished April 1st, and the final report from OTIS would be issued about November 1st of next year.

Then the rest of these milestones have to do with MIST.

The facility specification, it will be in final form by about the 1st of October or the end of September, but our final approval of it is scheduled for

the end of October.

There will be some individual items that we have to approve before that in order to meet the schedules for acquiring major items of hardware.

Building modifications is a major task to be finished by the 1st of April next year.

Then the loop reconfiguration meaning disassembly of the OTIS facility and removal of the steam generator and those components that are need for MIST, that will start next July 1st. So you see that falls three months behind the completion of the OTIS test here.

The total construction then will be done during this period here, and the loop hydro test is scheduled for about one year later, July 1st, 1985.

Then the testing phase is really in three parts. The debug testing will be until December 1st and then the characterization tests which are really separate effects tests and the composite tests which are system tests will be finished in two phases, with the last phase being completed September 1st, 1986.

Then a final report is scheduled to be issued on March 1st, 1987.

MR. ZUDANS: Are you finished?

MR. HOLLOWELL: Yes, I am finished.

MR. ZUDANS: One question has been bugging me

all day long and I as ashamed to ask it. What is the precise difference between your IST and PMG?

MR. HOLLOWELL: IST is the name of the program, Integral System Test Program. Now that is the name of the entire program, including OTIS ---

MR. ZUDANS: Okay, and the PMG?

MR. HOLLOWELL: The PMG is the Program Management Group.

MR. ZUDANS: It is the group that manages that program.

MR. HOLLOWELL: Right.

MR. ZUDANS: And it is still the same members as in the other one?

MR. HOLLOWELL: Well, IST isn't a group. IST is the name of the program itself.

MR. ZUDANS: Oh, just the name of the program. So it is not a physical entity. The PMG is a legal entity.

MR. HOLLOWELL: It is a group of four.

MR. EBERSOLE: Is there one representative from each owner?

MR. HOLLOWELL: No, I am representing all of the owners.

MR. EBERSOLE: Does it have a counterpart to yourself for each owner?

MR. HOLLOWELL: Well, the way we are set up

within the B&W Owners Group, we have an Executive Committee, a Steering Committee and then we have subcommittees. This particular area is covered by our Analysis Subcommittee and each utility has a member on the Analysis Subcommittee and Bob Detrich is Chairman of the Analysis Subcommittee. I am acting now for the Analysis Subcommittee on this particular program and I will be reporting back to the Analysis Committee.

If there are major funding changes, then I would have to go back to the Executive Committee.

MR. EBERSOLE: May I ask who represents Bc lefonte?

MR. HOLLOWELL: Bob Bryan.

MR. EBERSOLE: Of the laboratory?

MR. HOLLOWELL: No, he is in Knoxville.

MR. WARD: Any other questions for Mr. Hollowell?

(No response.)

MR. WARD: Okay. Thank you.

MR. MICHELSON: Let me ask one thing to make sure I understand.

MR. WARD: Okay.

MR. MICHELSON: Both OTIS and GERDA and whatever is done with the GERDA data, plus the OTIS and plus the MIST is all under a joint NRC effect and so

forth.

MR. WARD: Plus the University of Maryland and the SRI programs, part of IST.

MR. MICHELSON: That is also in that same package that is being managed by you people.

MR. HOLLOWELL: Right. Now the Owners Group, our participation is divided into parts. For one thing we are purchasing the GERDA data. That is one of our major financial contributions. We are providing a million dollars approximately for the benchmarking computer work and we are providing also a substantial cash contribution to the program, the Owners Group.

MR. MICHELSON: But that whole Owners Group, I mean the entire project is being jointed sponsored, including the GERDA work that is left, plus OTIS and so forth, the whole package and the University of Maryland.

MR. HOLLOWELL: Right, and the entire package is called the IST program.

MR. ZUDANS: The IST program is not a legal entity this way. It is just a name.

MR. HOLLOWELL: The University of Maryland program is not part of that and neither is SRI-II.

MR. ZUDANS: The PMG though is an organizational unit, right.

MR. HOLLOWELL: Yes.

MR. MICHELSON: So it is just the MIST, the OTIS and whatever you are still doing on GERDA.

MR. HOLLOWELL: Right.

MR. ZUDANS: You know, we manage to get confused.

(Laughter.)

MR. MICHELSON: That is what I thought it was.

MR. WARD: So the NRC is financing the University of Maryland and the SRI programs.

MR. HOLLOWELL: No. SRI is EPRI.

MR. WARD: Both of them.

MR. HOLLOWELL: Yes.

MR. ZUDANS: And the PMG is responsible for all the facilities that are being built.

MR. HOLLOWELL: No. PMG is responsible for OTIS and MIST.

MR. ZUDANS: Then why did you list all the others?

MR. HOLLOWELL: GERDA was built by B&W and BBR.

MR. ZUDANS: That we know.

MR. HOLLOWELL: And that was program was completed by B&W and BBR.

MR. ZUDANS: And now pieces of it are going to be taken out and used in OTIS?

MR. HOLLOWELL: Right, and that represents part

of B&W's contribution.

MR. ZUDANS: Good.

MR. HOLLOWELL: The buying of the data from the Germans, the Germans owned the data, the buying of the data from the Germans for use in this program is the contribution of the Owners Group.

MR. WARD: Okay. I don't think we have it straight, but probably it is not important right now.

(Laughter.)

MR. WARD. Go ahead, Mr. Sursock.

MR. SURSOCK: For the record, the SRI program is solely sponsored by EPRI.

MR. WARD: And the University of Maryland program is sponsored by whom?

MR. HOLLOWELL: NRC.

MR. WARD: The NRC, okay.

Well,in the interest of saving time, let me try to give a summary of what I think is a consensus of what would represent the subcommittee' position on this program at the present time, and when I finish the other members and consultants can comment on that if they would like, particularly if they have differences.

I think compared with where we were two years ago in this sort of activity that the subcommittee is very pleased to see that all these resources have been brought

together under one name or another to address what we are seeing as several major safety issues concerning the B&W reactors.

I think that before today we didn't all appreciate the comprehensiveness, for example, of the Univerisity of Maryland program and the SRI program, and that probably will have a considerable influence on our opinion.

I think regarding MIST certainly as the centerpiece of the overall program, and I guess it must be the most expensive part, I think at the present time that we are not able to take the position that we agree fully with the choice of the design for MIST.

I think what is missing is the sort of thing that we brought up early this morning. So I want to address this to the staff. Mike, you are the only one here.

(Laughter.)

MR. WARD: I think what we are going to need is a more systematic and comprehensive story from you assessing the ability of each one of these proposed experimental programs to deal with the safety issues.

I would suggest that you are pretty far down the road and it looks to me like the MIST system, if the design isn't all on paper yet, maybe the ink isn't quite

dry, but it is getting close. I think the committee is going to want to take a position on it and, as I say, our position right now is not one of endorsing it. I think we need to be convinced further.

So what I would like to do is arrange for another subcommittee meeting, and I think the burden should be on the staff to prepare material for that. What I would like to see is really a listing of the several issues, and really the TAG group has done this pretty well, but with priorities assigned, and then with your evaluation of how far each of the experimental programs is going to go in providing effective data for resolution of those issues. I think that is the sort of thing that hasn't really come across clearly today.

I think it is clear that there are some powerful resources behind the MIST program and something very good is going to come from it, but whether it is the optimum program, I think those of us on the subcommittee are still unclear.

Are there other comments?

MR. MICHELSON: I think I would endorse everything you said. I would like to state, however, that in the case of the vent valve simulation, that is a real tough problem. I had perhaps more concerns about it before today than I do now. Unfortunately, I won't hear the

information tomor ,w that might even alleviate the concerns further, but the vent valve simulation I think, other than for the possibility of using a check valve instead of a flow control valve is perhaps about as good as can be done at least as near as I can see it. So I don't have any other reservations other than I think there ought to be a clear indication of why they use a flow control valve instead of a check valve to simulate the check valve.

The other item that I feel rather strongly about and haven't heard any discussion of, but I have asked the question, and that is why aren't we considering spraying the U bend as a means of getting rid of condensible vapors and re-establishing natural circulation in certain situations. Maybe for our next subcommittee meeting they could just tell us why spraying the U bend is not a good idea and then I would be willing to accept it.

The other area which I have some concern with is the selection of the tests to be performed, and that would have to be the subject of the next meeting. There I think I have already indicated what my concerns are and it is just a matter of getting answers to those questions on the next go-round.

I believe that takes care of it.

MR. EBERSOLE: My only comment was I would like to see a much more definitive list of the actual tests that we intend to do and a validation that we can do it in fact with this facility as it has been described to us.

MR. WARD: Zenons, did you have anything else?

MR. ZUDANS: No more.

MR. WARD: Virgil?

MR. SCHROCK: I agreed with everything you said, Dave.

I would just add that in regard to my earlier comments on the vent valve design or the downcomer design that we might want to have a look at the problems of modeling that with RELAP 5 or even TRAC for that matter. I think the design itself is creating problems for the computer simulation of the experimental system.

MR. WARD: Okay. Thank you.

Does anyone else want to add anything?

(No response.)

MR. WARD: Okay. We will recess now and reconvene at 8:30 in the morning, and tomorrow morning's session will be proprietary. So anybody who shouldn't be here, don't come.

(Laughter.)

MR. WARD: Thank you very much.

(Whereupon, at 6:50 p.m., the subcommittee recessed, to reconvene in proprietary session at 8:30 a.m., Friday, July 20, 1983.)

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CERTIFICATE OF PROCEEDINGS

This is to certify that the attached proceedings before the Advisory Committee Committee on Reactor Safeguards Subcommittee on Emergency Core Cooling Systems held at the Babcock & Wilcox Alliance Research Center in Alliance Ohio on July 19, 1983, were held as herein appears, and that this is the original transcript for the file of the Nuclear Regulatory Commission..

Mary C. Simons

Official Reporter - Typed

Mary C Simons

Official Reporter - Signature

MIST RVVV AND DOWNCOMER SCALING
AND REFERENCE DESIGN

JOHN KLINGENFUS
B&W

ACRS MEETING IN ALLIANCE, OHIO
JULY 19, 1983

MIST DOWNCOMER SCALING

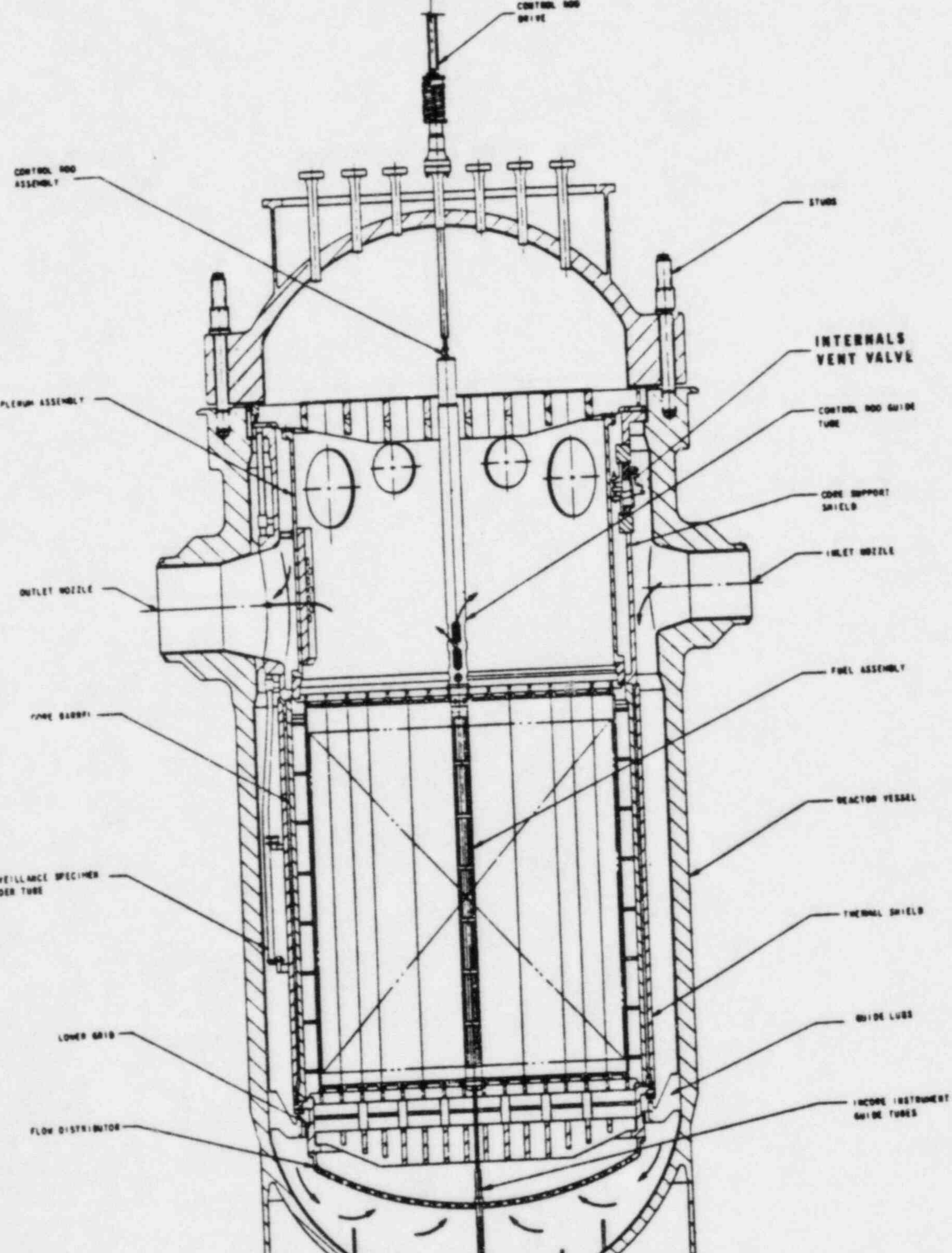
I. DESIGN CRITERIA

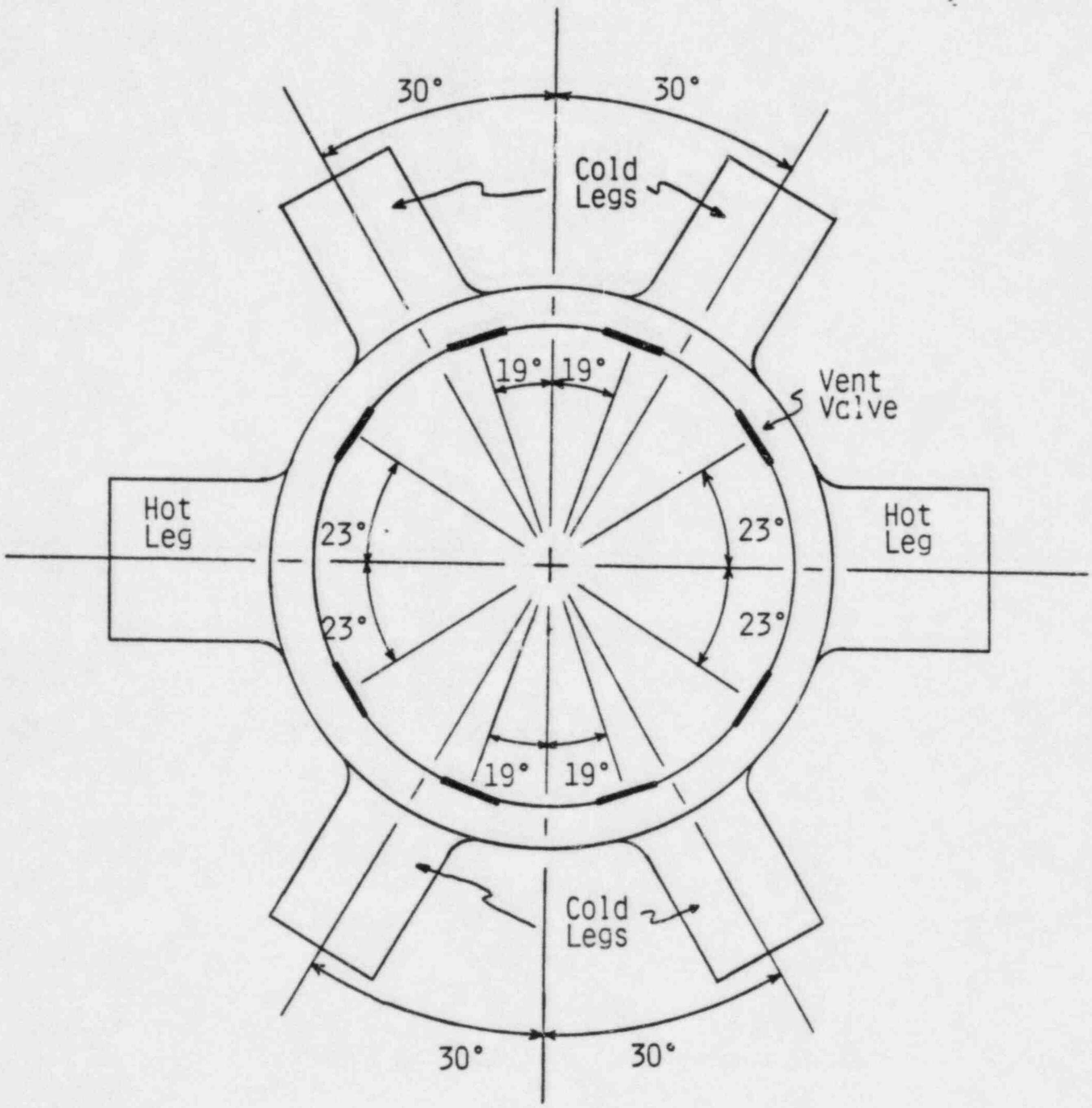
II. SCALING APPROACH

III. COMPONENT DESCRIPTION

IV. ATYPICALITIES AND LIMITATIONS

Figure 4. Reactor Vessel Arrangement





AZIMUTHAL CROSS-SECTION OF THE REACTOR VESSEL

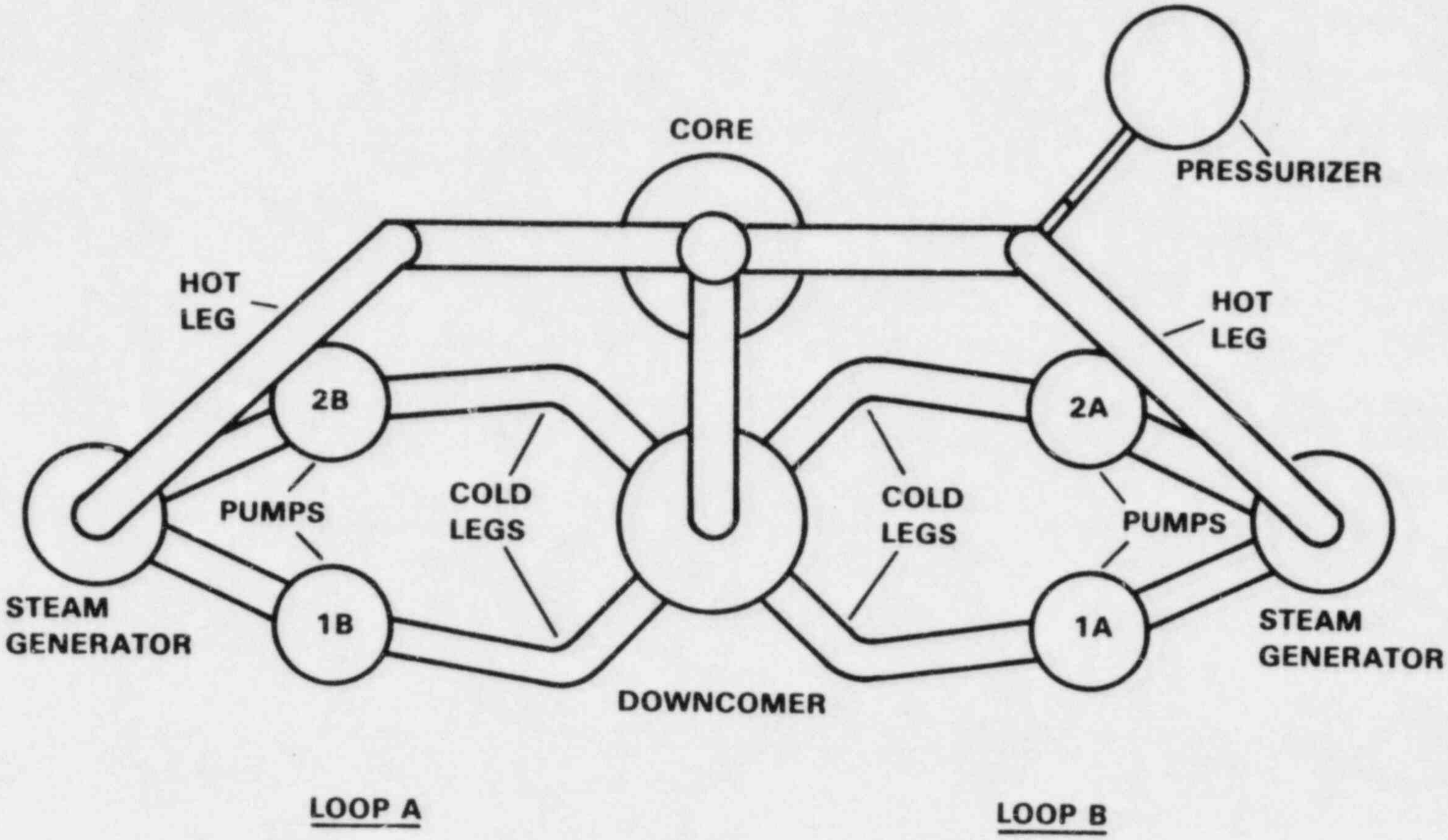
DOWNCOMER DESIGN CRITERIA

- MAINTAIN EXACT POWER-TO-VOLUME SCALING BELOW TOP OF CORE.
- PRESERVE CHARACTERISTIC PHENOMENA AT COLD LEG NOZZLE REGION ASSOCIATED WITH THE HPI, COLD LEG, RVVV, AND CORE FLOOD NOZZLE FLUID STREAMS DURING SINGLE AND TWO-PHASE CONDITIONS.
- MAINTAIN TYPICAL BOUNDING ELEVATIONS.
- PROVIDE COLD LEG-TO-COLD LEG COUPLING FOR ASYMMETRIC LOOP OPERATION.
- APPROXIMATE PLANT AXIAL AND TANGENTIAL FLOW RESISTANCES.
- DEVELOP A DOWNCOMER WHICH WILL PRESERVE OVERALL PLANT SYMMETRY AND BE COMPATIBLE WITH THE LOWER PLENUM AND RVVV COMPONENTS.
- MINIMIZE ATYPICAL WATER-TO-METAL VOLUMES AND SURFACE AREAS.

DOWNCOMER SCALING APPROACH

- SEPARATE THE DOWNCOMER INTO AN UPPER MIXING CHAMBER AND LOWER POWER-TO-VOLUME SCALED PIPE TO PRESERVE GOVERNING PHENOMENA.
- PRESERVE THE BOUNDING ELEVATIONS BETWEEN THE RVVV SPILL-OVER POINT AND THE TOP HOLE IN THE RV FLOW DISTRIBUTOR.
- UTILIZE AN UPPER EXTERNAL ANNULAR MIXING CHAMBER IN THE REGION NEAR THE INLET NOZZLES.
- SIZE THE UPPER DOWNCOMER USING BAFFLES TO SIMULATE TANGENTIAL FLOW RESISTANCE BETWEEN THE COLD LEGS.

MIST System Sketch



SIZING OF ANNULAR UPPER DOWNCOMER

- THE MIXING CHAMBER IS SIZED BY PRESERVING THE RATIOS OF THE INLET NOZZLE FLOW AREAS TO THE DOWNCOMER AXIAL FLOW AREA, WHICH RESULTS IN FROUDE NUMBER SCALING.

- FROUDE SCALING ALSO APPROXIMATELY PRESERVES:

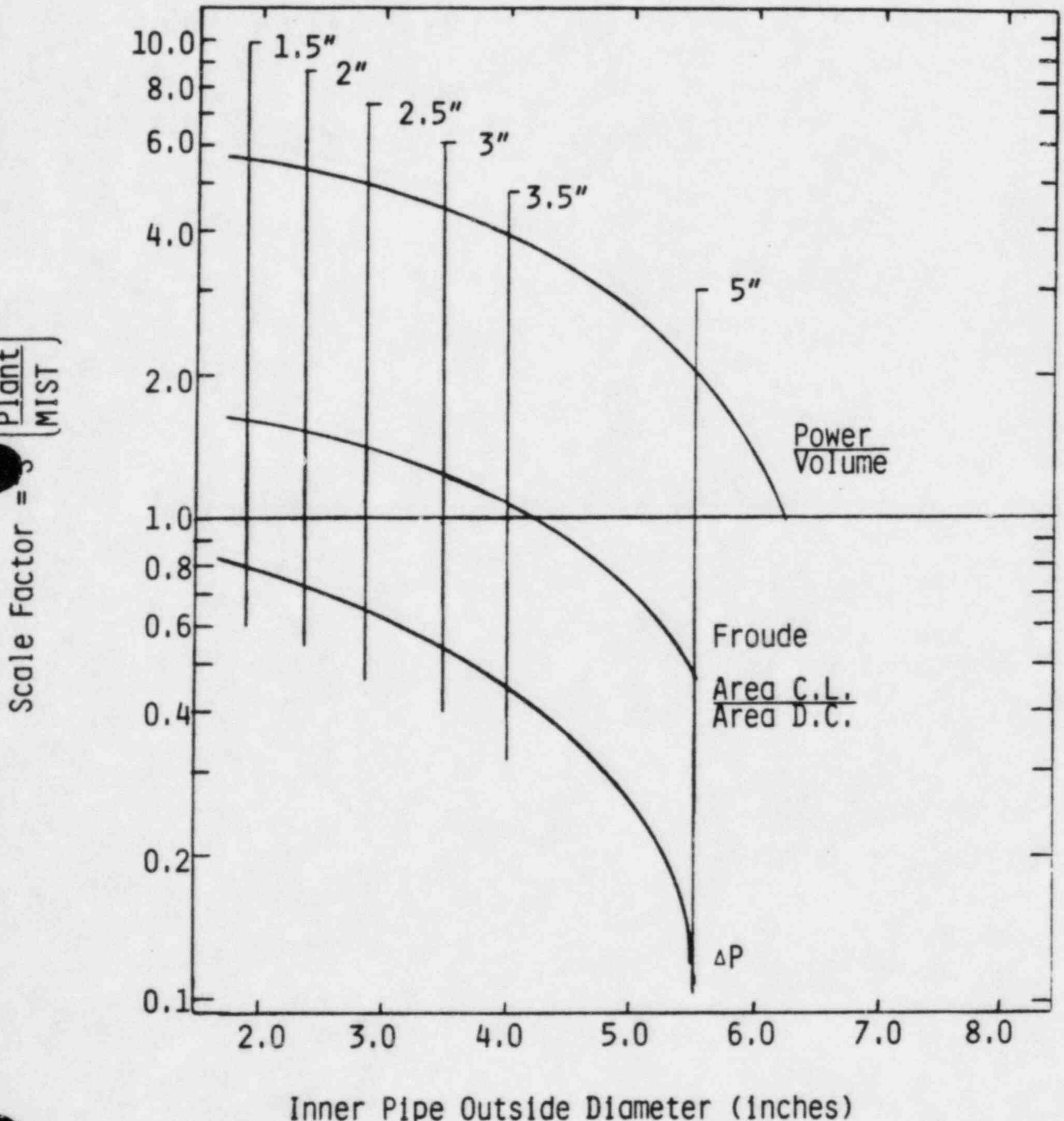
  - IRRECOVERABLE FLOW LOSSES

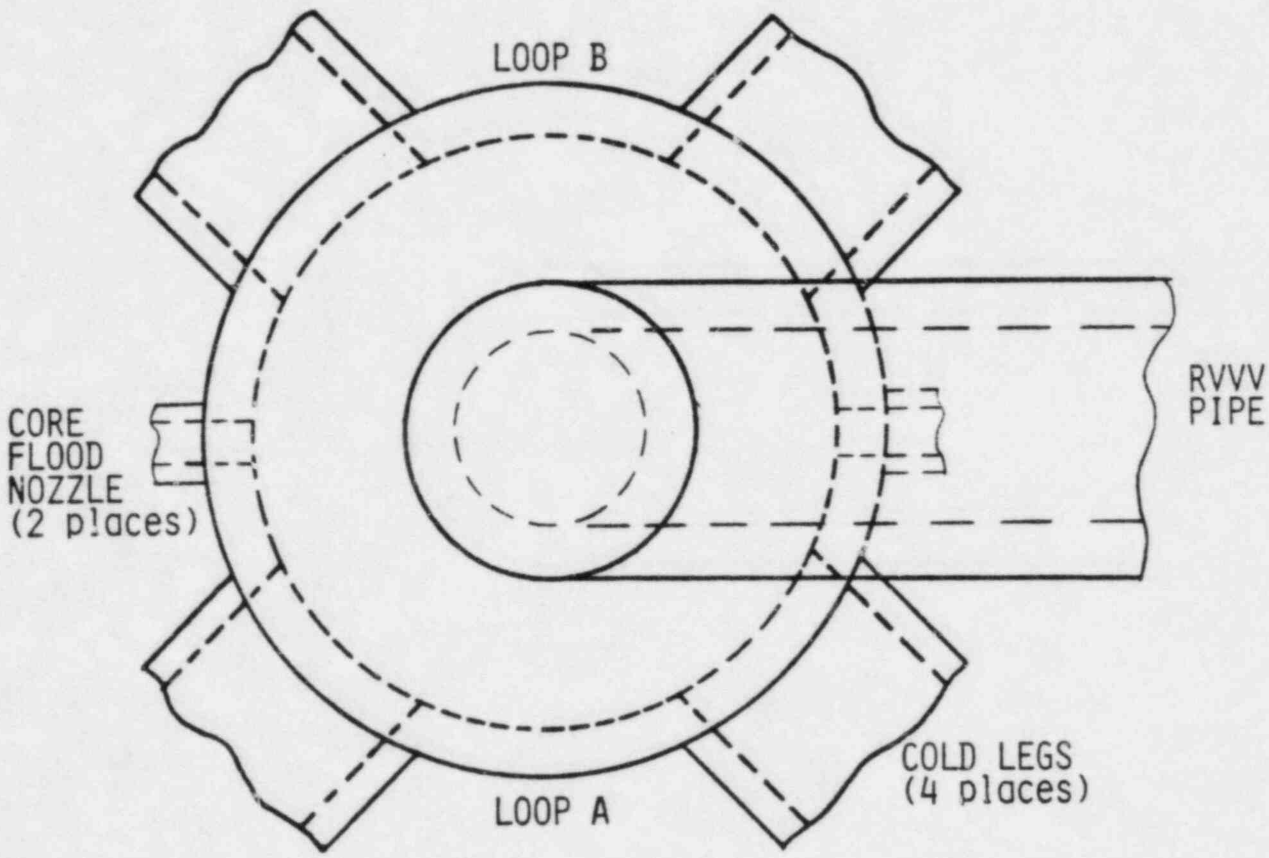
  - SIMILAR FLOW REGIMES

  - METAL-TO-WATER VOLUME RATIO

- FROUDE SCALING RESULTS IN A WIDER ANNULUS WHICH WILL NOT RESULT IN EXCESSIVE FLUID HOLDUP.

UPPER DOWNCOMER SCALE FACTORS FOR AN 8" SCHEDULE 160 (ID = 6.813") OUTER PIPE AS A FUNCTION OF INNER PIPE OUTSIDE DIAMETER.





TOP VIEW OF EXTERNAL ANNULAR DOWNCOMER WITH ONE REACTOR VESSEL VENT VALVE PIPE.

Figure 4.4-1

AXIAL CROSS-SECTION OF THE DOWNCOMER

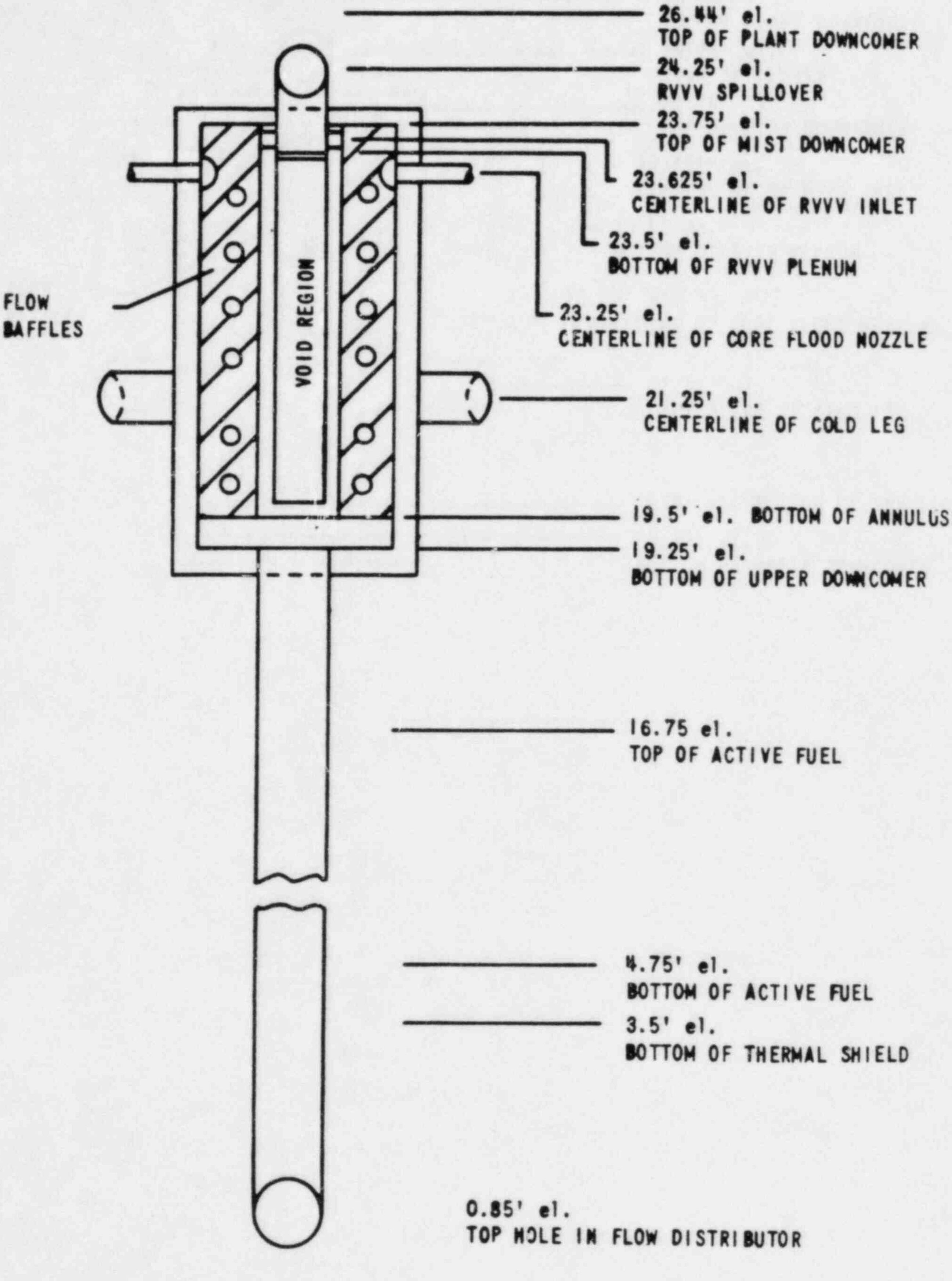


Figure 4.4-2

DOWNCOMER CROSS-SECTION THROUGH THE CENTER OF THE VENT VALVE OPENING

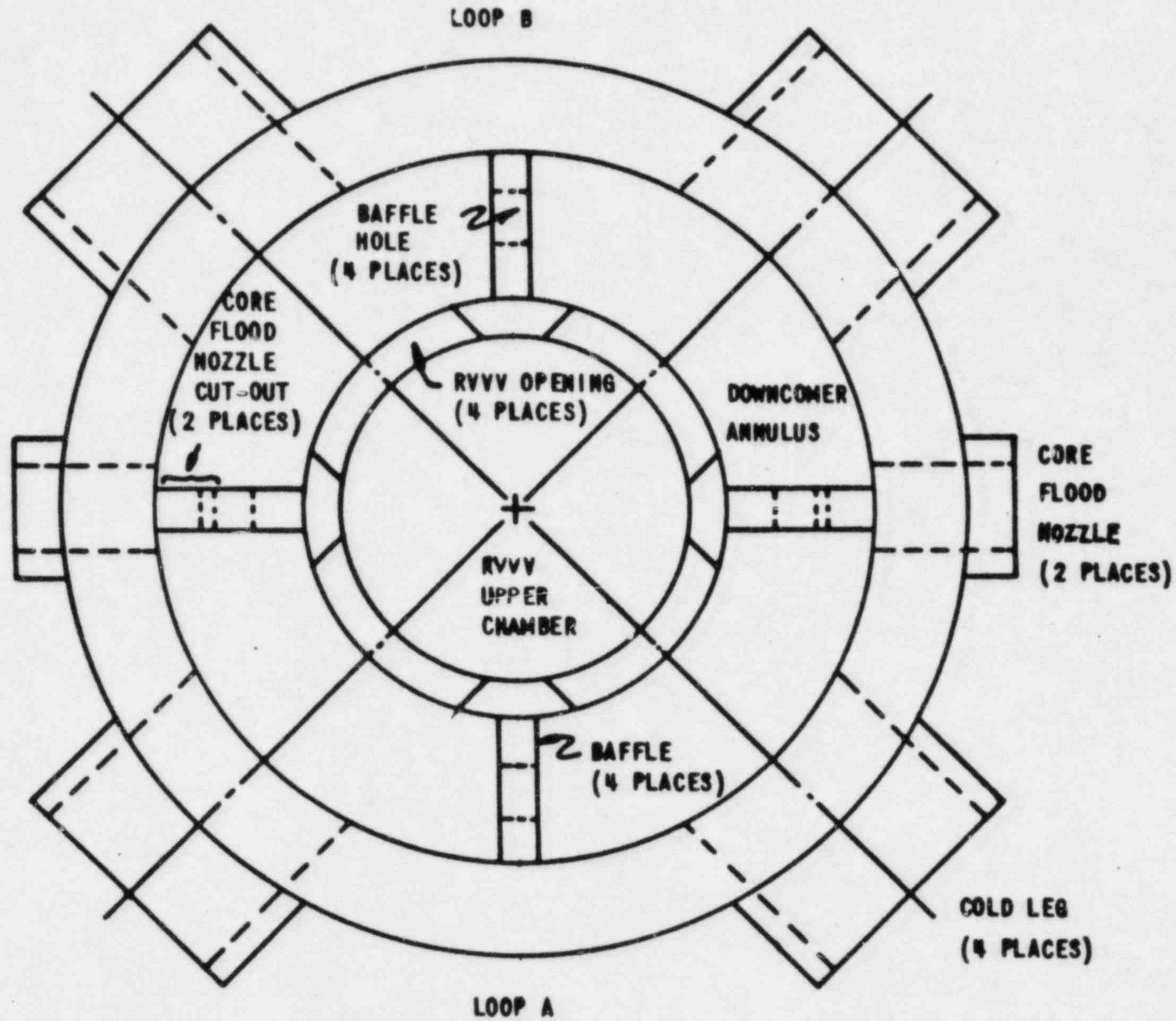
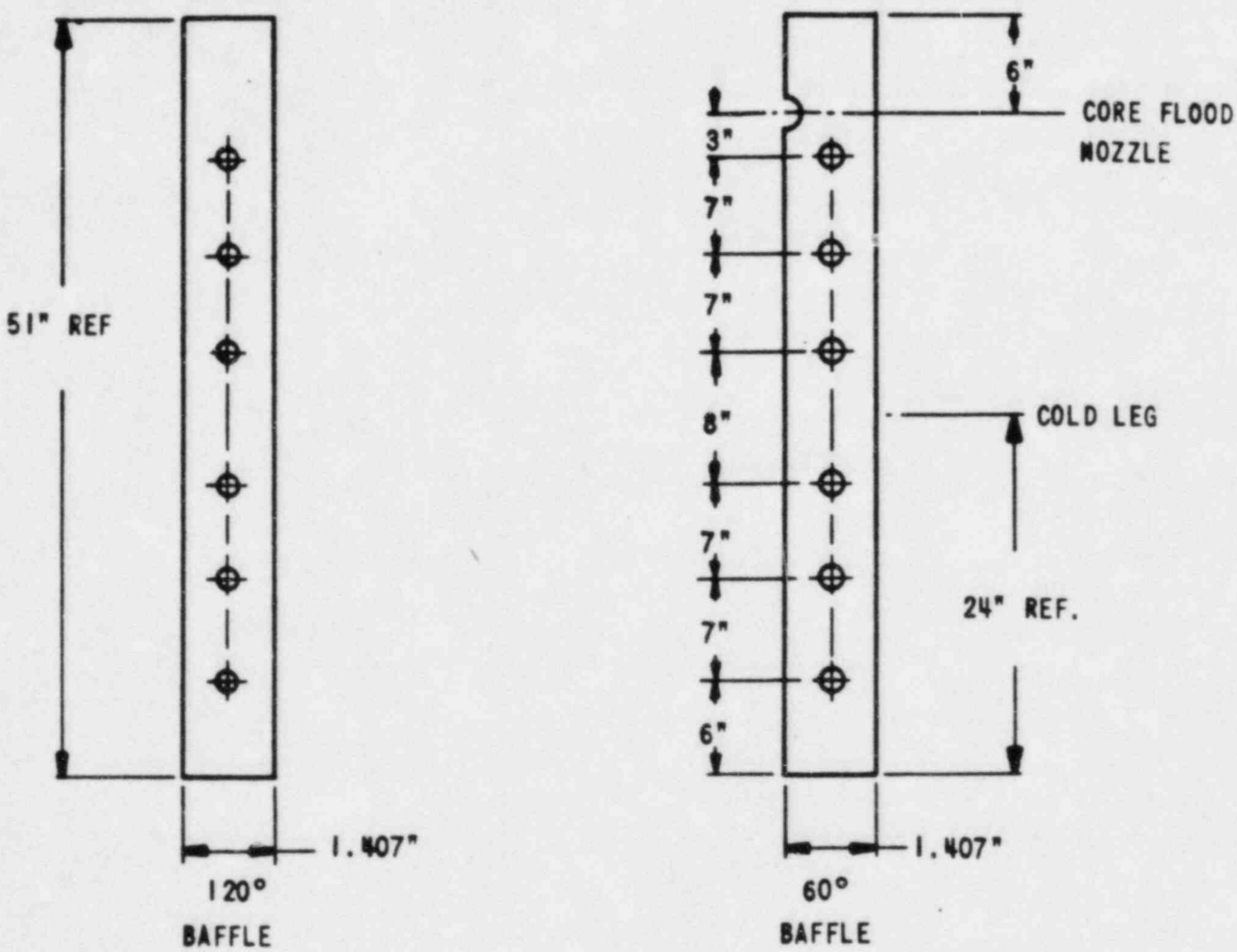


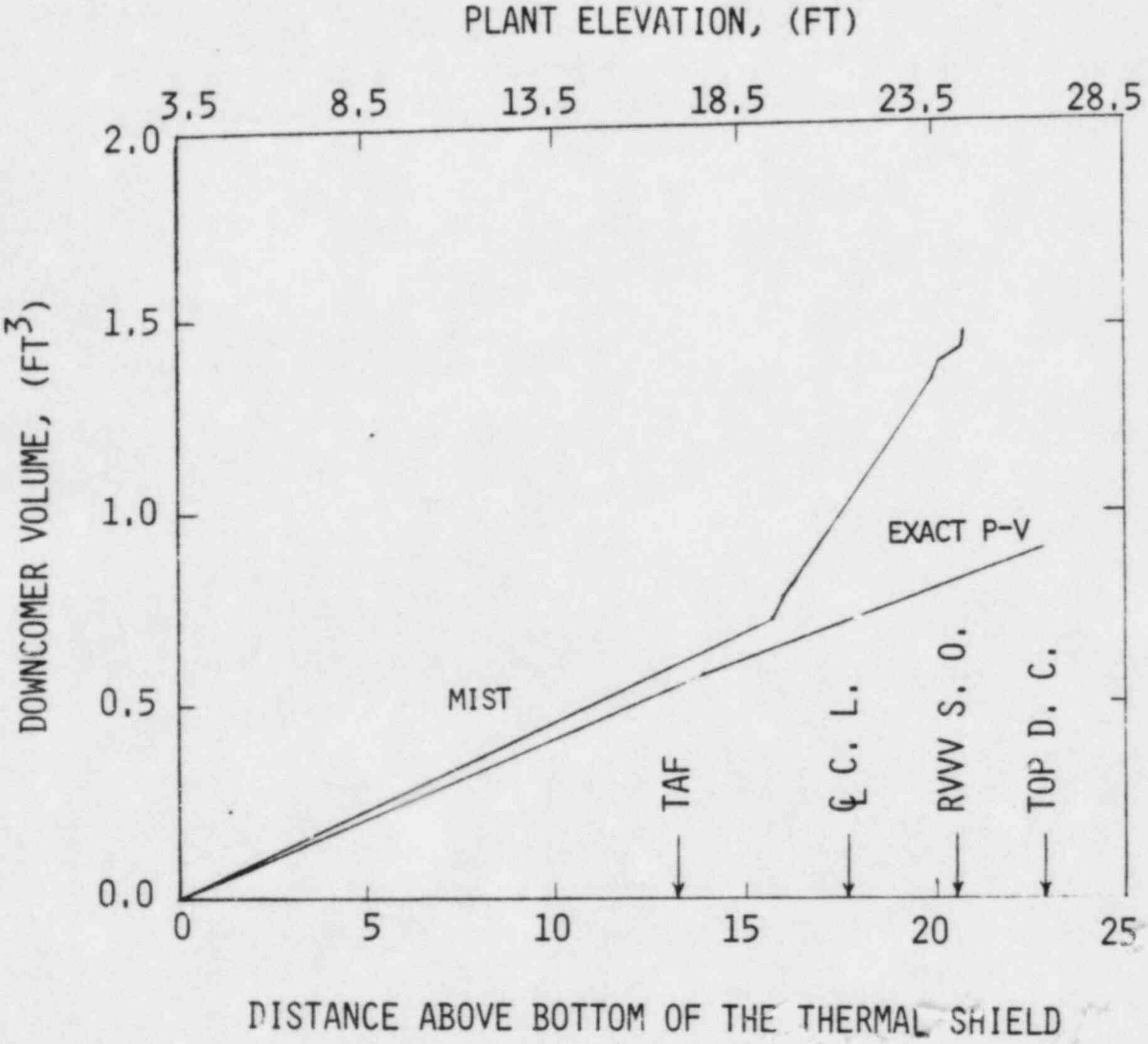
Figure 4.4-3

BAFFLE DETAILS

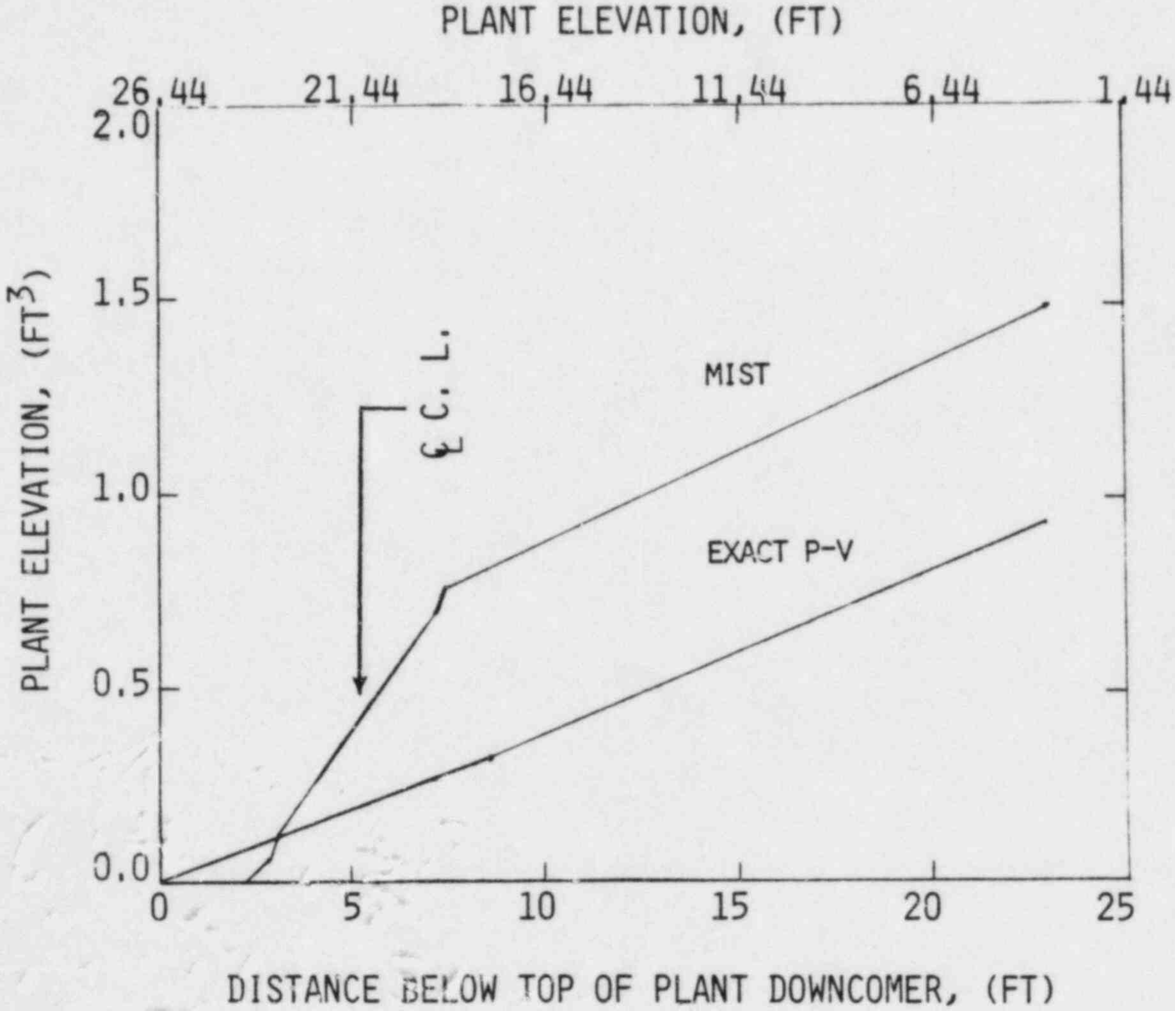


BOTH BAFFLES REQUIRE CENTERED 1/2 INCH HOLES WITH EXCEPTION OF SEMI-CIRCLE AT THE CORE FLOOD NOZZLE WHICH IS 1 1/8 INCH DIAMETER.

INTEGRATED DOWNCOMER VOLUME AS A FUNCTION OF THE DISTANCE FROM THE BOTTOM OF THE THERMAL SHIELD



INTEGRATED DOWNCOMER VOLUME AS A FUNCTION OF THE DISTANCE FROM THE TOP OF THE PLANT DOWNCOMER



MIST REACTOR VESSEL VENT VALVE SIMULATION

I. FULL-SIZED RVVV HARDWARE

II. RVVV OPERATION

III. MIST RVVV DESIGN REQUIREMENTS

IV. ATYPICALITIES AND LIMITATIONS

NOTE: Potential MIST RVVV hardware options are still under investigation using the criteria contained within this presentation.

Figure 4. Reactor Vessel Arrangement

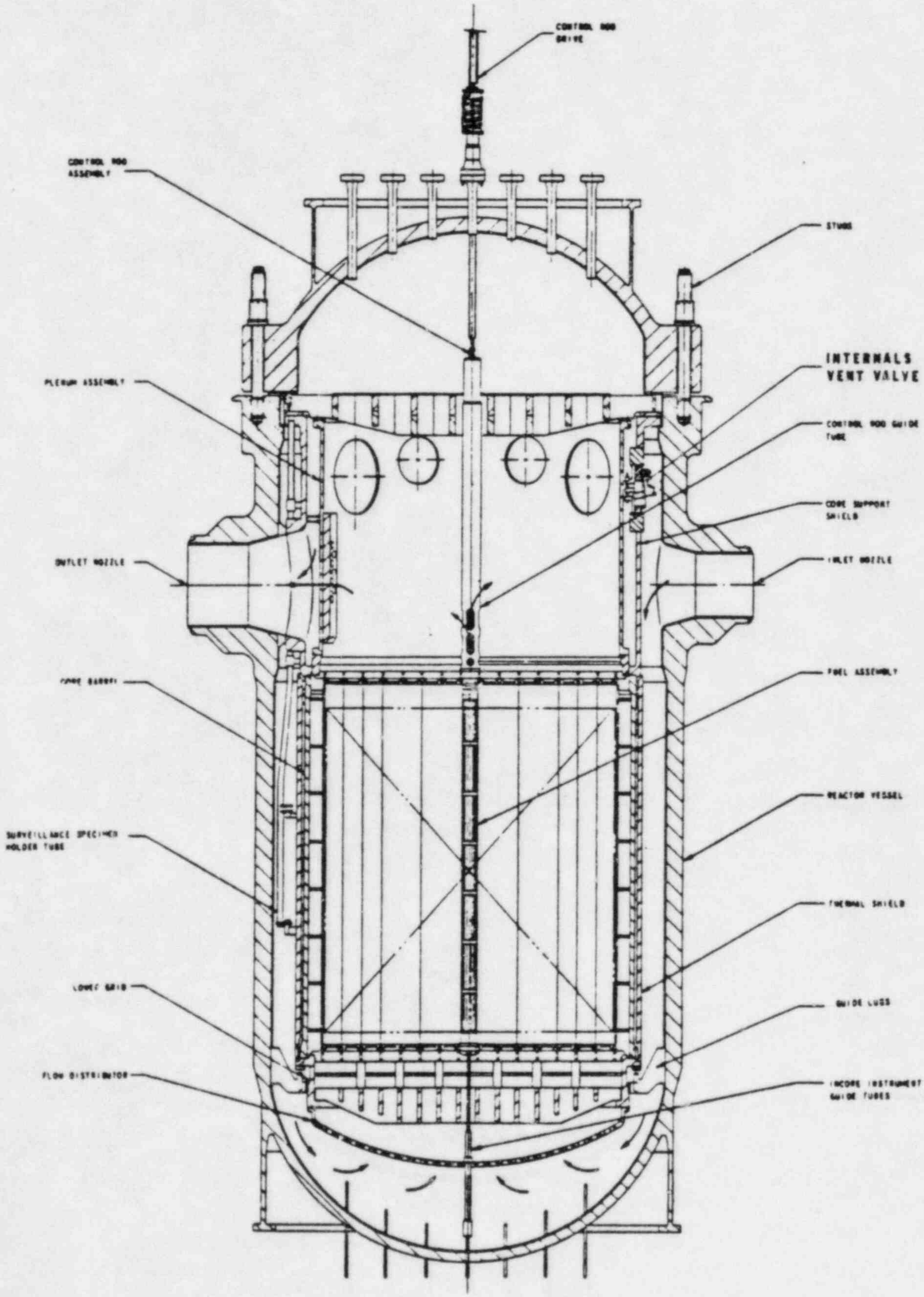
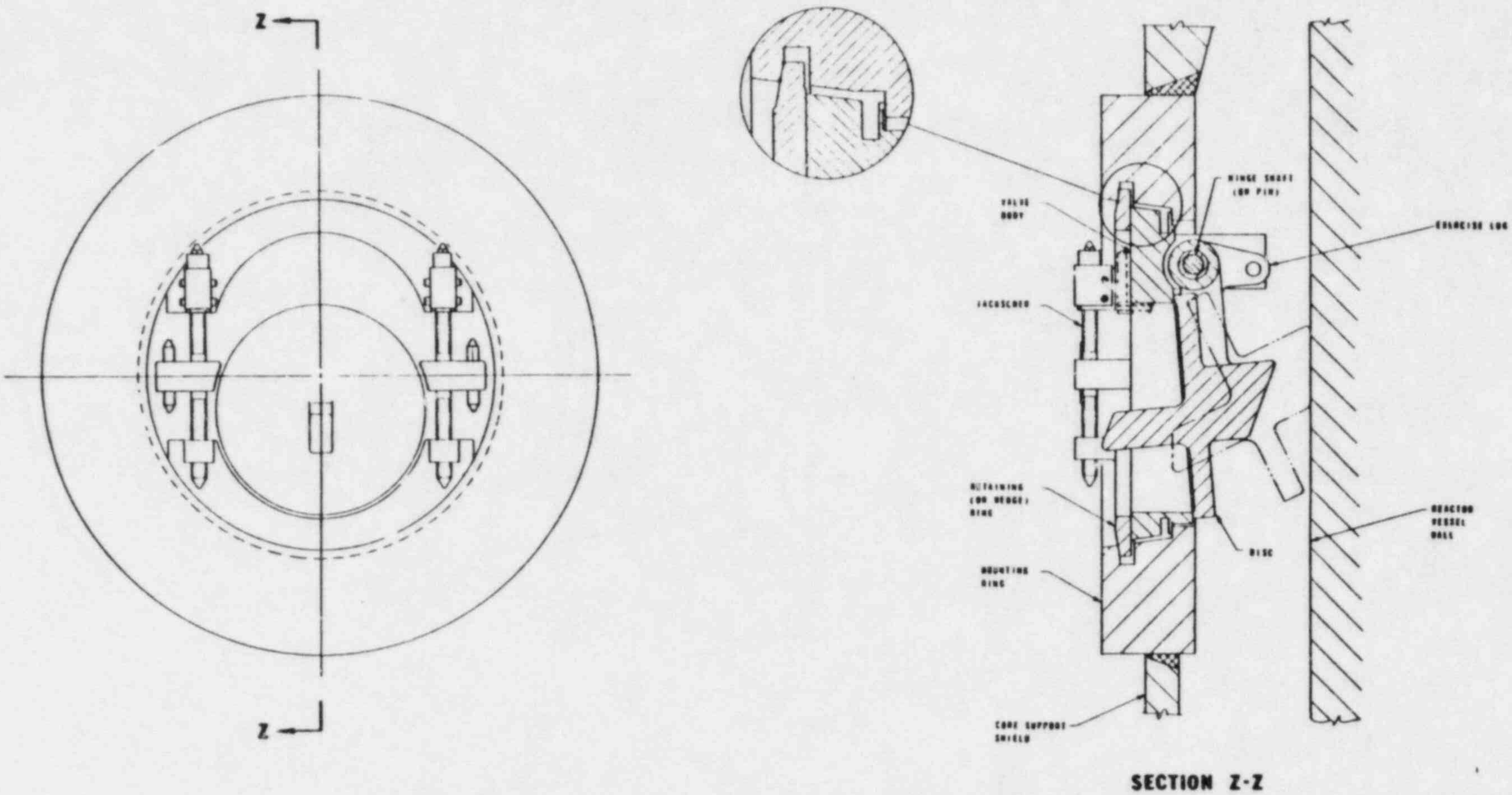


Figure 5. Vent Valve Final Arrangement



PROTOTYPE RVVV OPERATION

- The RVVV opens and closes on differential pressures between the RV upper head and the upper downcomer.

- The RVVV volumetric flow rate is a function of the differential pressure, upstream local fluid density, RVVV loss coefficient, and the full open flow area.

- The loss coefficient is only a function of valve open angle which is only a function of differential pressure.

Figure 4.5-2

MECHANICALLY MEASURED OPENING ANGLE VS. STATIC DIFFERENTIAL PRESSURE

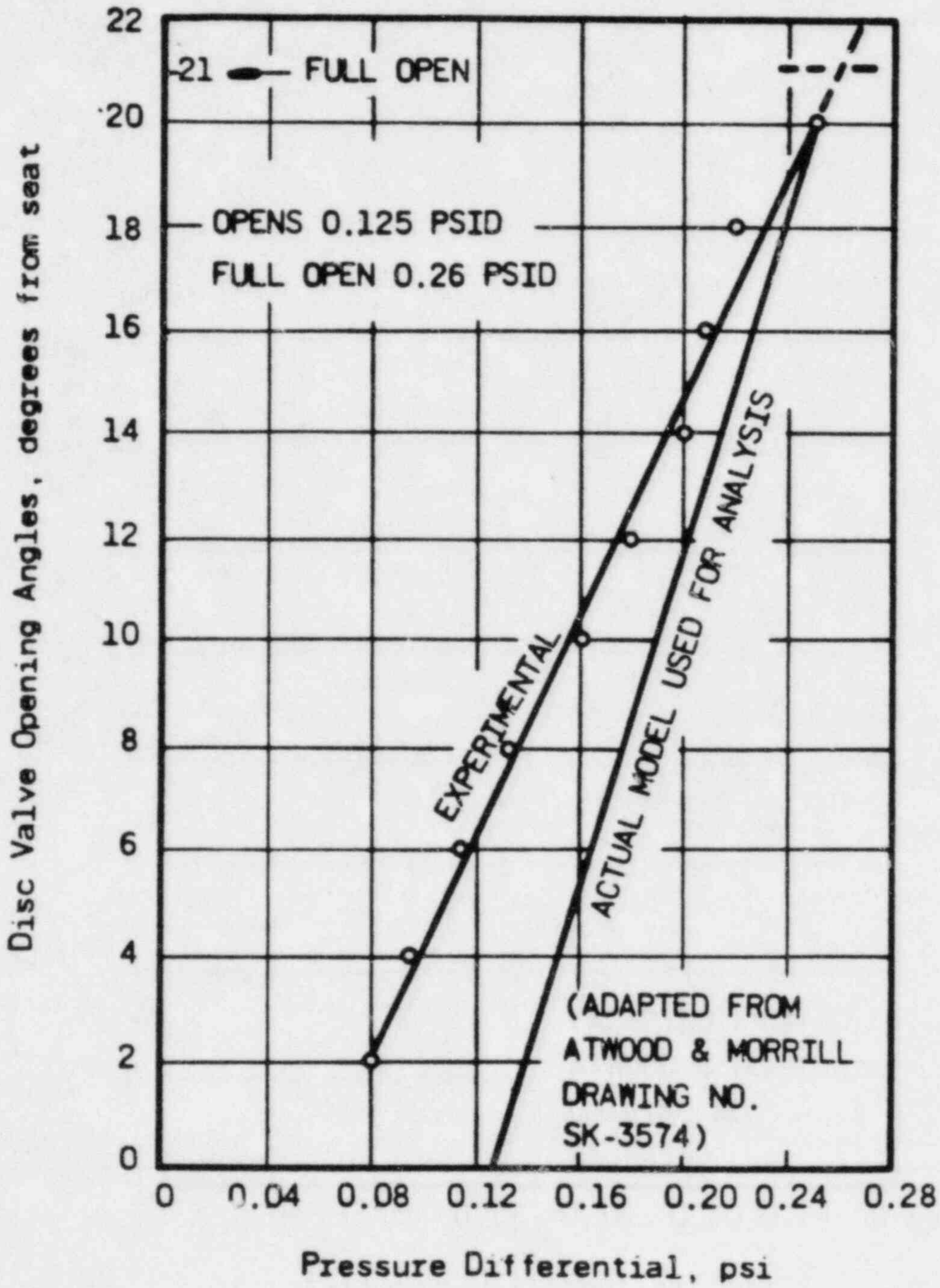
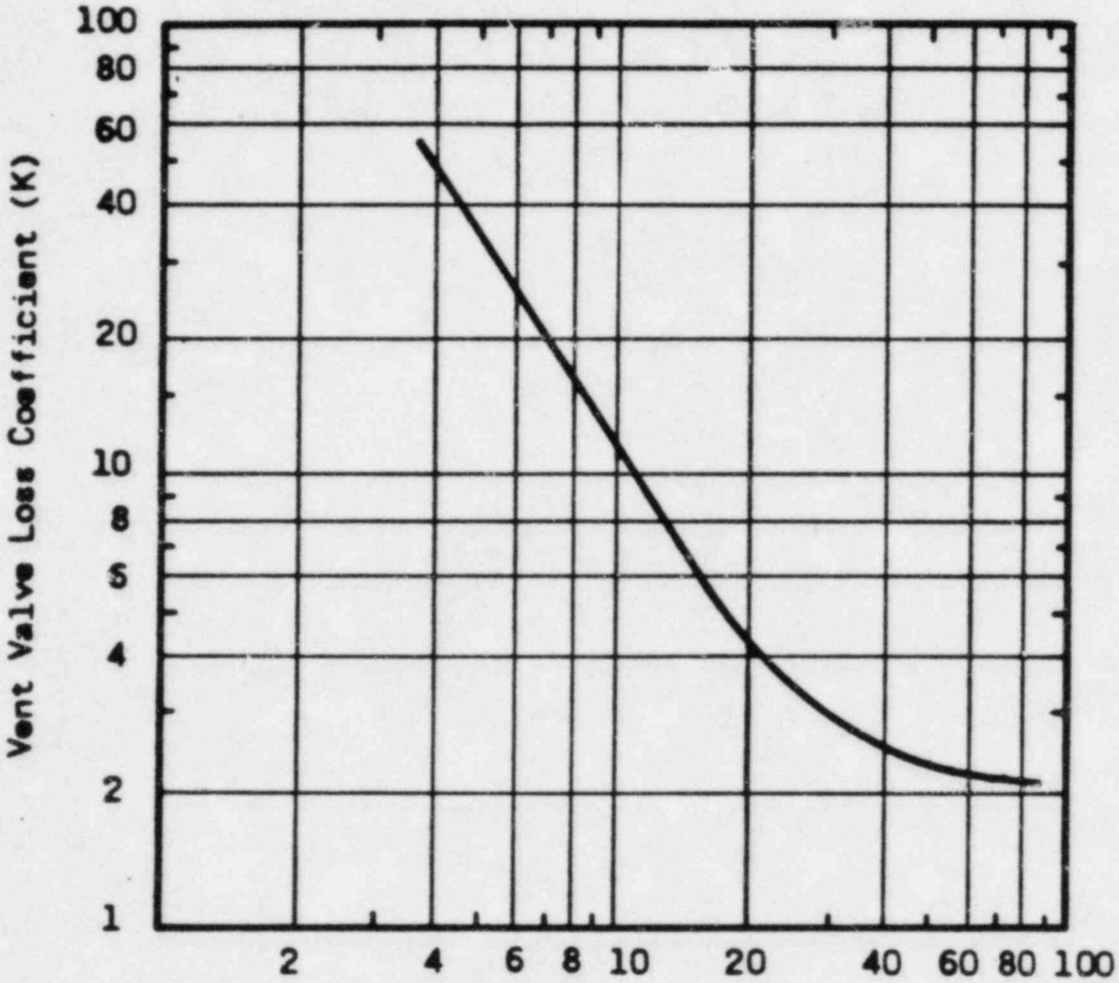


Figure 4.5-1

RVVV LOSS COEFFICIENT, K, VS VALVE POSITION



Valve Position
Degrees Open
(21° is Full Open)

$$K \frac{W^2}{2\rho g_c A^2} = \Delta P$$

$K = 10^{[2.5982 - 1.4937 \log_{10}(\text{angle in deg.})]}$

W = lbm/s ρ = lbm/ft^3 A = ft^2

K Full open = 4.2 ΔP = lb/ft^2

MIST RVVV DESIGN REQUIREMENTS

- The RVVV is located at the spill-over elevation of the prototype.

- The simulated valve should produce volumetrically scaled flows.

- The valve opening and closing ΔP setpoints as well as the flow resistance should be variable for parameter sensitivity studies.

- The RVVV should be fast acting.

- The associated piping should be Froude Number scaled to minimize excessive pipe flow losses and unfavorable flow regime transitions.

- The simulated valve must be compatible with the existing RV and external annular downcomer components.

CONCLUSIONS

- THE RVVV AND DOWNCOMER IN MIST PRESERVE THE PLANT BOUNDING ELEVATIONS.
- THE EXTERNAL ANNULAR DOWNCOMER MAINTAINS THE CHARACTERISTIC PROTOTYPE GEOMETRY WHICH PROVIDES COLD LEG-TO-COLD LEG COUPLING AND PRESERVES MAJOR GOVERNING PHENOMENA TYPICAL OF A SBLOCA.
- ALL MULTI-DIMENSIONAL PHENOMENA ARE NOT PRESERVED WITHIN A SMALL SCALE DOWNCOMER, HOWEVER, MAJOR EFFECTS RELATIVE TO THE OVERALL RCS BEHAVIOR DURING A SBLOCA ARE SIMULATED.
- THE RVVV GEOMETRICAL ORIENTATION IS ATYPICAL, HOWEVER, THE REFERENCE DESIGN WILL PRESERVE POWER-TO-VOLUME VOLUMETRICALLY SCALED FLOWS AT SIMILAR LOCAL FLUID CONDITIONS AND DIFFERENTIAL PRESSURES.
- THE PROPOSED DOWNCOMER AND RVVV ARE NOT WITHOUT MINOR LIMITATIONS, BUT THEY SHOULD PROVIDE PLANT TYPICAL BEHAVIOR DURING SBLOCA TRANSIENTS.

DOWNCOMER AND ADJACENT COMPONENT PIPE SIZES

COMPONENT	SCALING	SIZE
COLD LEG	FROUDE	2" SCH. 80
RVVV	FROUDE	3" SCH. 160
CORE FLOOD LINE	FROUDE	1" SCH. 160
LOWER DOWNCOMER	POWER-TO-VOLUME	3" SCH. 80
UPPER DOWNCOMER	FROUDE	8" SCH. 160 OUTER 3½" SCH. 80 INNER

PROGRAM MANAGEMENT GROUP

PURPOSE: TO PROVIDE REPRESENTATIVE MANAGEMENT PANEL TO OVERSEE PROJECT.

DUTIES:

- MONITOR TECHNICAL PROGRAM DETAILS AND DIRECT CONTRACTOR EFFORTS
- MONITOR AND CONTROL SCHEDULES
- CONTROL COSTS WITHIN MAJOR TASKS
- PROVIDE FEEDBACK TO ORGANIZATION BEING REPRESENTED
- OBTAIN ORGANIZATIONAL APPROVAL FOR MAJOR PROGRAM CHANGES

MAJOR MILESTONES

1.	GERDA available for modification	10/1/83
2.	OTIS modifications complete	2/1/84
3.	OTIS testing completed	4/1/84
4.	OTIS final report issued	11/1/84
5.	PMG approval of MIST facility specification	10/31/83
6.	Complete building modifications	4/1/84
7.	Begin loop reconfiguration	7/1/84
8.	Loop hydrotest	7/1/85
9.	Complete debug testing	12/1/85
10.	Complete characterization tests	3/1/86
11.	Complete composite tests	9/1/86
12.	Final report issued	3/1/87

MIST

PURPOSE

DESIGN

- Key features
- Description

INSTRUMENTATION

TEST PROGRAM

MIST

(MULTI-LOOP INTEGRAL SYSTEM TEST)

PURPOSE: CODE VERIFICATION

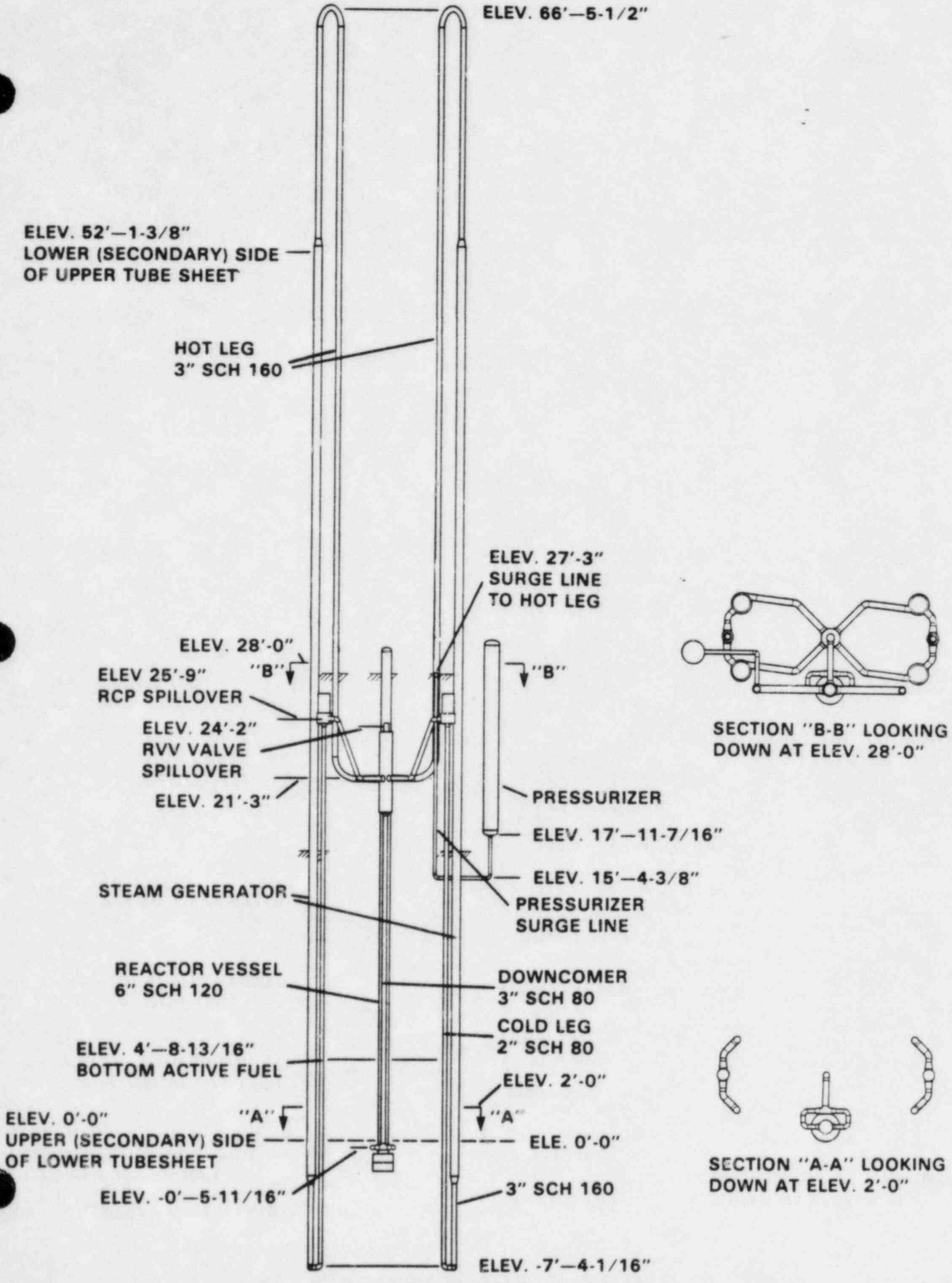
Provide lowered loop separate- and integral-effect data for code verification.

SBLOCA EVENTS AND RELATED PHENOMENA

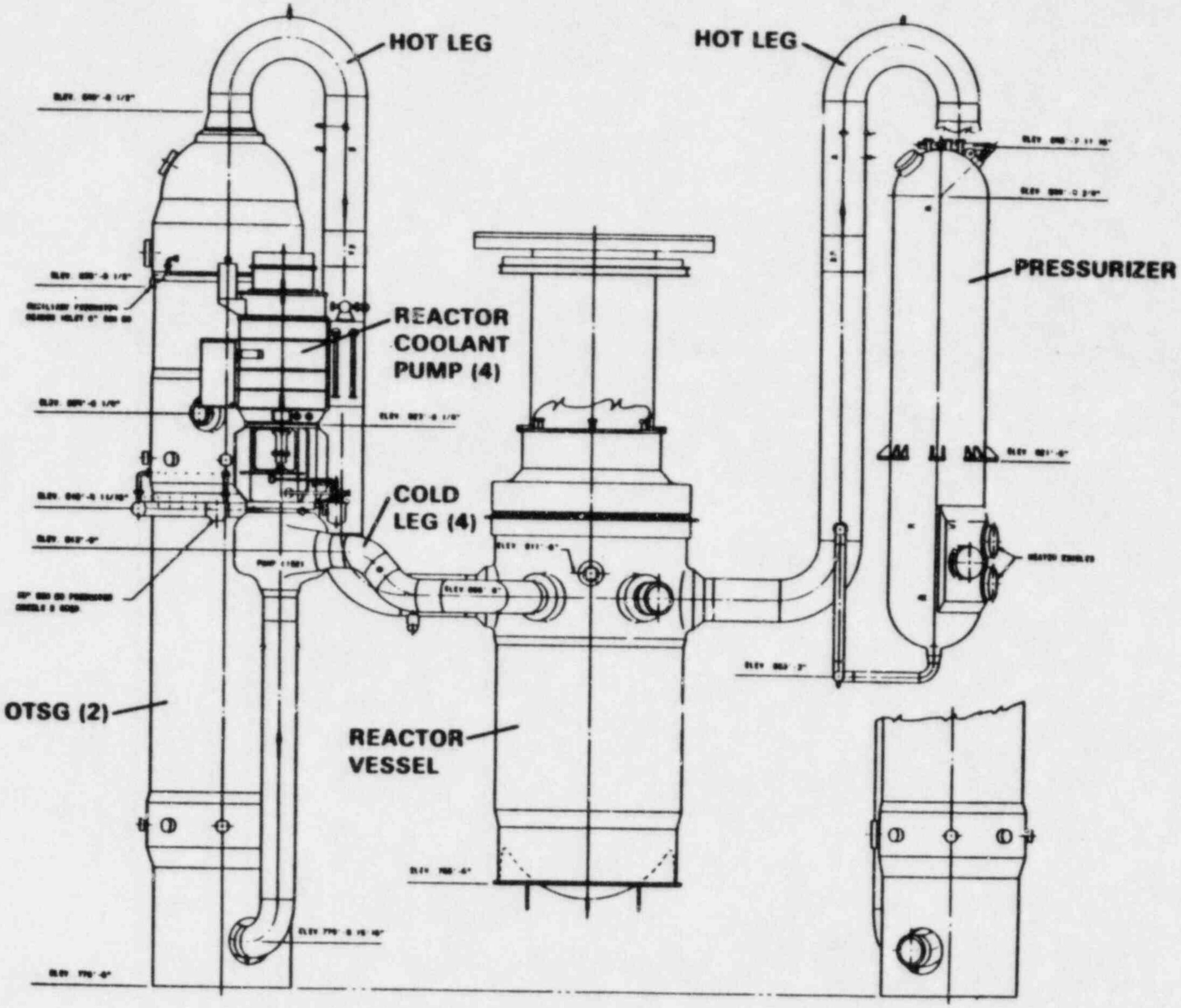
EVENT	PHENOMENA
• INITIATION	THERMAL CENTER ELEVATION FLOW COASTDOWN STEAM GENERATOR INITIALIZATION AND TRANSIENT COMPONENT IRRECOVERABLE ΔP FLUID TRANSIT TIME
• SATURATION	FLUID LEVEL VS. BOUNDING ELEVATIONS HLUB VOIDING POWER DECAY LEAK AND HPI CHARACTERISTICS RVVV PERFORMANCE HEAT LOSS, METAL THERMAL CAPACITY, FLUID/METAL COUPLING
• INTERMITTENT CIRCULATION	HLUB CHARACTERISTICS RVVV CHARACTERISTICS STEAM GENERATOR CONDITIONS DOWNCOMER AND COLD LEG VOIDING, CONDENSATION, BOUNDING ELEVATIONS
• STEAM GENERATOR HEAT REMOVAL (BOILER-CONDENSER MODE)	PRIMARY FLUID VOLUME VS. ELEVATION STEAM GENERATOR PERFORMANCE LEAK/HPI CHARACTERISTICS
• PRIMARY REFILL	BOUNDARY ELEVATIONS VOLUME VS. ELEVATION HIGH POINT VENT PERFORMANCE HEAT LOSS LEAK/HPI CHARACTERISTICS

MIST SCALING CRITERIA

- PRESERVATION OF FULL ELEVATION
- PHENOMENA
  - TWO-PHASE FLOW BEHAVIOR (VOIDING, ENTRAINMENT, ETC.)
  - FLOW REGIME TRANSITION
- MAINTAIN POWER TO VOLUME SCALE, AS CLOSE AS POSSIBLE
  - SCALE FACTOR = 31062/38 = 817
- PRESERVE LOOP IRRECOVERABLE LOSSES



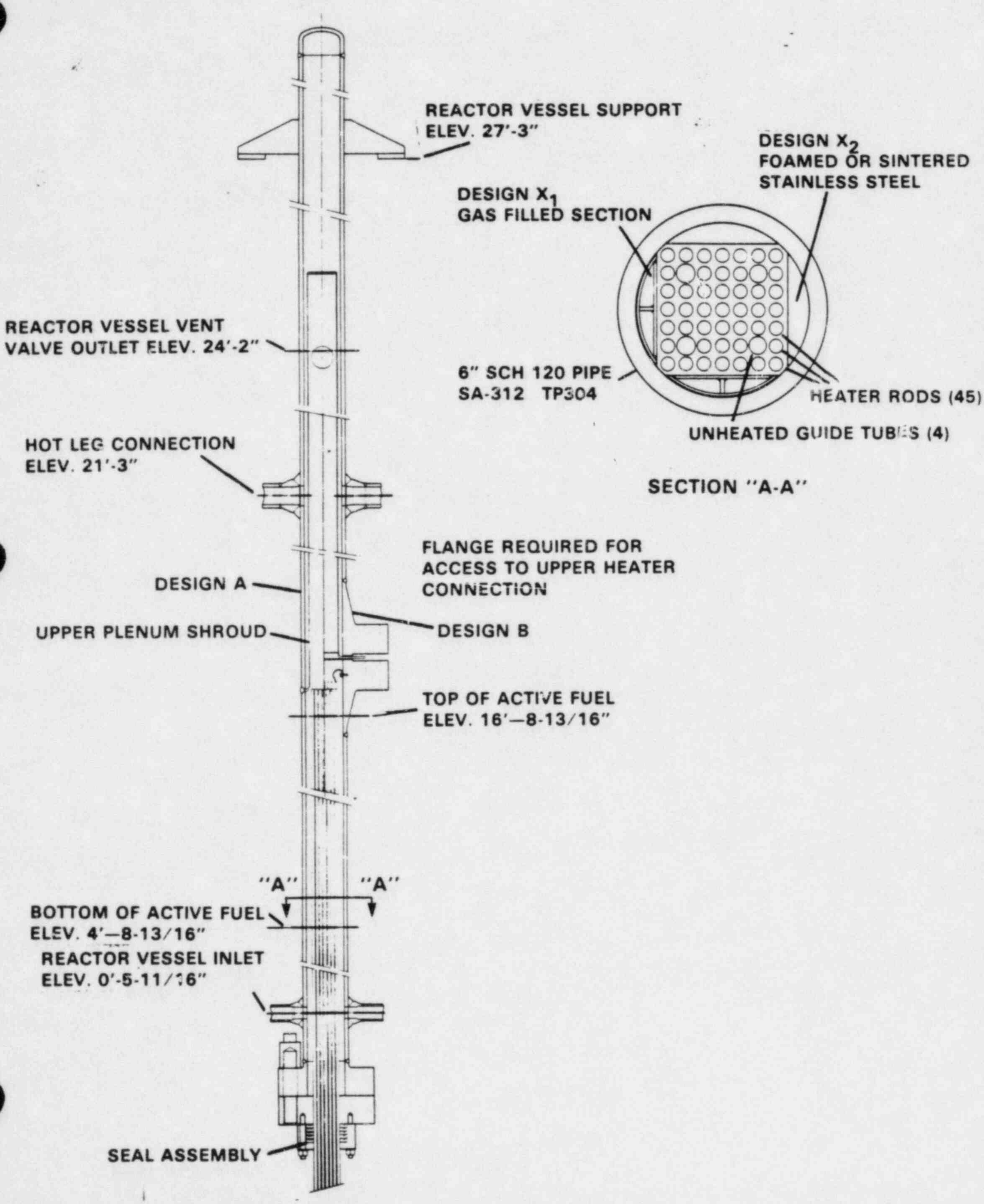
REACTOR COOLANT SYSTEM ARRANGEMENT



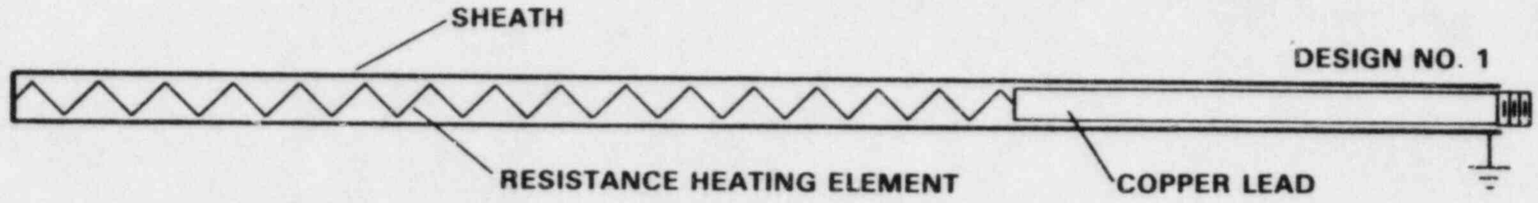
ELEVATION VIEW OF A 177 FUEL ASSEMBLY LOWER LOOP PLANT

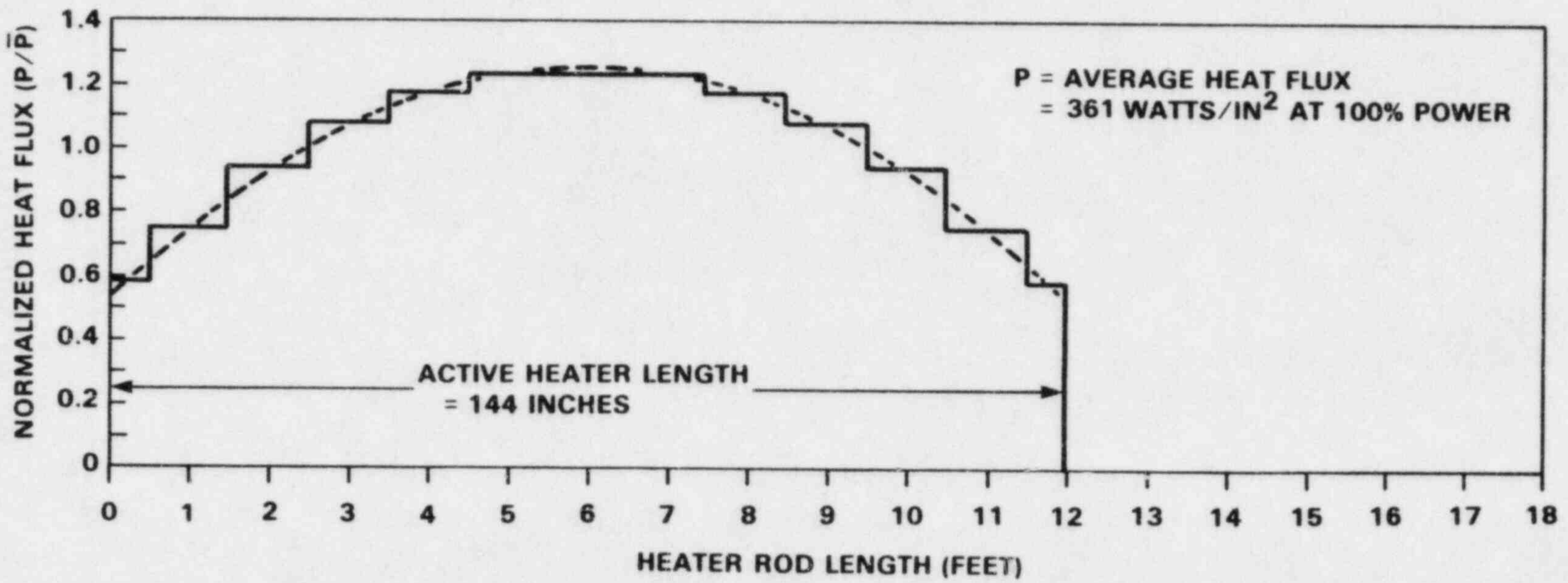
KEY FEATURES OF THE MIST FACILITY

- 2X4 LOOP
- POWER AND VOLUME SCALE FACTOR OF 817 (PLANT/MODEL)
- TWO 19-TUBE STEAM GENERATORS
- 3" DIAMETER HOT LEGS
- FULL LOOP GUARD HEATING
- 10% SCALED POWER
- FULL LENGTH CORE
- MODELED FUEL PIN DIAMETER, LENGTH, HEAT FLUX
- CORE POWER SHAPING
- REACTOR VESSEL VENT VALVE
- HPI
- LPI
- CORE FLOOD
- REACTOR COOLANT PUMPS (4)
- NCG ADDITION AND DETECTION
- CONTROLLED LEAKS
- NEW OTSG

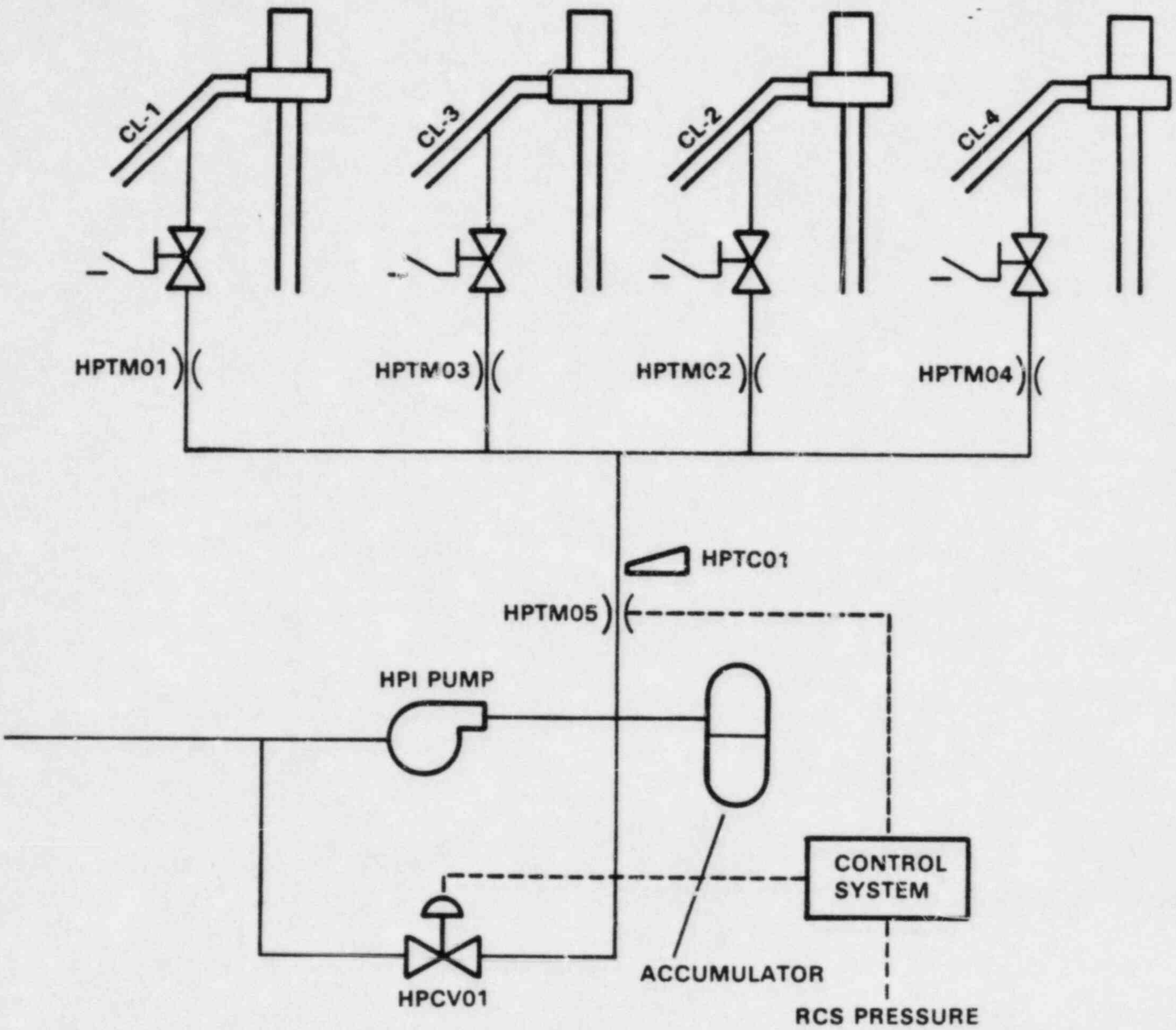


REACTOR VESSEL ARRANGEMENT ELEVATION

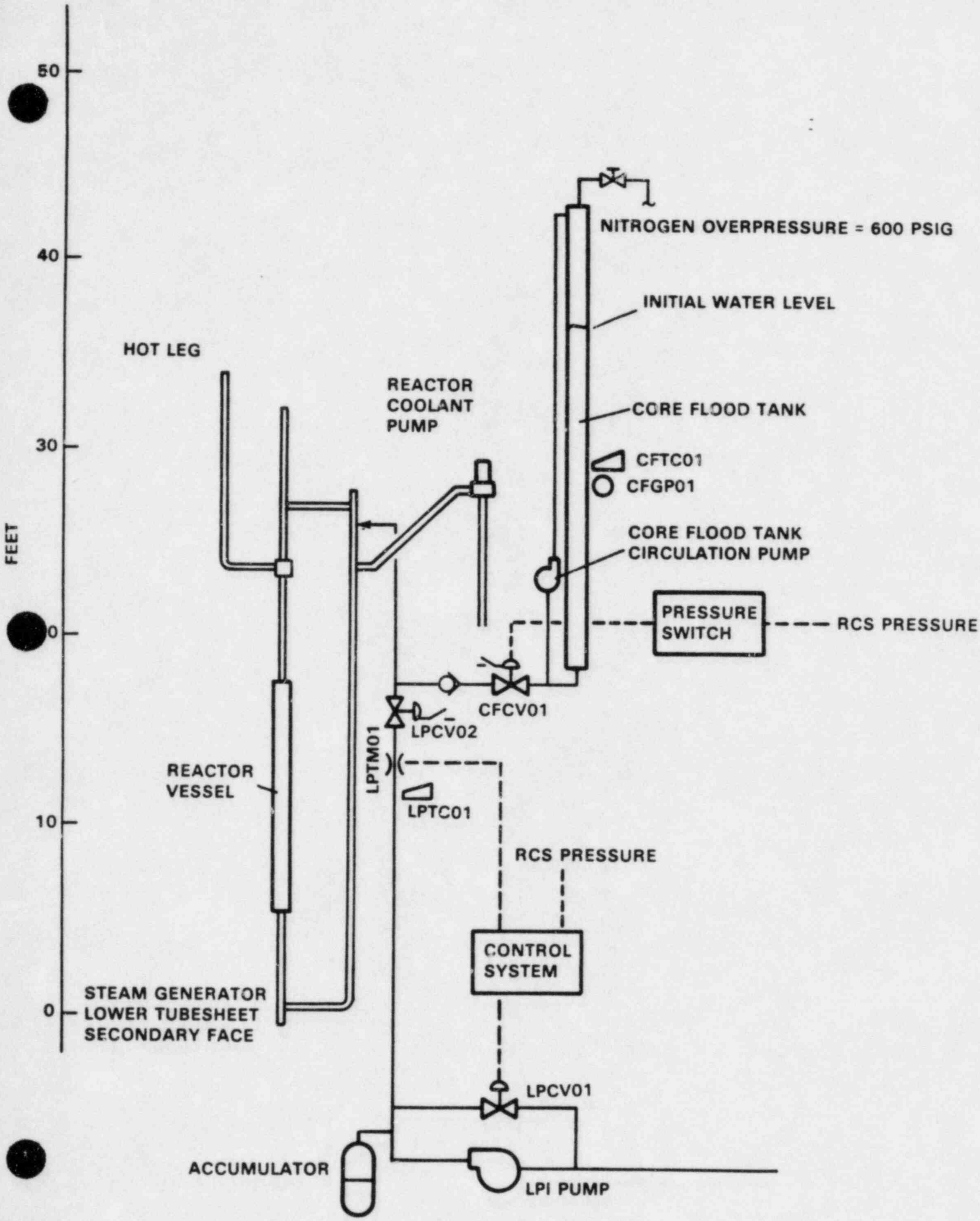




HEAT FLUX PROFILE IN MODEL CORE

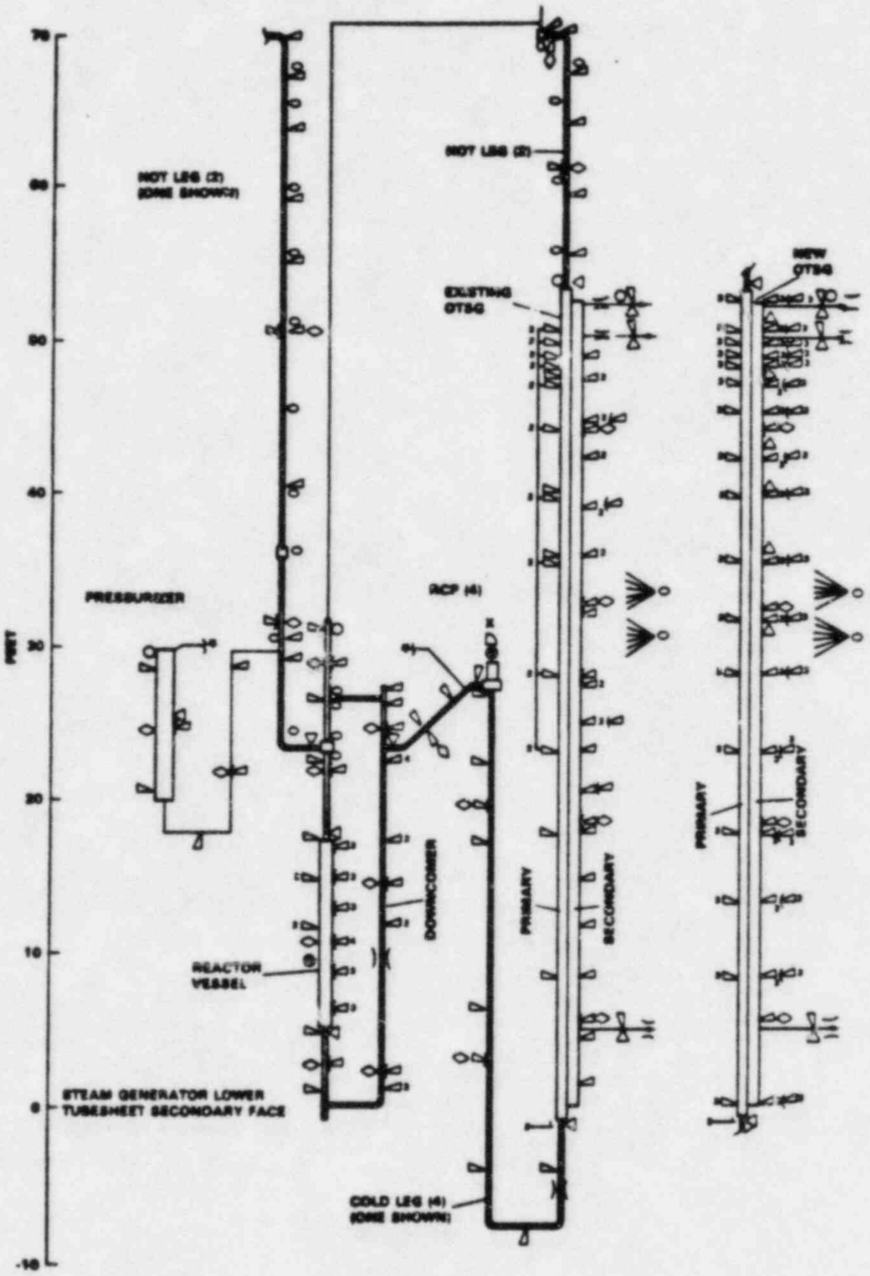


MODEL HPI SYSTEM



MODEL LPI AND CORE FLOOD SYSTEM

MIST INSTRUMENTATION



MIST TEST PROGRAM

TEST CATEGORY	NUMBER OF TESTS
CHARACTERIZATION	~30
MODE TRANSITION	6
SBLOCA	19
OTSG TUBE RUPTURE	6
FEED AND BLEED	4
UNDEFINED	5

	70

COMPUTER CODE

ASSESSMENT PROGRAM

OBJECTIVE OF INTEGRAL SYSTEM TEST PROGRAM

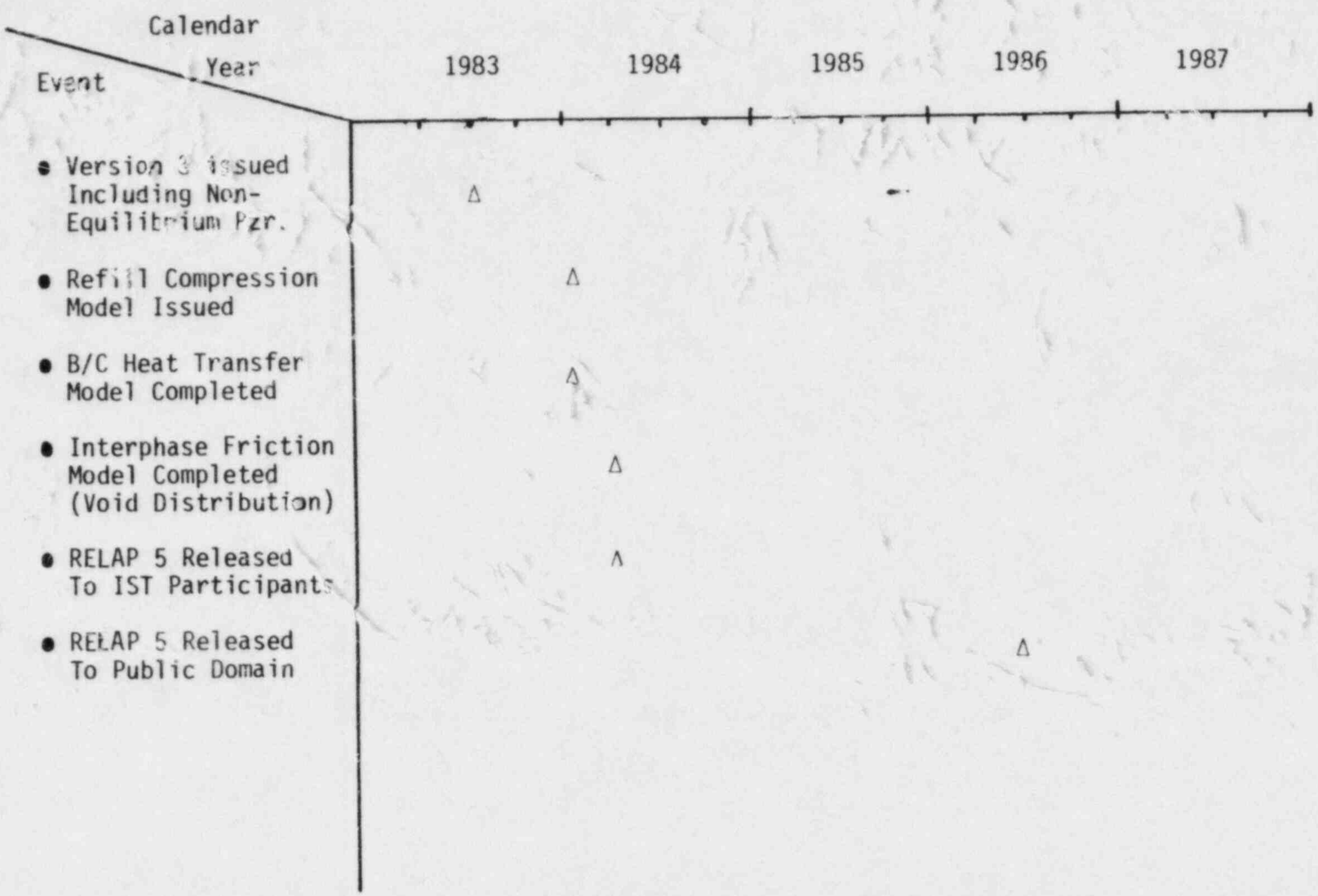
-- PROVIDE DATA ON A FACILITY WHICH IS REPRESENTATIVE OF A B&W NSS.

-- DATA TO BE USED FOR VERIFICATION OF ANALYTICAL MODELS (CODES) USED TO PREDICT TRANSIENT NSS BEHAVIOR.

RELAP5 DEVELOPMENT

- DEVELOP & INSTALL 3 REGION NON-EQUILIBRIUM PRESSURIZER MODEL
- DEVELOP & INSTALL LOOP VOID COMPRESSION MODEL
- REFINE INTERPHASE DRAG & MASS TRANSFER MODELS
- UPGRADE STEAM GENERATOR HEAT TRANSFER COEFFICIENT
- PLANNED TO BE COMPLETED BY APRIL 1984

RELAP 5 CODE DEVELOPMENT



OWNERS GROUP CODE ASSESSMENT PROGRAM

- RELAP 5 CODE
  - SET UP RELAP5 MODEL OF OTIS FACILITY
  - BENCHMARK CODE TO
    - STEADY-STATE BOILER-CONDENSOR MODE
    - SBLOCA TRANSIENT TEST
    - COMPOSITE TEST
      - LEAK/HPI COOLING (NO AFW)
      - SG COOLING AFTER 1 HOUR
    - REFILL PHASE OF TRANSIENT

MIST ANALYSES

- DESIGN VERIFICATION

  - PURPOSE: TO DETERMINE WHETHER THE MIST FACILITY WILL EXPERIENCE DESIRED PHENOMENA

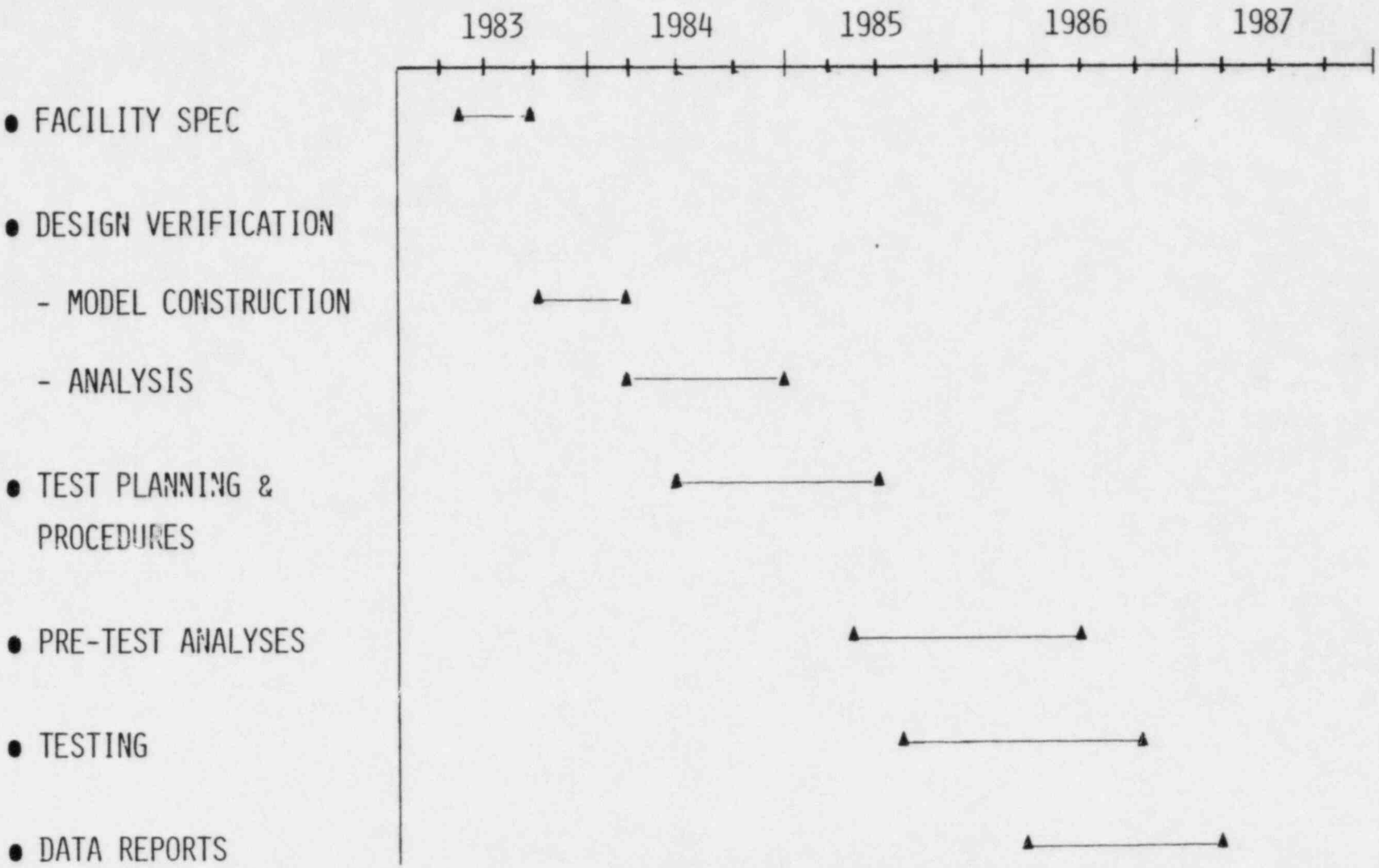
- PRE-TEST ANALYSES

  - PURPOSE: PROVIDE CODE BENCHMARK

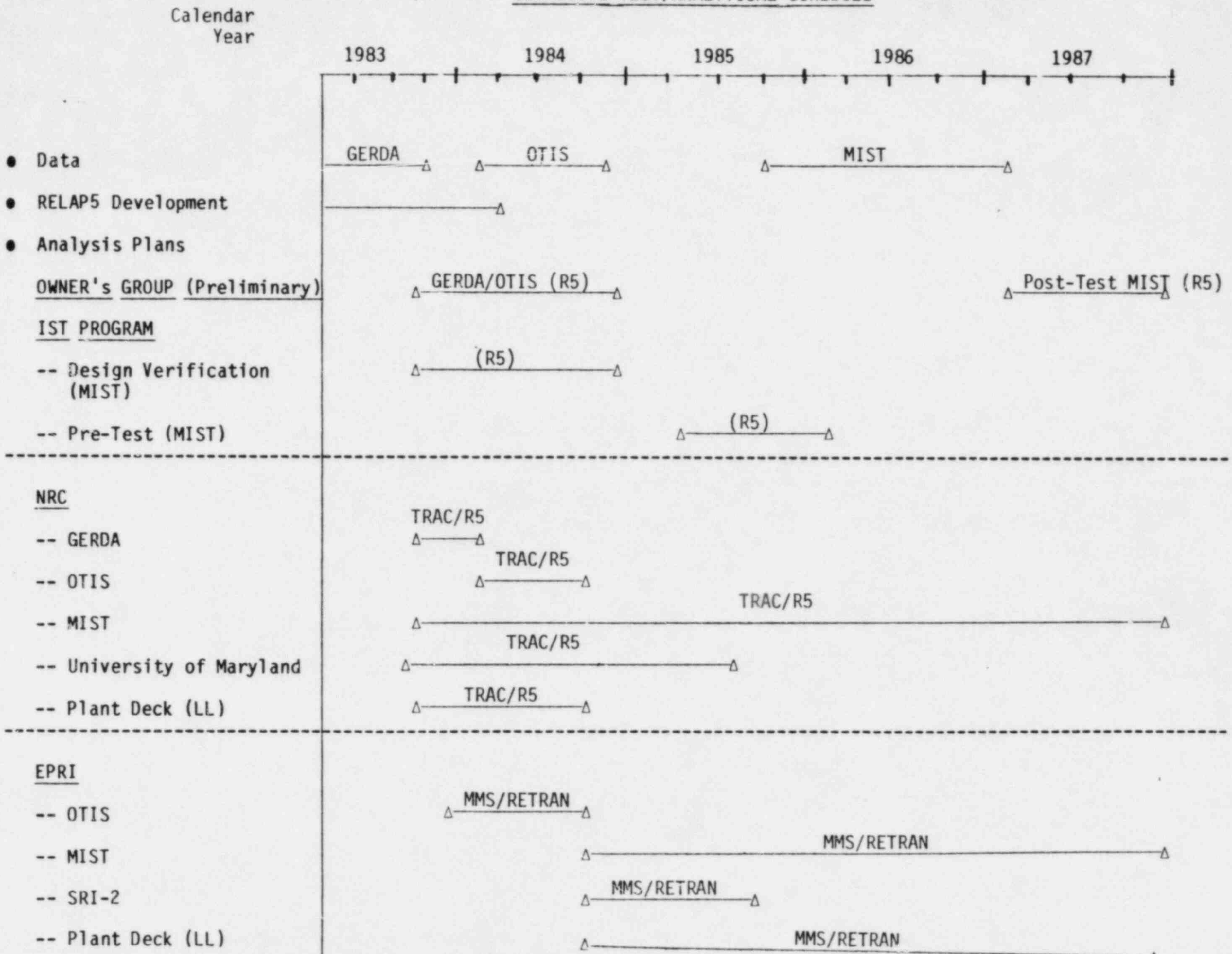
- EACH TASK WILL BE PERFORMED FOR EACH MAJOR TEST CATEGORIES

  - MODE TRANSITION
  - SBLOCA
  - SG TUBE RUPTURE
  - FEED & BLEED

MIST PROGRAM ANALYTICAL SCHEDULE



COMPOSITE TEST/ANALYTICAL SCHEDULE



GERDA

BACKGROUND

Purpose

Chronology

DESIGN

Scaling

DESCRIPTION

Arrangement

Features

INSTRUMENTATION

SUMMARY

GERDA

Purpose:

Provide Post—SBLOCA Integral-effects Data for Comparison with Code Predictions of Model Behavior

GERDA

```
                                    1980                1981                      1982        1982        1983
Job Description                     Apr   Jul   Oct   Jan   Apr   Jul   Oct   Jan   Apr   Jul   Oct   Jan   Apr   Jul   Oct
                                    0     1     2     3     4     5     6     7     8     9     10    11    12    13    14
  1 BBR/B&W TASK FORCE              0     .     .     .     .     .     .     .     .     .     .     .     .     .     .
  2 FACILITY REVIEW                 >=================>     .     .     .     .     .     .     .     .     .     .     .
  3 GERDA CONTRACT                  .     .     .     *     .     .     .     .     .     .     .     .     .     .     .
  4 FACILITY DESIGN & CONSTRUCTION  .     .     .     >=============================>     .     .     .     .     .     .
  5 DESIGN VERIFICATION             .     .     .     >=======================X     .     .     .     .     .     .     .
  6 FACILITY CHARACTERIZATION       .     .     .     .     .     .     .     .     >===========>     .     .     .     .
  7 PHASE 1 TESTING                 .     .     .     .     .     .     .     .     .     .     >===========X     .     .
  8 REPORTING                       .     .     .     .     .     .     .     .     .     .     >=======================X
```

Scaling

- Criteria
- Methods
- Results
- Atypicalities

GERDA SCALING CRITERIA

ELEVATIONS	FULL SCALE MK ELEVATIONS MAINTAINED
PHENOMENA	IMPORTANT SBLOCA PHENOMENA PRESERVED (e.g. HOT LEG TWO-PHASE FLOW BEHAVIOR)
VOLUME	COMPONENTS SCALED BY RATIO OF STEAM GENERATOR TUBES (32,026/19 = 1686)
IRRECOVERABLE PRESSURE LOSSES	ORIFICES USED TO MATCH MK LOSSES

Scaling Methods

Size the Hot Leg Piping to Preserve the Plant Fluid Behavior

1. Determine the <u>Governing</u> Post-SBLOCA <u>Phenomena</u>
2. <u>Convert</u> the Models of These Phenomena to Their Scaling Requirements
3. <u>Compare</u> Model Typicality Versus Scaling
4. <u>Select</u> the Optimum Model Scale

3. Scale Comparison

Preserved Phenomena Versus Hot Leg Pipe ID

1.3″ (33 MM)

- Volumetric Scaling
- Superficial Vapor Velocity
- Flow Regimes (Taitel-Dukler, Mandhane)

~ 2″ (50 MM)

- Void Fraction (Wilson-Grenda-Patterson, Viecenz)

2.6″ (66 MM)

- Froude Number, The Ratio of Fluid Inertial and Buoyant Forces
- Flow Regimes (Dukler-Taitel Generalized Coordinates)
- Flooding (Wallis)

4. Scale Selection

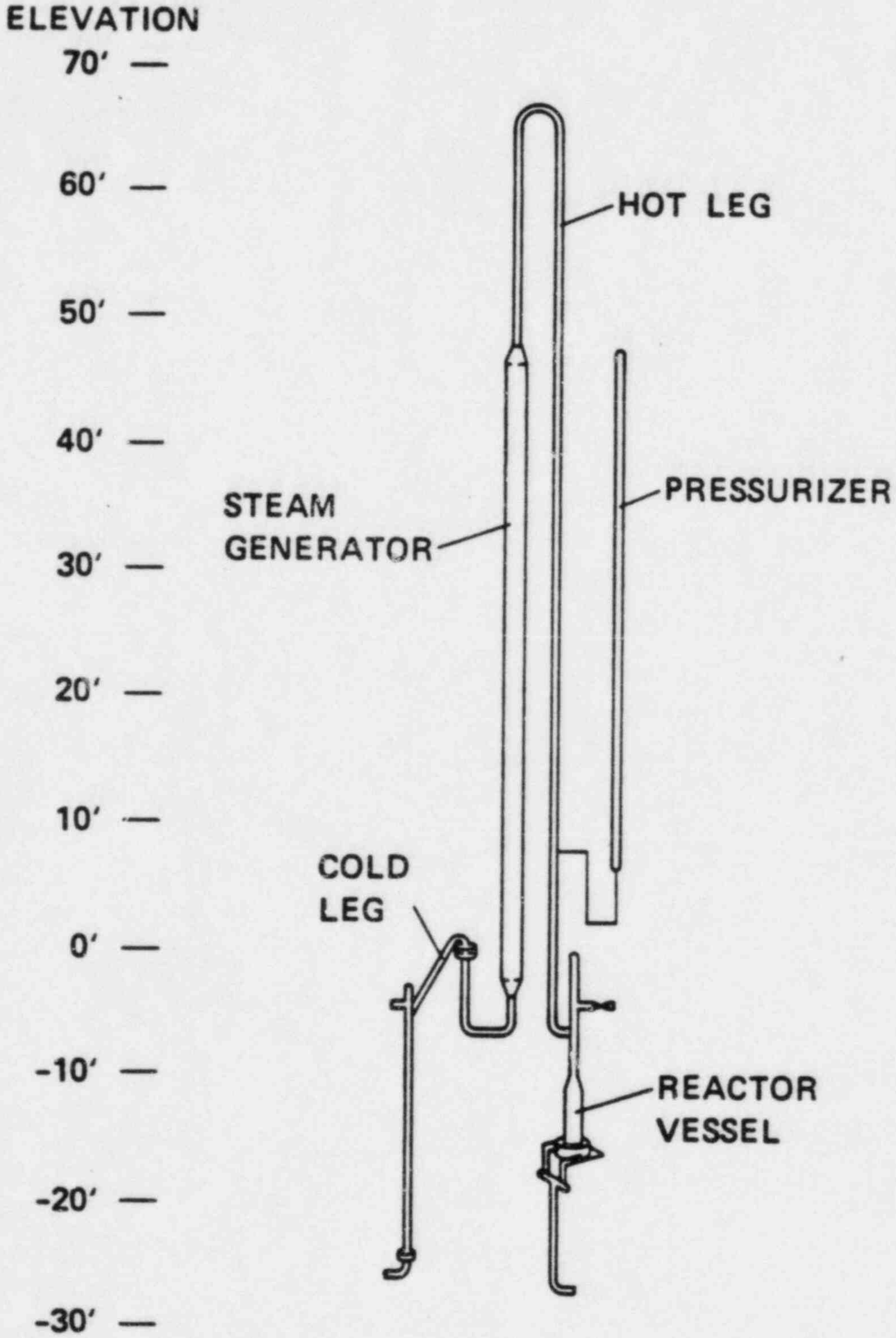
The 2.6" (66 MM) Pipe Diameter is Selected

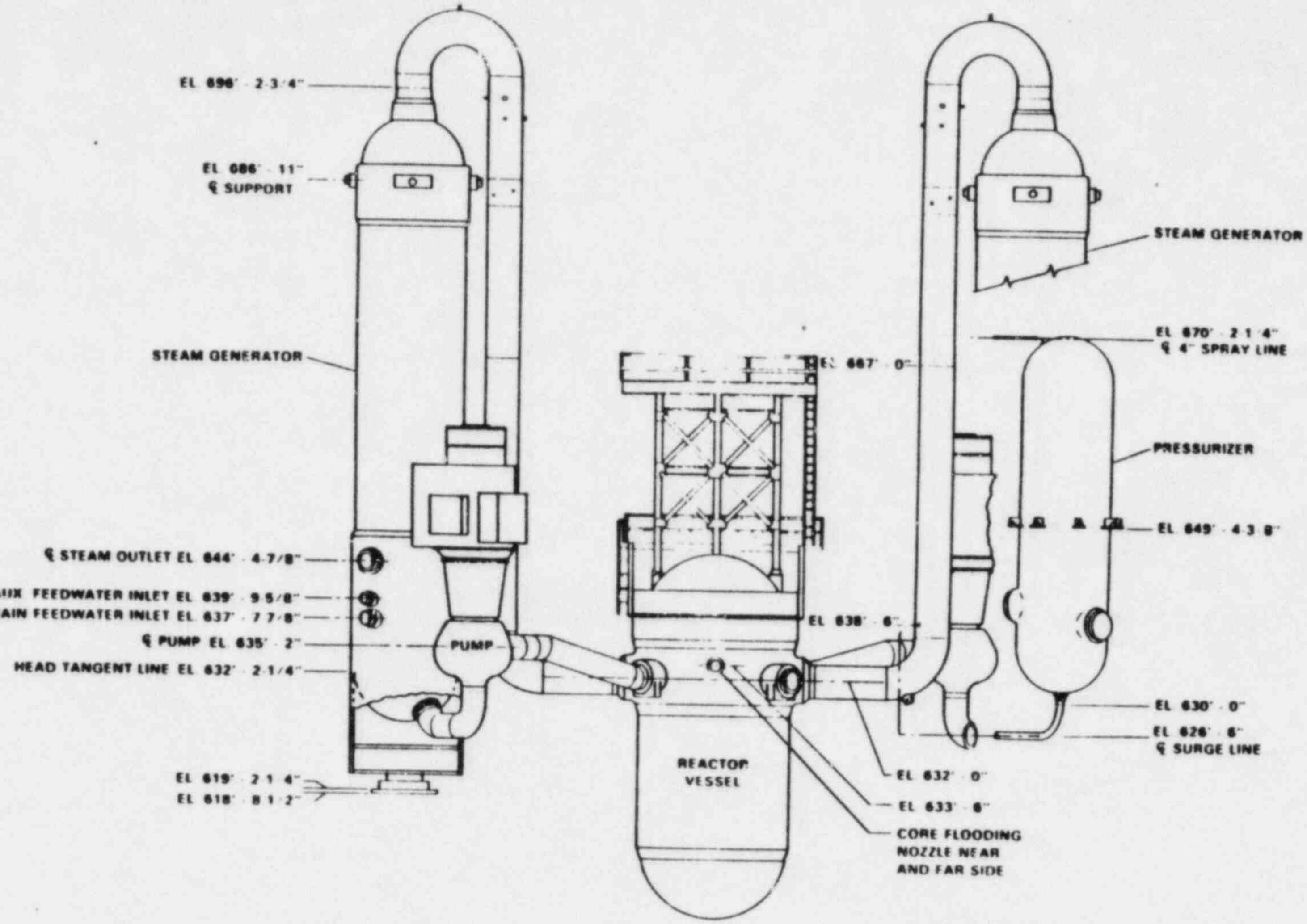
This preserved Froude Number, Flow Regimes According to Some Maps, and Flooding Criteria

Among the Pipe-Size Choices:

- It Has the Least Atypical Fluid Surface-To-Volume Ratio
- It is Conceptually Least Likely to Support Whole-Pipe Slugging

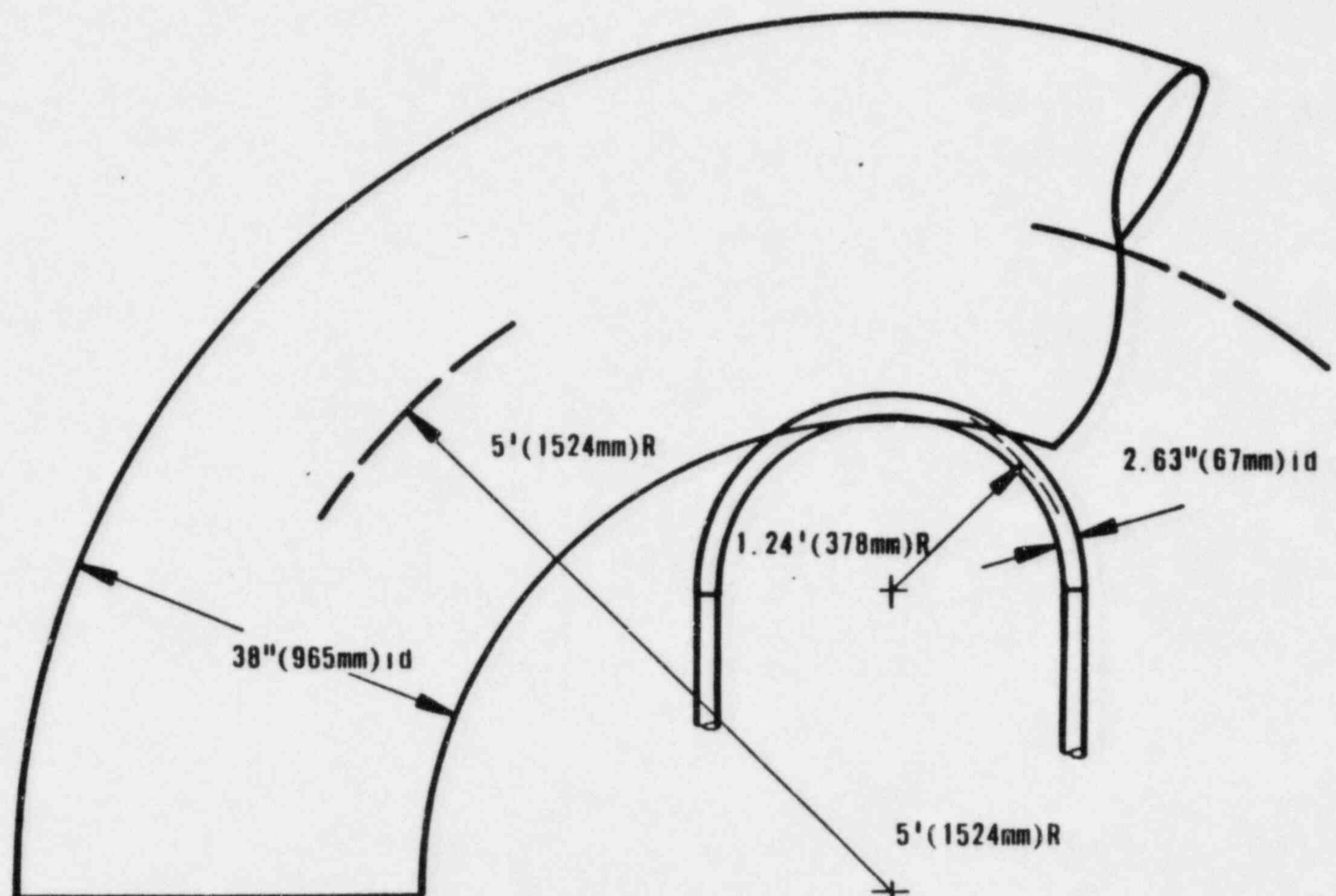
GERDA SCALED ARRANGEMENT





ELEVATION VIEW OF A 205 FUEL ASSEMBLY PLANT

Plant And Model HLUB



Model HLUB

Features:

- Preserves HLUB spillover elevation
- Retains the hot leg pipe diameter (2.63" or 67mm)
- Scales HLUB volume based on overall power-to-volume scale factor
- Preserves fluid mixture residence time (both HLUB length and mixture velocity are reduced by ~4)
- Obtains reduced fluid centrifugal force (force $\propto V^2/r$ reduced by ~ 4), and reduced void migration distance

Result:

Voids in the HLUB are at least as likely to separate and accumulate in the model as in the plant

Atypicalities

One-Dimensionality
GERDA is Predominantly a Vertical System

Surface-To-Volume Ratio (~1/D)
GERDA Fluid and Wall-Surface Temperature Are Much More Closely Coupled Than Those of a Plant (~X20)

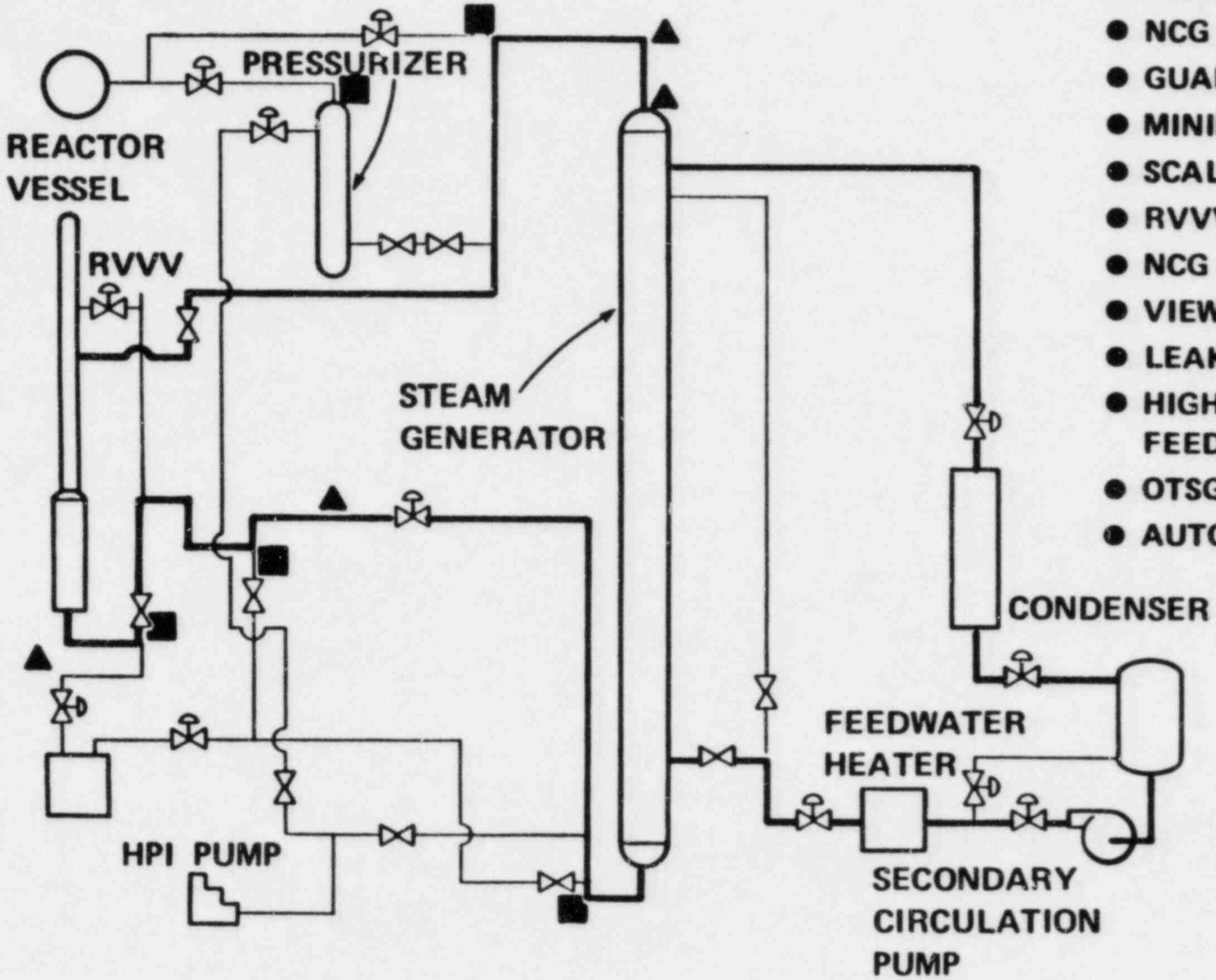
Metal Mass (~ 1/ D)
In High-Pressure Models, the Ratio of Metal Volume to Fluid Volume Increases With Scaling. The GERDA Ratio is ~2X that of a Plant

Hot Leg Volume
The Hot Leg Piping is Oversized, for Phenomenological Scaling

The Hot Leg Volume is ~3X Volume-Scaled, The Loop is 20% Oversized

(Heat Losses and System Leakage Are Specifically Minimized)

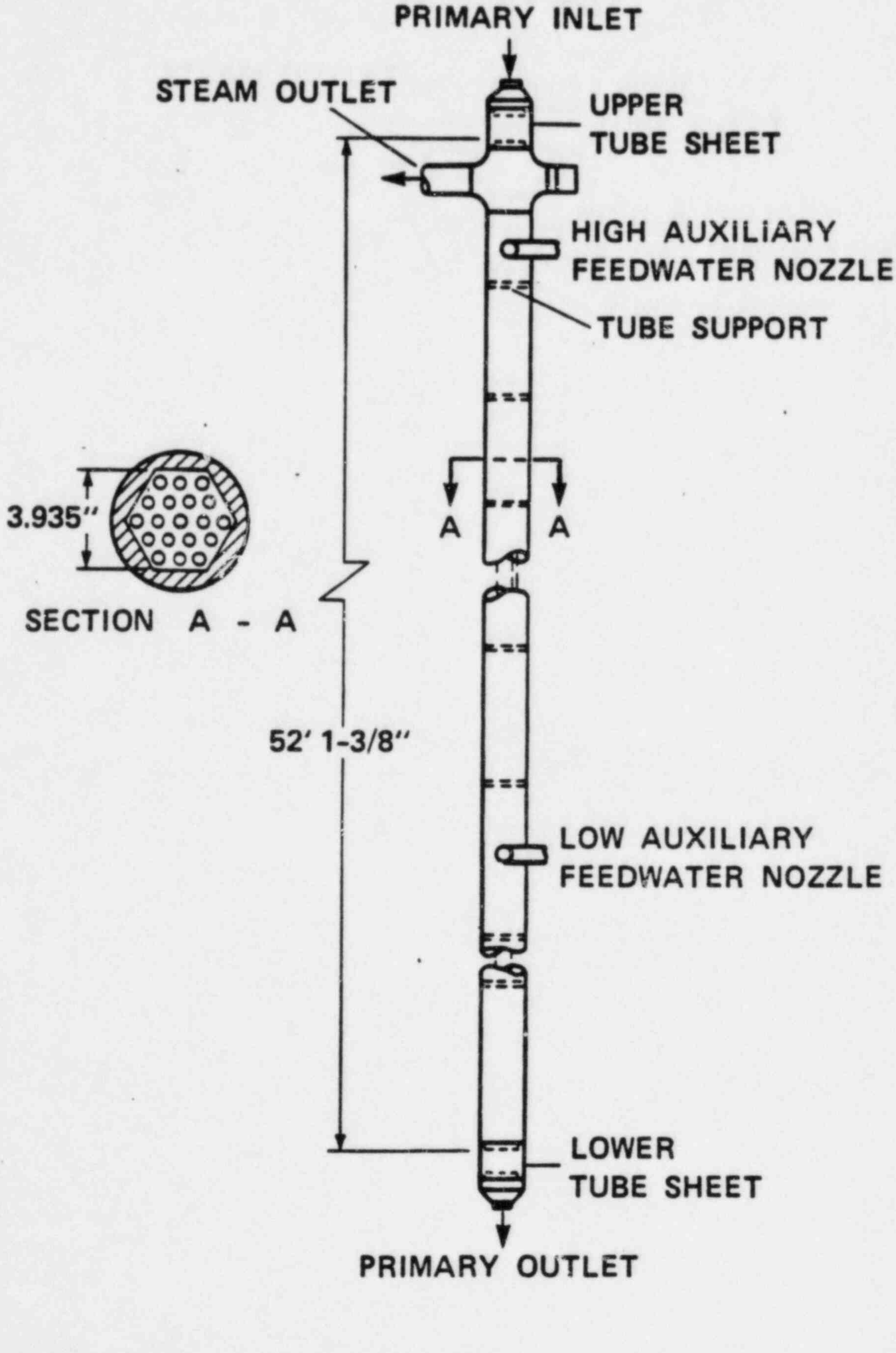
GERDA General Arrangement



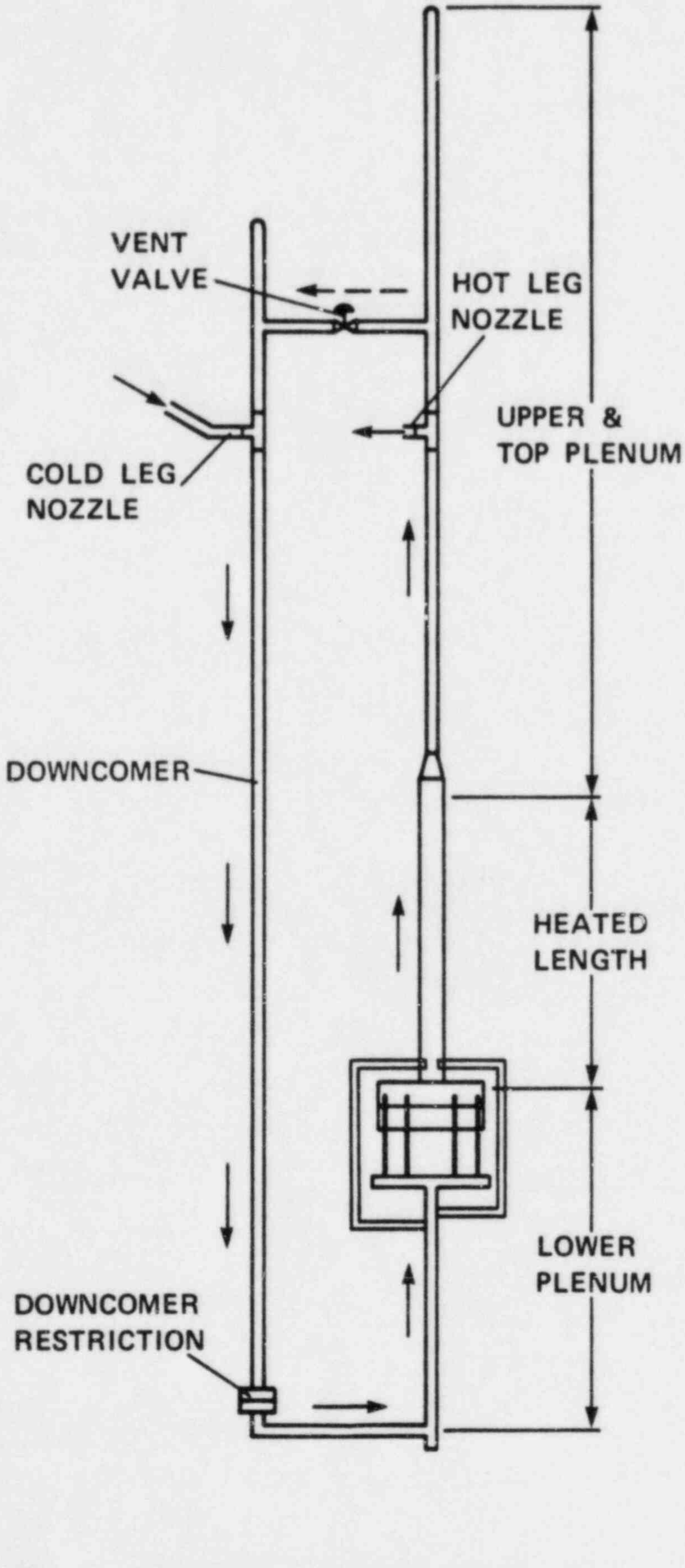
SPECIAL FEATURES

- 1 BY 1 LOOP
- 1 - 8% SCALED POWER
- MULTIPLE LEAK LOCATIONS
- NCG ADDITION
- GUARD HEATING
- MINIMUM HEAT LOSS
- SCALED HPI
- RVVV SIMULATION
- NCG DETECTION
- VIEW PORTS
- LEAK INTEGRITY
- HIGH AND LOW AUXILIARY FEEDWATER ADDITION
- OTSG LEVEL CONTROL
- AUTOMATIC COOLDOWN

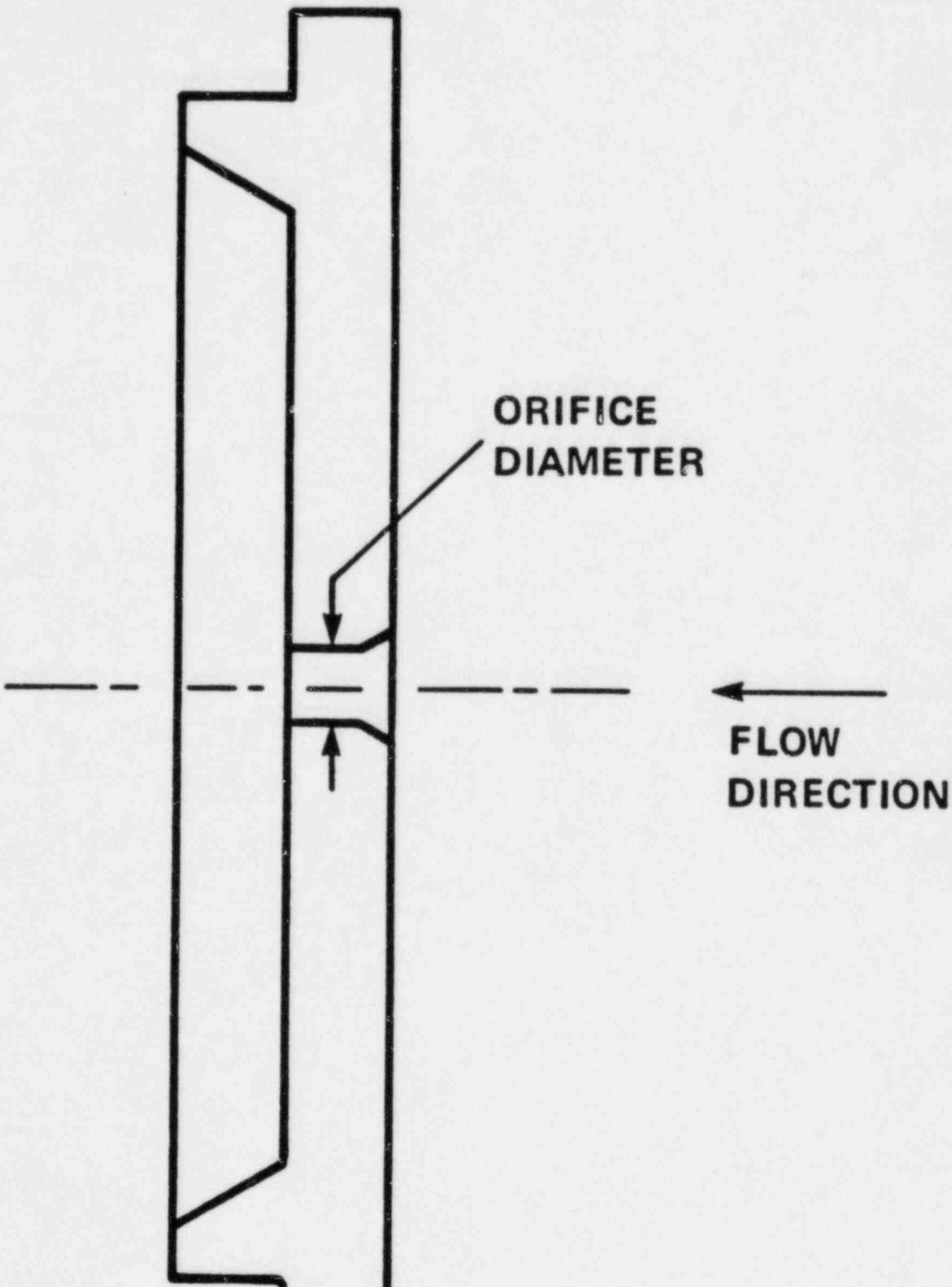
ONCE-THROUGH STEAM GENERATOR



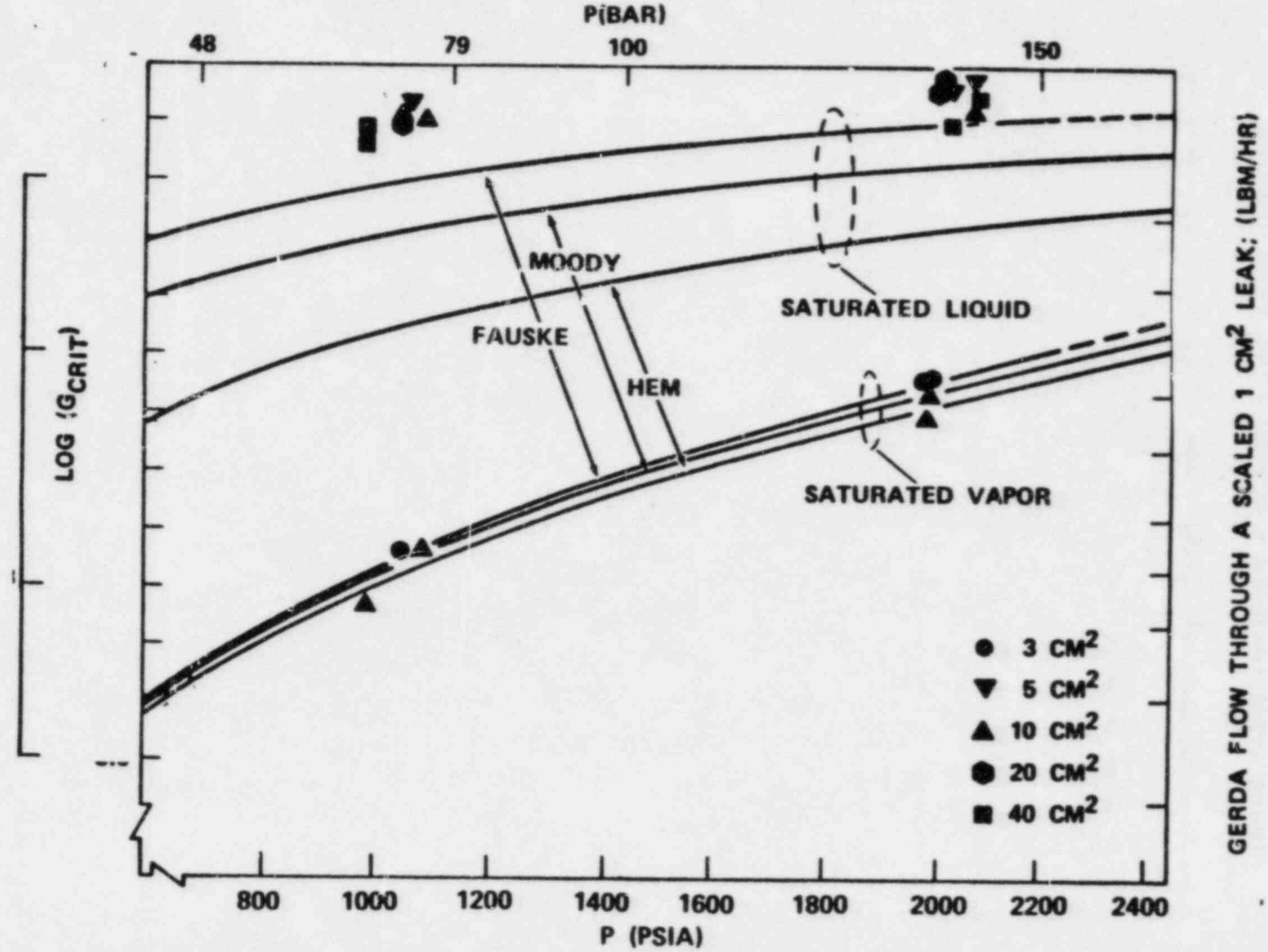
REACTOR VESSEL



Leak Flow Control Orifice

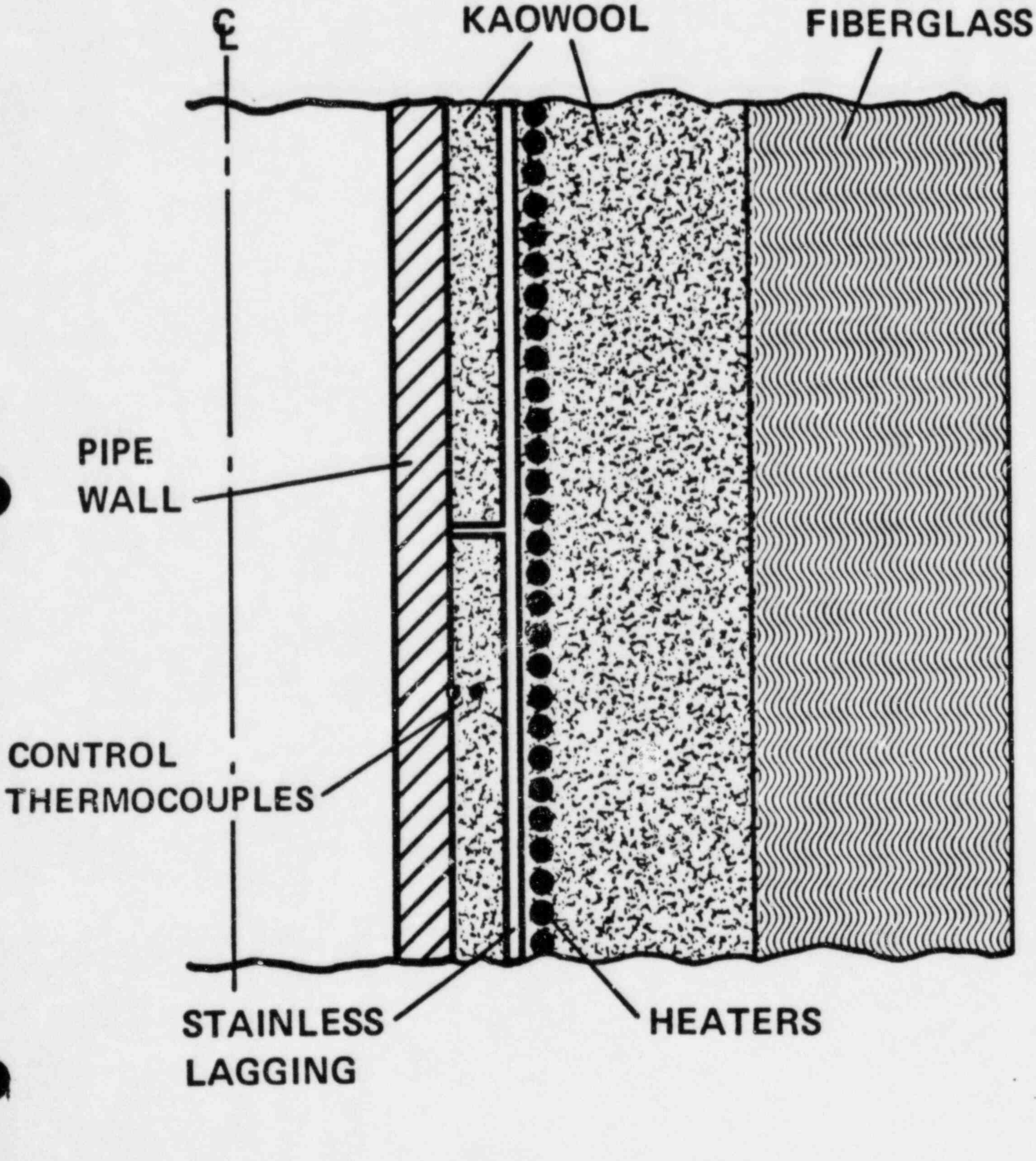


Measured and Predicted Critical Flows

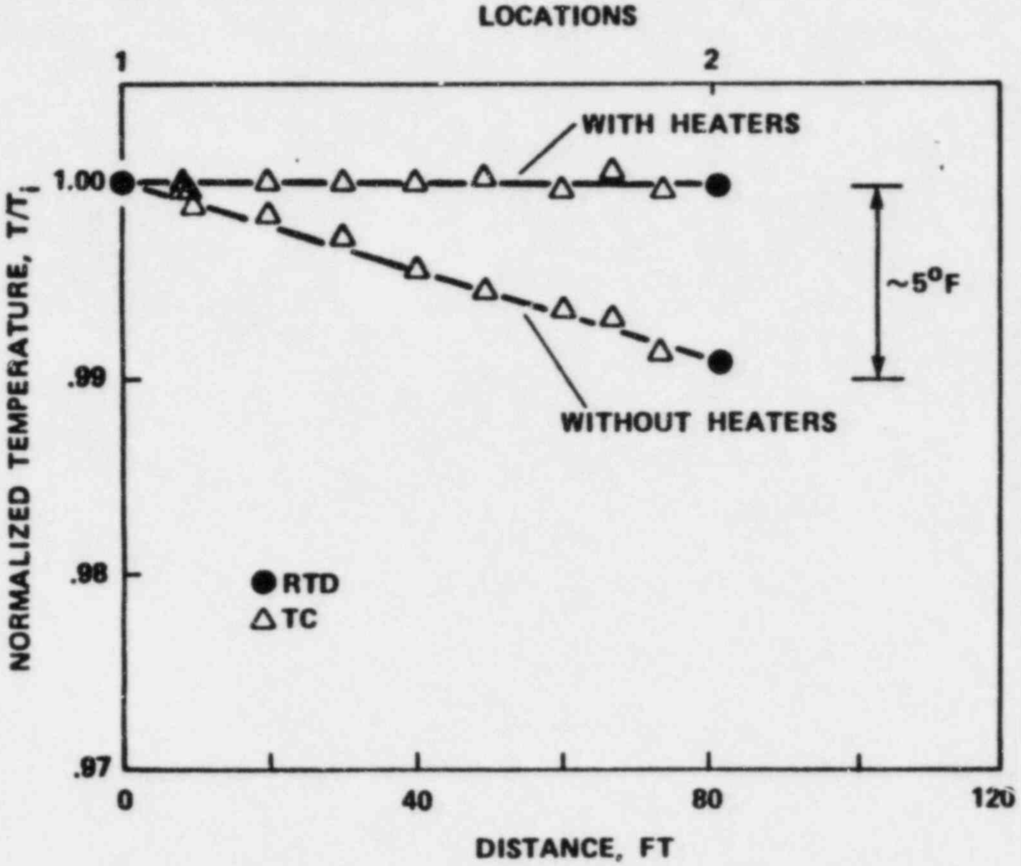


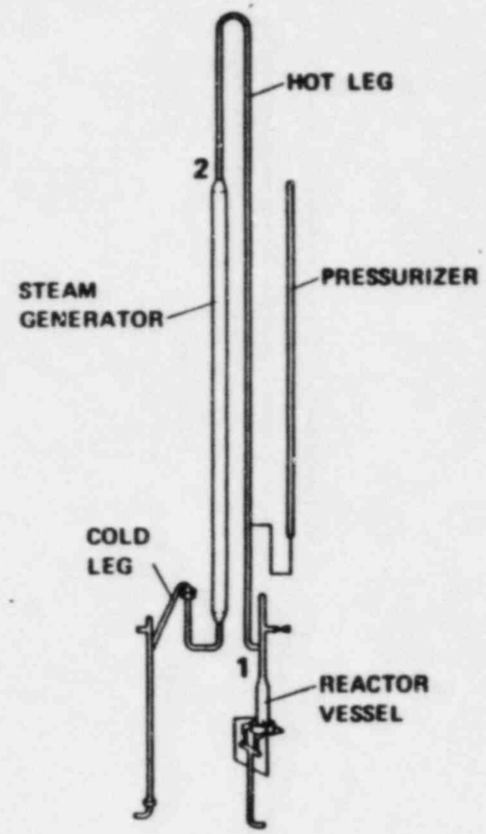
FAUSKE, MOODY, AND HEM (HOMOGENEOUS EQUILIBRIUM MODEL) CRITICAL FLOW AT SATURATED CONDITIONS. GERDA CRITICAL FLOW IS FOR A SCALED 1 CM^2 LEAK.

Guard Heaters

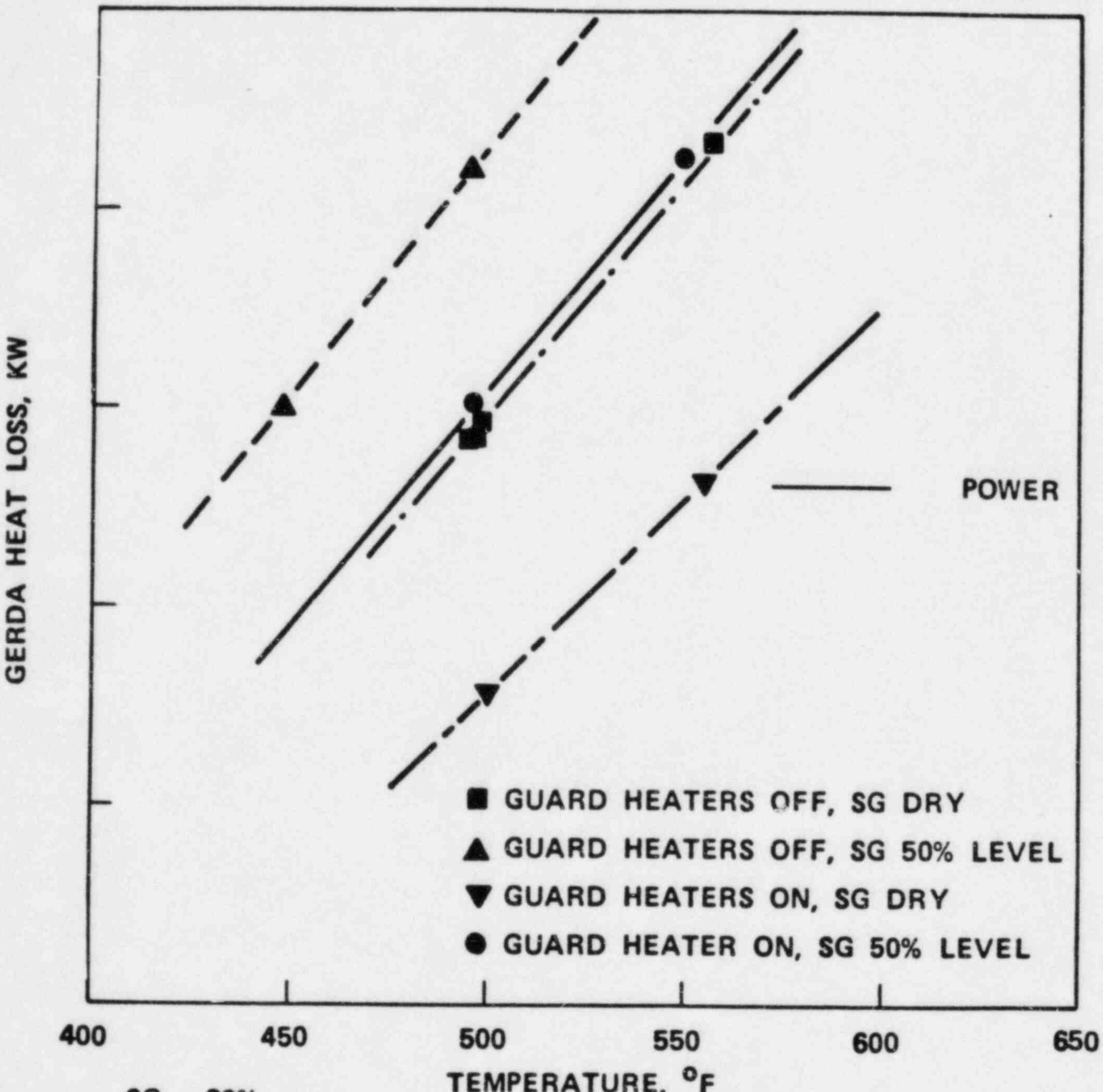


Hot Leg Fluid Temperatures With and Without Guard Heaters





GERDA Heat Loss



SG - 30%
RV - 35%
CL - 35%
HL - 0%

100%

GERDA Instrumentation

OVER 200 INSTRUMENTS FOR MEASUREMENT OF SELECTED PARAMETERS

- FLUID STATE

  CONDUCTIVITY PROBES, HEATED RTD ARRAYS, VISUAL PORTS

- NATURAL CIRCULATION FLOWRATE

  ULTRASONIC AND ORIFICE FLOWMETERS

- DOWNCOMER FLOWRATE

  ULTRASONIC AND ORIFICE FLOWMETERS

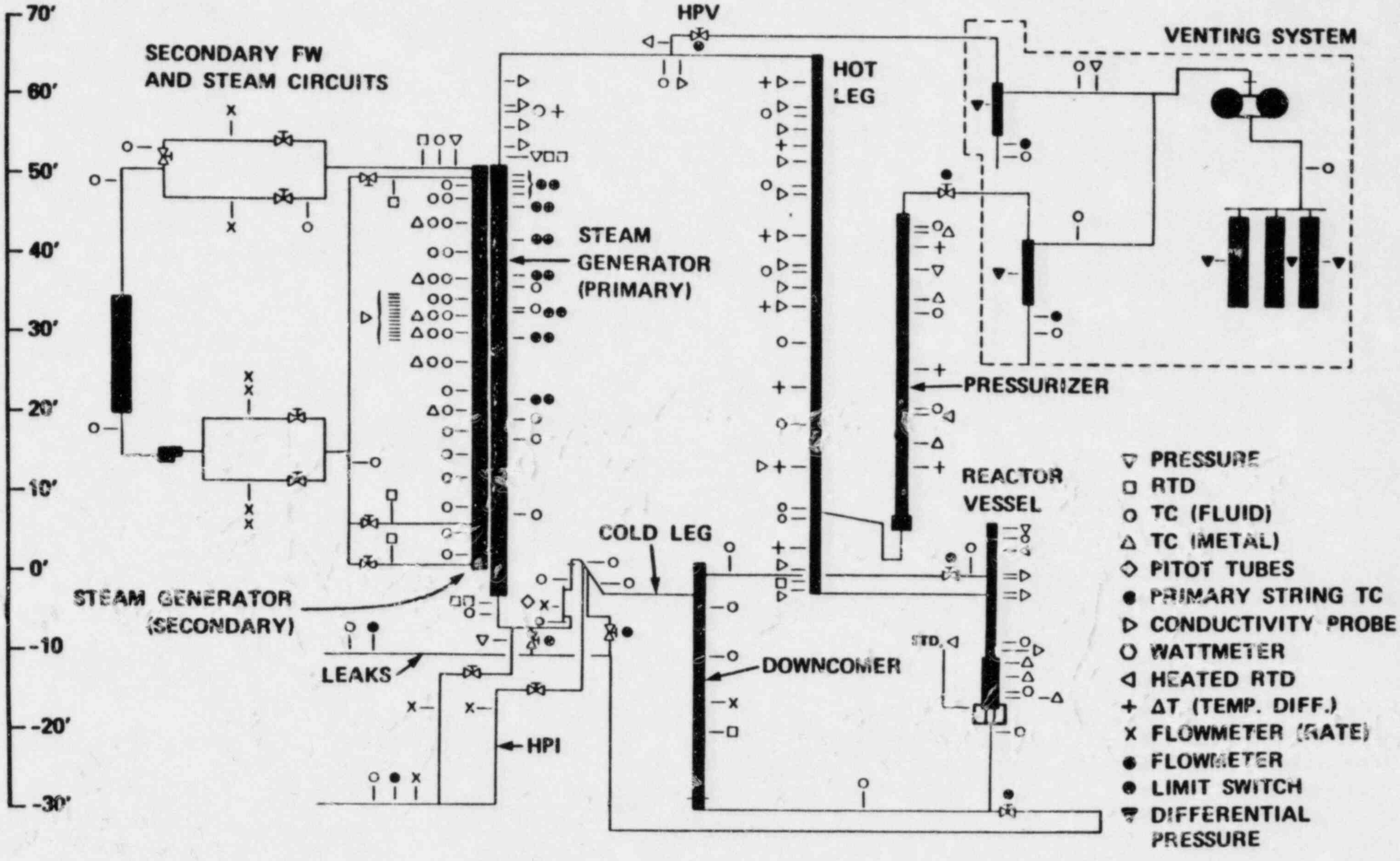
- INVENTORY SWELL

  CONDUCTIVITY PROBES, DIFFERENTIAL PRESSURES

- STANDARD MEASUREMENTS

  OF TEMPERATURES, PRESSURES, DIFFERENTIAL PRESSURES, FLOWS AND POWER

GERDA Instrumentation



SUMMARY (CON'T)

- LESSONS LEARNED
  - -HEAT LOSS (GUARD HEATING)
  - -INSTRUMENTATION LOCATIONS
  - -RVVV
  - -2X4 FOR LEAKS > 20 SQ. CM

OTIS

PURPOSE

MODIFICATIONS TO GERDA

Hardware

Setpoints

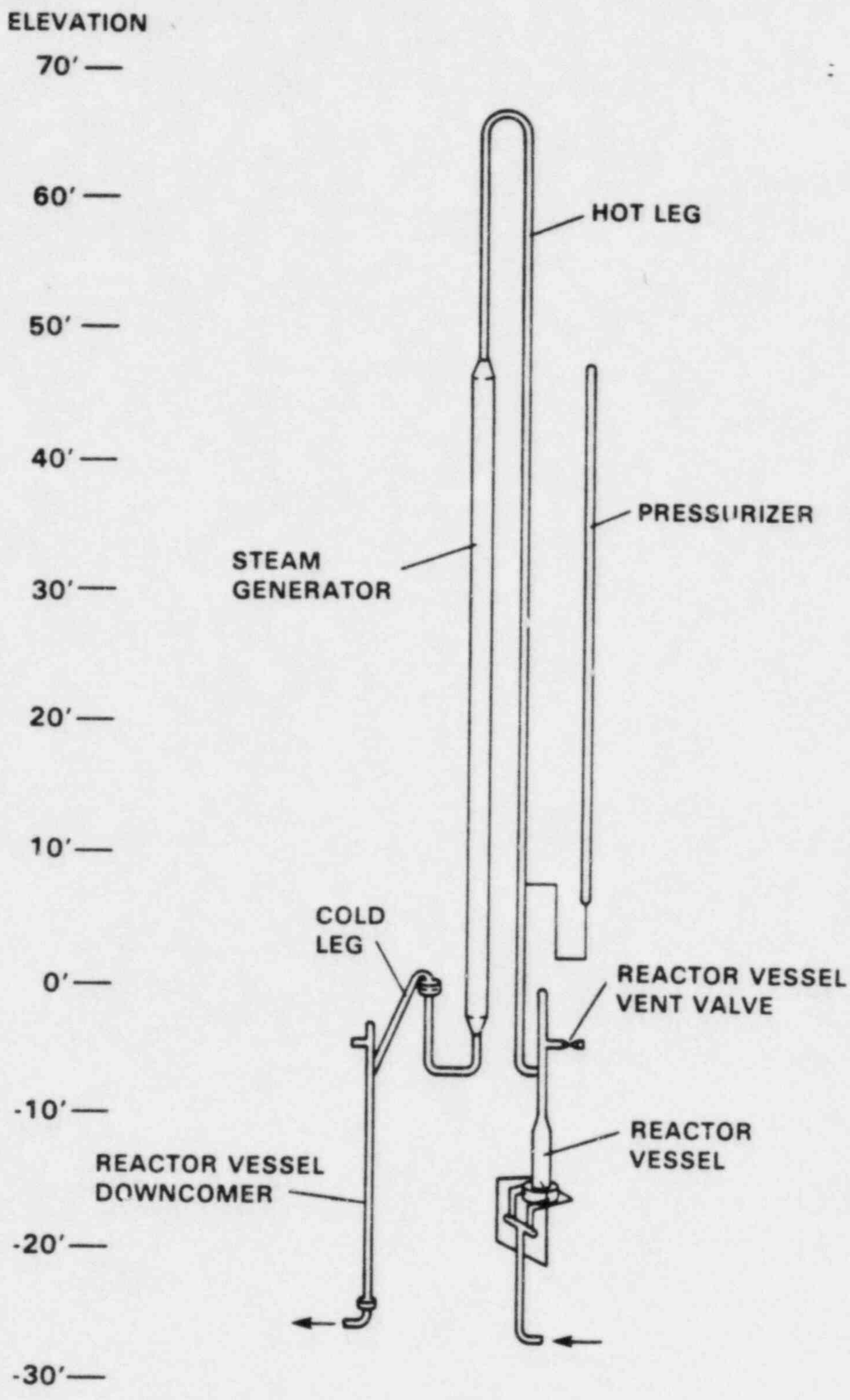
TEST PROGRAM

OTIS

(ONCE THROUGH INTEGRAL SYSTEM)

PURPOSE: CODE VERIFICATION

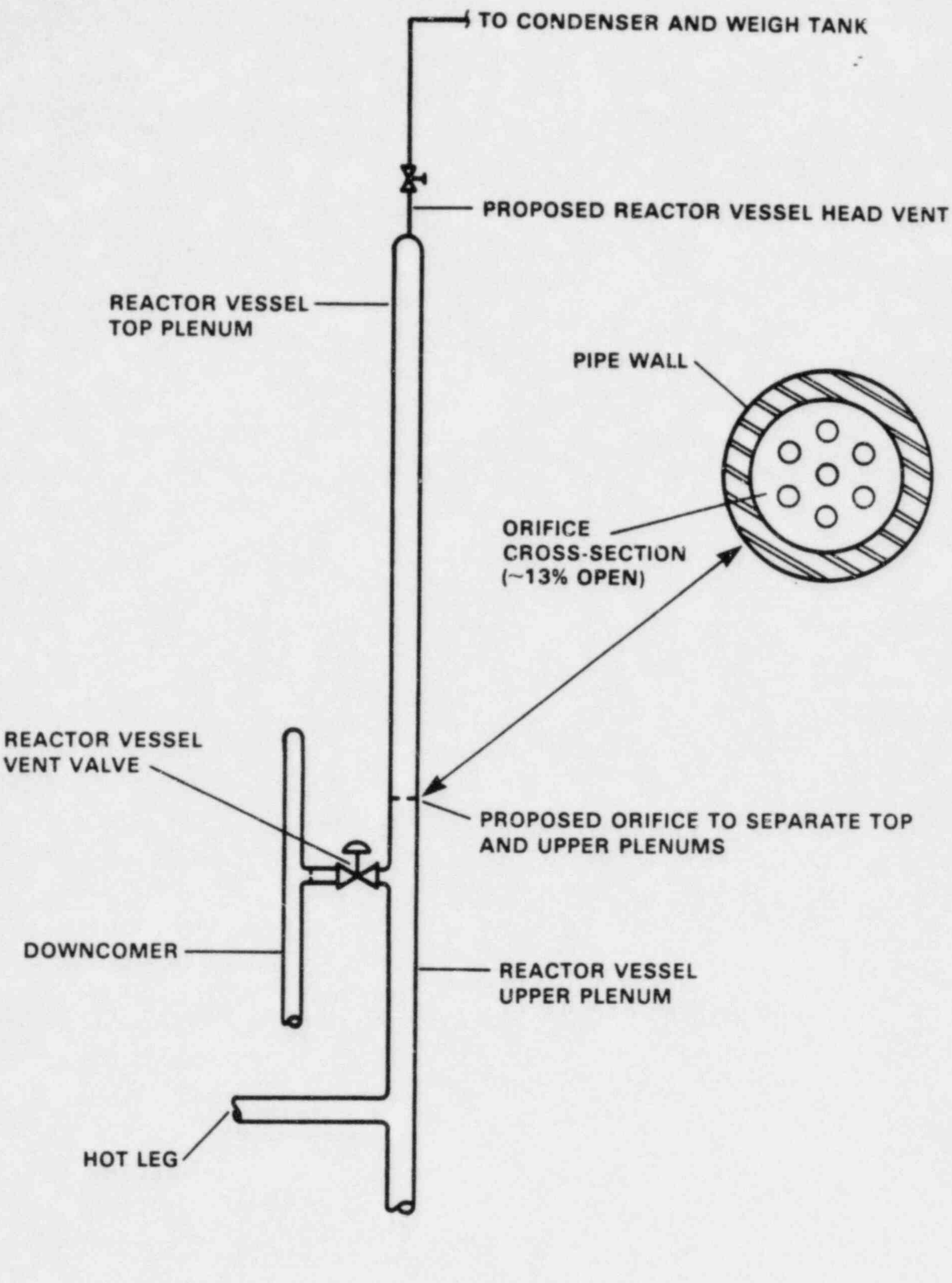
Provide raised loop SBLOCA data with domestic setpoints and leak locations to compliment GERDA data.



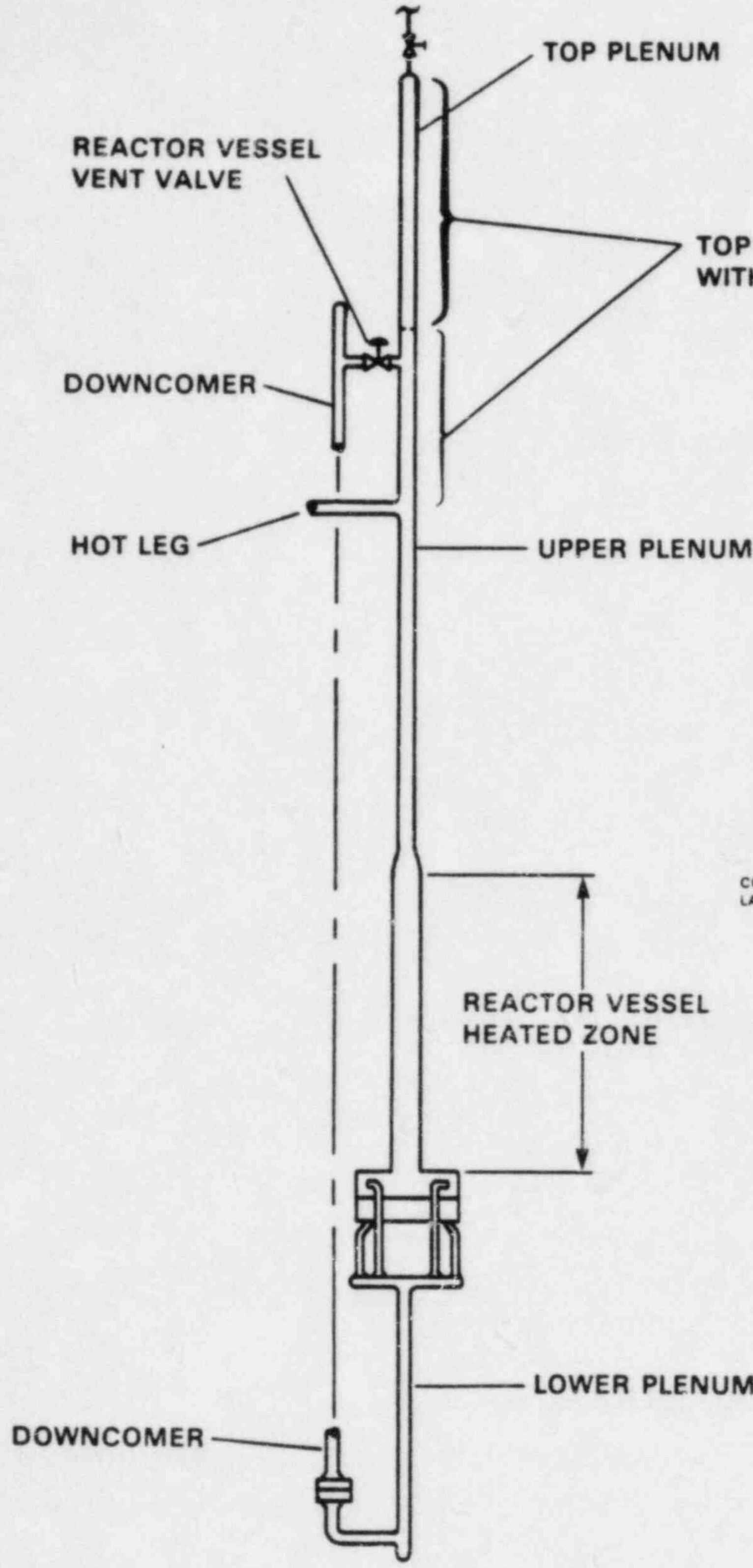
GERDA SCALED ARRANGEMENT

GERDA MODIFICATIONS FOR OTIS

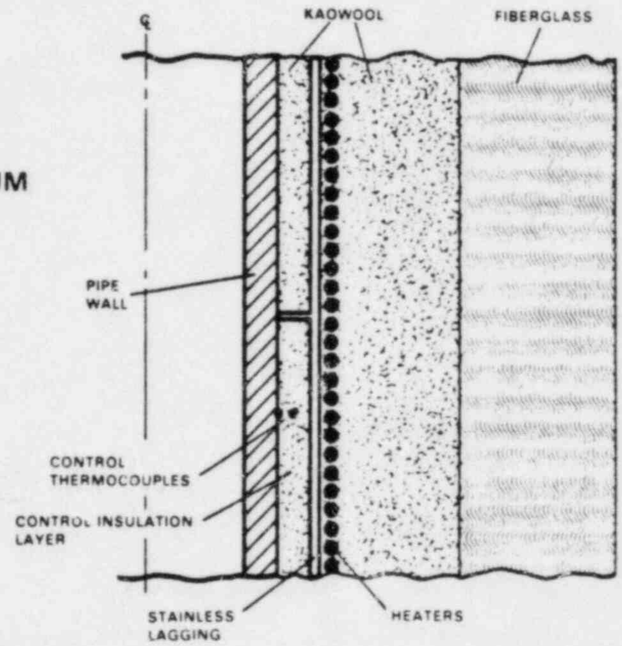
- REACTOR VESSEL HEAD VENT
- REACTOR VESSEL PLENUM RESTRICTOR
- REACTOR VESSEL PLENUM GUARD HEATING
- PRESSURIZER SURGE LINE GUARD HEATING
- RELOCATE COLD LEG FLOW MEASUREMENT
- BRANCHED LEAK SYSTEM
- OTSG STRING TC'S AND PITOT TUBES



PROPOSED REACTOR VESSEL HEAD VENT AND ORIFICE TO SEPARATE TOP AND UPPER PLENUMS

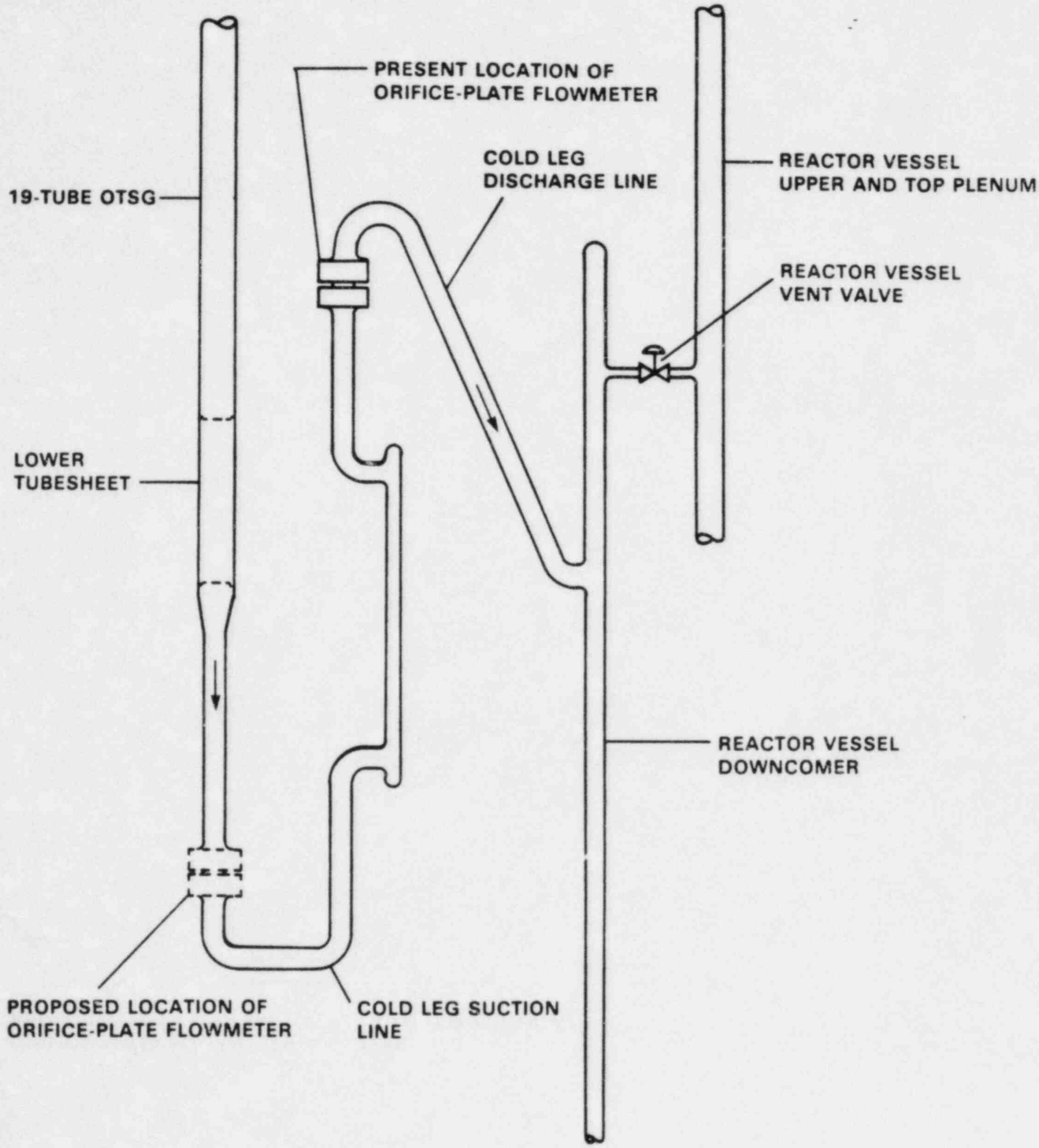


GERDA REACTOR VESSEL

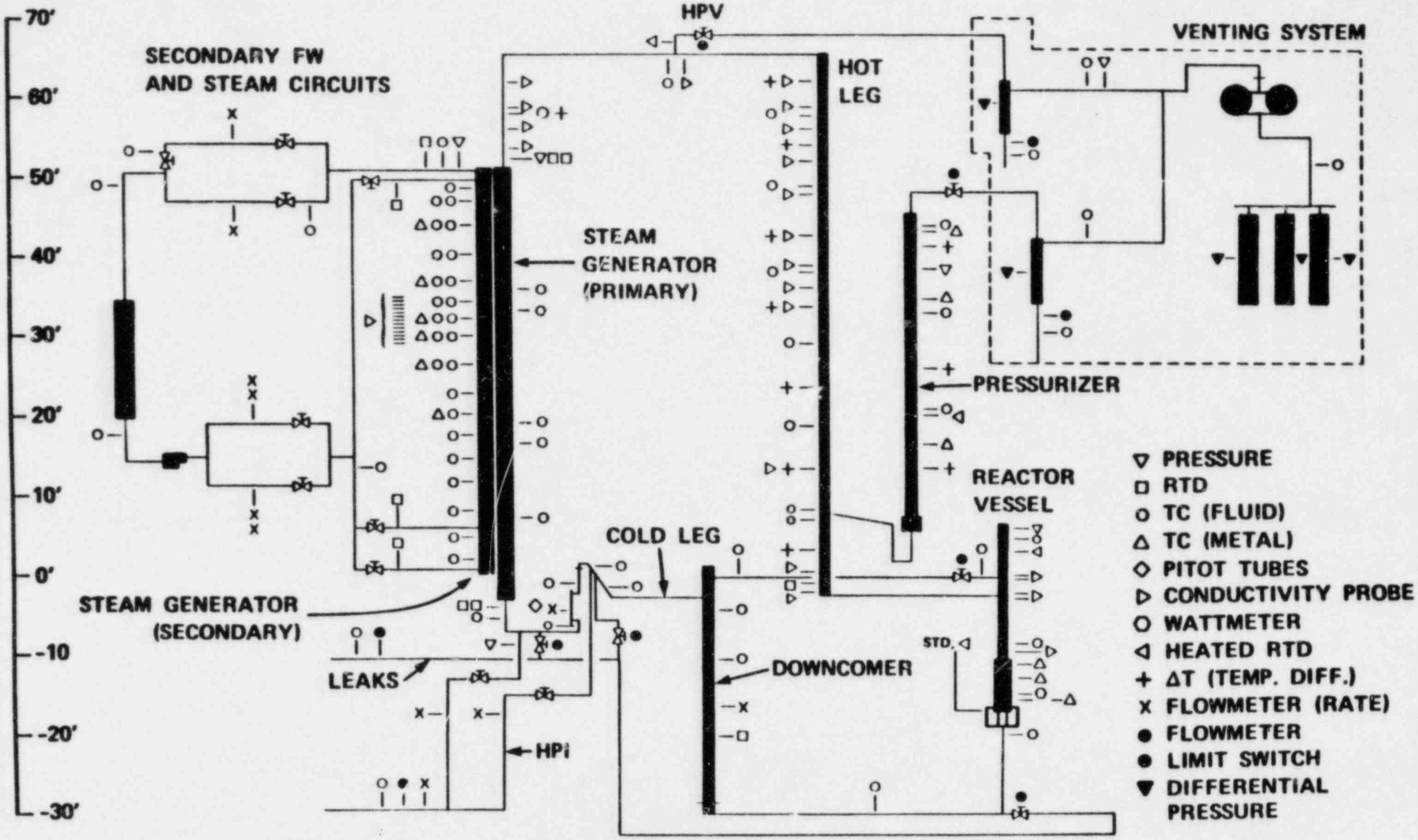


GUARD HEATERS

PROPOSED REACTOR VESSEL GUARD HEATING



PROPOSED COLD LEG FLOWRATE MEASUREMENT



GERDA INSTRUMENTATION

SETPOINTS CHANGES

AFW

- Level after trip
- Rate of level increase
- Level control

HPI

- Capacity
- Shutoff head

OTIS TEST PROGRAM

TEST CATEGORY	NUMBER OF TESTS
BENCHMARK	1
CHARACTERIZATION OF REACTOR VESSEL HPV	1
LEAK CONFIGURATION	3
LEAK LOCATION	2
SECONDARY CHARACTERISTICS	2
HPI CAPACITY	2
HPI COOLDOWN	1
COMPOSITE TRANSIENT	1
	13

UMCP 2x4 LOOP

Principal Investigator

Frank J. Munno

Co-Investigators

Y. Y. Hsu
Dirse Sallet
Gary Pertmer

College of Engineering
University of Maryland
College Park, MD 20742

July 19, 1983

1. Scaling Principles - Single Phase

2. Ranges of Important Scaling Parameters - Two-Phase

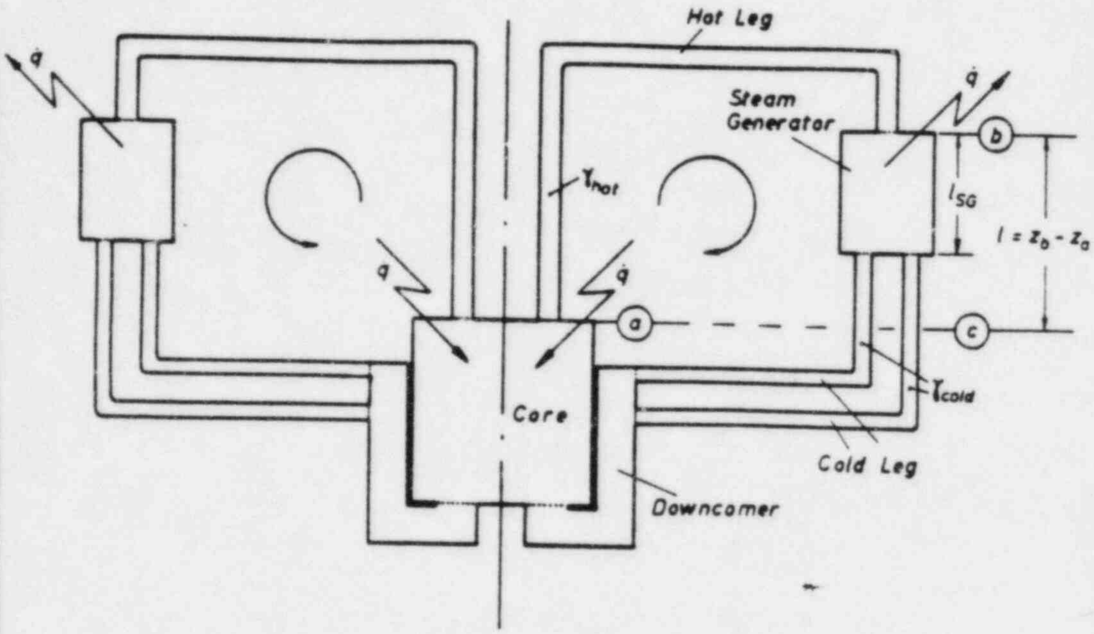
3. Facility Design

4. Schedule

5. Test Matrix

6. Test Results - ∩-bend bubble velocity

1. Scaling Principles - Single Phase



$$\frac{p_a}{\gamma_a} + \frac{V_a^2}{2g} + z_a = \frac{p_b}{\gamma_b} + \frac{V_b^2}{2g} + z_b + h_{losses}$$

$$\text{where} \quad h_{losses} = f\frac{L}{D}\frac{V^2}{2g} + k\frac{V^2}{2g}$$

$$(p_a - p_b) = \gamma_{hot}\ell + \gamma_{hot}h_{losses}$$

$$\left(\frac{\gamma_{cold} - \gamma_{hot}}{\gamma}\right)\ell = f\frac{L}{D}\frac{V^2}{2g} + k\frac{V^2}{2g}$$

Steady State Loop Behavior (A)

UMCP 2x4 Natural Circulation Loop | 4

$$\beta = \frac{1}{v}\left(\frac{\partial v}{\partial T}\right)_p = \left(\frac{\Delta\rho}{\rho}\right)\frac{1}{\Delta T} = \left(\frac{\gamma_c - \gamma_h}{\gamma}\right)\frac{1}{\Delta T}$$

$$\beta g \Delta T \ell = \sum_i K_i \frac{V_i^2}{2}$$

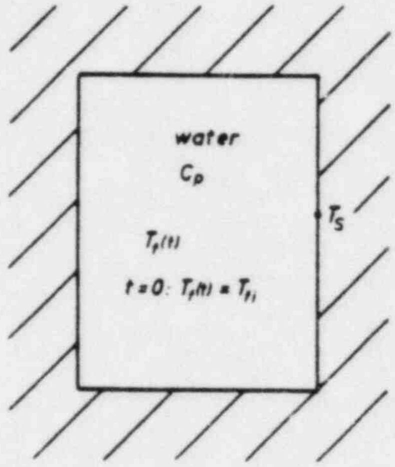
where $K = f\frac{L}{D} + k$

$$\sum_i K_i \frac{V_i^2}{2} = \frac{Q^2}{2}\left(\frac{K_1}{A_1^2} + \frac{K_2}{A_2^2} + \frac{K_3}{A_3^2} + \frac{K_4}{4A_4^2} + \frac{K_5}{A_5^2}\right) = \frac{Q^2}{2} K^*$$

$$Q = \left(\frac{2g\beta\ell\dot{q}}{\rho c K^*}\right)^{1/3}$$

Steady State Loop Behavior (B)

UMCP 2x4 Natural Circulation Loop	5



$$de = -c\,M\,dT$$

$$dq = \bar{h}A_s\,(T_f(t) - T_s)\,dt$$

$$\frac{T_f - T_s}{T_{fi} - T_s} = e^{-\frac{\bar{h}A_s}{cM}t} \qquad T_1 = \frac{cM}{\bar{h}A_s}$$

Transient Loop Response (A)

UMCP 2x4 Natural Circulation Loop	6

$$\sum_i F_i = \sum_{i=1}^{i=5} m_i \frac{du_i}{dt}$$

$$\sum_{i=1}^{i=5} m_i \frac{du_i}{dt} = \frac{du_2}{dt} \left[m_2 + \frac{A_2}{A_3} m_3 + \frac{A_2}{2A_4} 2m_4 + \frac{A_2}{A_5} m_5 + \frac{A_2}{A_1} m_1\right]$$

$$\sum_i \frac{F_i}{A_i} = \frac{dQ}{dt} M^*$$

where

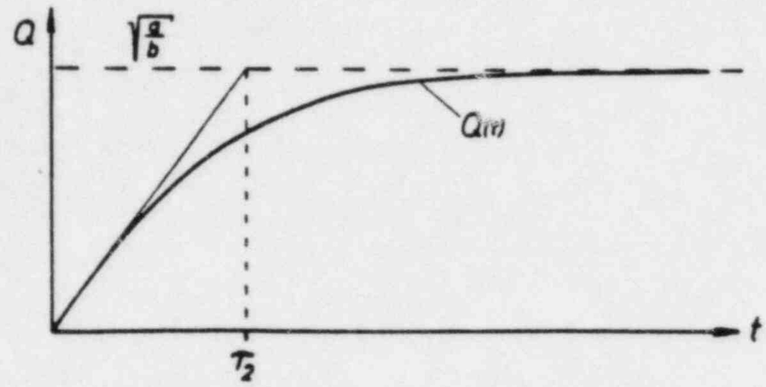
$$M^* = \left[\frac{m_1}{A_1^2} + \frac{m_2}{A_2^2} + \frac{m_3}{A_3^2} + \frac{2m_4}{(2A_4)^2} + \frac{m_5}{A_5^2}\right]$$

$$\frac{dQ}{dt} = \frac{1}{M^*} \left[\Delta\gamma \ell - \frac{1}{2} \rho K^* Q^2\right]$$

$$Q(t) = \sqrt{\frac{\Delta\rho g \ell}{\frac{1}{2}\rho K^*}} \tanh \left\{ \frac{\sqrt{(\frac{1}{2}\rho K^*)(\Delta\rho g \ell)}}{M^*} t \right\}$$

Transient Loop Response (B)

UMCP 2x4 Natural Circulation Loop	7



$$Q(t) = \sqrt{\frac{a}{b}} \tanh \left\{ \frac{\sqrt{a\,b}}{M^*} t \right\}$$

$$a = \Delta\rho g \ell$$

$$b = \frac{1}{2} \rho K^*$$

$$T_2 = \frac{M^*}{\sqrt{a\,b}} = \frac{M^*}{\sqrt{\left(\frac{1}{2}\rho K^*\right)(\Delta\rho g \ell)}}$$

$$M^* = \rho \left[\frac{v_1}{A_1^2} + \frac{v_2}{A_2^2} + \frac{v_3}{A_3^2} + \frac{2v_4}{(2A_4)^2} + \frac{v_5}{A_5^2} \right]$$

$$K^* = \frac{K_1}{A_1^{\,2}} + \frac{K_2}{A_2^{\,2}} + \frac{K_3}{A_3^{\,2}} + \frac{K_4}{4A_4^{\,2}} + \frac{K_5}{A_5^{\,2}}$$

Transient Loop Response (C)

UMCP 2x4 Natural Circulation Loop	8

$$\frac{p_c}{\gamma_c} + \frac{V_c^{\ 2}}{2g} + h_p + z_c = \frac{p_d}{\gamma} + \frac{V_d^{\ 2}}{2g} + h_L + z_d + \frac{1}{g}\int \frac{\partial v_s}{\partial t} ds$$

$$\int_o^V \frac{dV}{\frac{\Delta\rho}{\rho} g\ell - \frac{A^2 K^*}{2} V^2} = \int_o^t \frac{dt}{L^*}$$

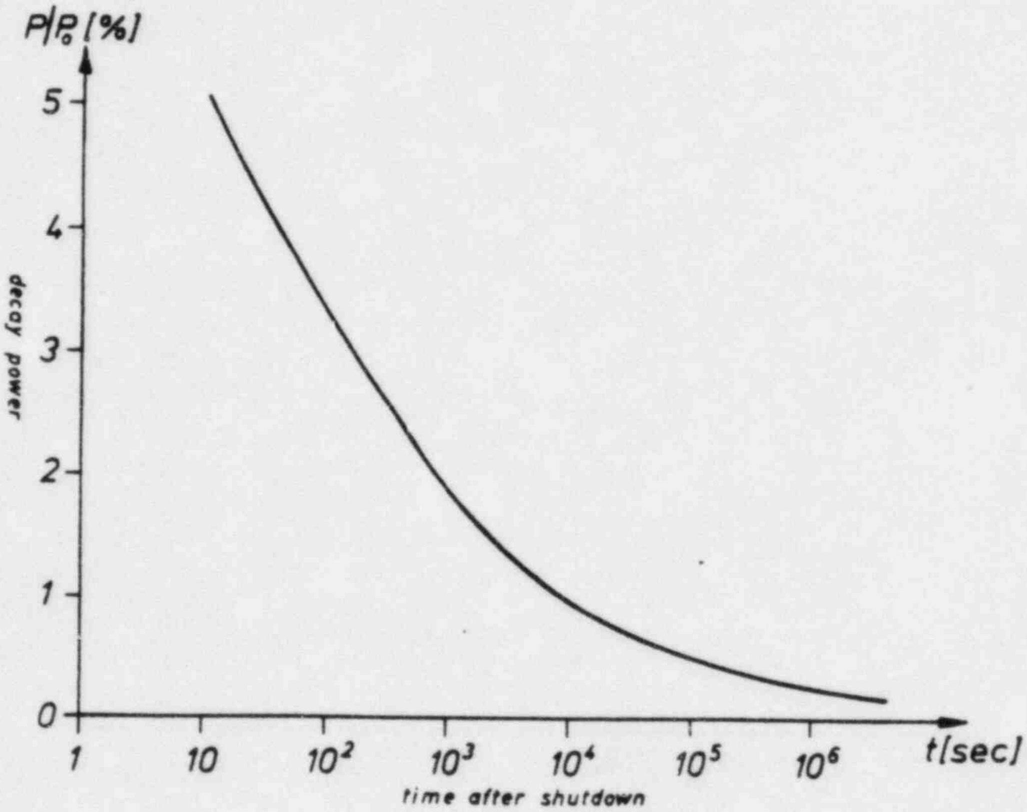
$$Q(t) = \sqrt{\frac{\Delta\rho\ g\ell}{\frac{1}{2}\ \rho\ K^*}}\ \tanh \left\{ \sqrt{(\tfrac{1}{2}\ \rho\ K^*)(\Delta\rho\ g\ell)}\ \ (\frac{A}{\rho L^*})\ t \right\}$$

$$\text{where } K^* = (\frac{K_1}{A_1^2} + \frac{K_2}{A_2^2} + \frac{K_3}{A_3^2} + \frac{K_4}{4A_4^2} + \frac{K_5}{A_5^2})$$

$$L^* = A_2\ (\frac{L_1}{A_1} + \frac{L_2}{A_2} + \frac{L_3}{A_3} + \frac{L_4}{2A_4} + \frac{L_5}{A_5})$$

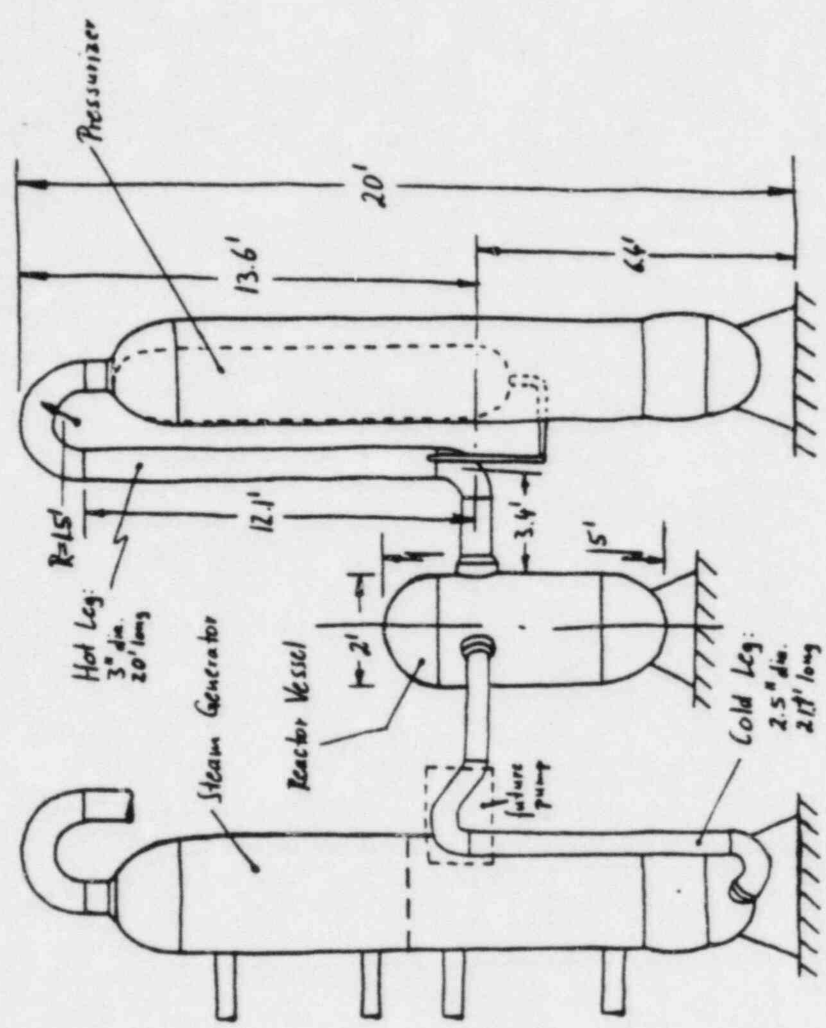
Transient Loop Response (D)

UMCP 2x4 Natural Circulation Loop	9



ANS Heat Decay Curve

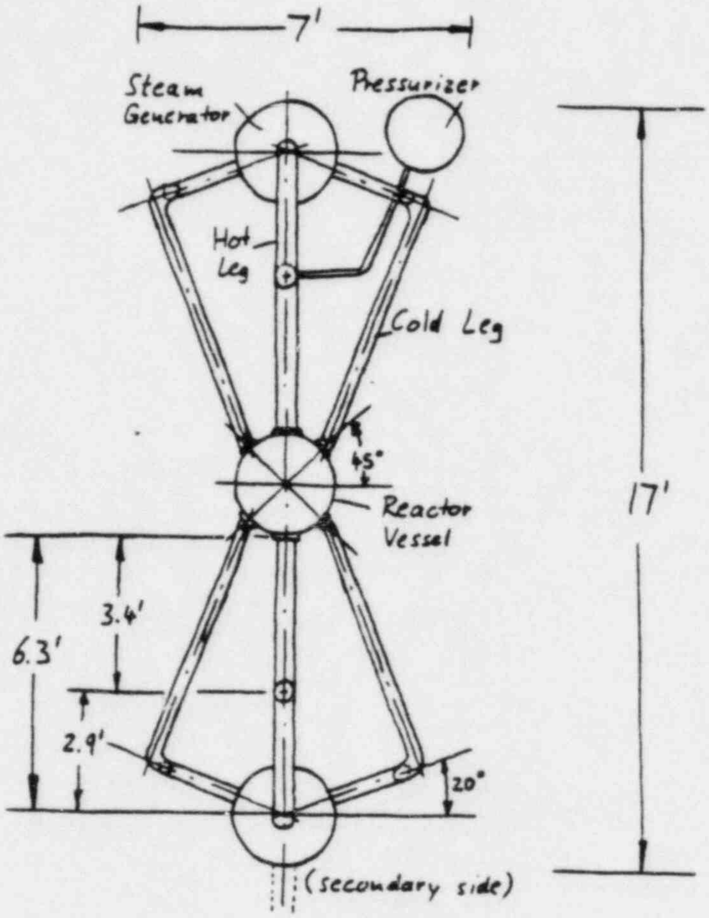
UMCP 2x4 Natural Circulation Loop	10



Elevation View of UMCP Loop

UMCP 2x4 Natural Circulation Loop

11



Plan View of UMCP Loop

UMCP 2x4 Natural Circulation Loop

Sizes of Components used in Scaling and for Flow Prediction Calculations

	Model		Prototype	
1/2 Core Barrel: A_1	113.49	$inch^2$	24.61	ft^2
1 Hot Leg: A_2	7.07	"	7.07	ft^2
1 S.G.: A_3	36.54	"	38.96	ft^2
1 Cold Leg: A_4	4.91	"	4.28	ft^2
1/2 D.C.: A_5	35.83	$inch^2$	20.75	ft^2
1/2 Core Barrel: V_1	2.644	ft^3	1322.2	ft^3
1 Hot Leg: V_2	0.979	"	489.5	ft^3
1 S.G.: V_3	4.060	"	2030.0	ft^3
1 Cold Leg: V_4	0.738	"	369.2	ft^3
1/2 D.C.: V_5	0.826	ft^3	413.2	ft^3
Core Barrel: L_1	3.35	ft	53.7	ft
Hot Leg: L_2	19.94	"	69.3	ft
S.G.: L_3	16.00	"	52.1	ft
Cold Leg: L_4	21.65	"	86.3	ft
D.C.: L_5	3.32	ft	19.9	ft

Model and Prototype Component Sizes

UMCP 2x4 Natural Circulation Loop

Model and Prototype L/D Ratios

Length to Diameter Ratios for Scaling Considerations
(Based on hypothetical circular cylinders containing the actual water volumes and using either actual lengths or actual diameters)

Component	Model	Prototype
Core Barrel $(\frac{L}{D})_1 = \frac{L_1}{\sqrt{\frac{8}{\pi} A_1}}$	$(\frac{L_1}{D_1})_{model} = 2.36$ (Dia. of component: 17.00 inch)	$(\frac{L_1}{D_1})_{prototype} = 6.78$ (Dia. of component: 7.91 ft)
Hot Leg $(\frac{L}{D})_2 = \frac{L_2}{\sqrt{\frac{4}{\pi} A_2}}$	$(\frac{L_2}{D_2})_{model} = 33.84$ (Dia. of component: 3.00 inch)	$(\frac{L_2}{D_2})_{prototype} = 23.10$ (Dia. of component: 3.00 ft)
Steam Generator $(\frac{L}{D})_3 = \frac{L_3}{\sqrt{\frac{\pi}{4} A_3}}$	$(\frac{L_3}{D_3})_{model} = 5.25$ (Dia. of component: 6.82 inch)	$(\frac{L_3}{D_3})_{prototype} = 7.40$ (Dia. of component: 7.04 ft)
Cold Leg $(\frac{L}{D})_4 = \frac{L_4}{\sqrt{\frac{\pi}{4} A_3}}$	$(\frac{L_4}{D_4})_{model} = 103.92$ (Dia. of compoinent: 2.50 inch)	$(\frac{L_4}{D_4})_{prototype} = 34.04$ (Dia. of component: 2.33 ft)
Downcomer $(\frac{L}{D})_4 = \frac{L_5}{\sqrt{\frac{8}{\pi} A_5}}$	$(\frac{L_5}{D_5})_{model} = 4.17$ (Dia. of component: 9.55 inch)	$(\frac{L_5}{D_5})_{prototype} = 2.74$ (Dia. of component: 7.27 ft)

UMCP 2x4 Natural Circulation Loop

Model and Prototype Values for K^* and v^*

	$\frac{1}{2}$ Core		1 Hot Leg		1 Steam Gen.		1 Cold Leg		$\frac{1}{2}$ Downcomer
$K^* =$	$\frac{K_1}{A_1^2}$	+	$\frac{K_2}{A_2^2}$	+	$\frac{K_3}{A_3^2}$	+	$\frac{K_4}{4A_4^2}$	+	$\frac{K_5}{A_5^2}$
$K^*_{model} =$	18	+	611	+	147	+	332	+	2
	1.6%		55%		13%		30%		0.2%
$K^*_{proto} =$	0.019	+	0.029	+	0.006	+	0.021	+	0.0004
	25%		38.5%		8%		28%		0.5%

	$\frac{1}{2}$ Core		1 H.L.		1 S.G.		1 C.L.		$\frac{1}{2}$ D.C.
$v^* =$	$\frac{v_1}{A_1^2}$	+	$\frac{v_2}{A_2^2}$	+	$\frac{v_3}{A_3^2}$	+	$\frac{2v_4}{(2A4)^2}$	+	$\frac{v_5}{A_5^2}$
$v^*_{model} =$	4.26		406.14		63.05		317.39		13.34
	0.53%		50.5%		7.84%		39.5%		1.6%
$v^*_{prototype} =$	2.18		9.79		1.34		10.08		0.96
	8.9%		40%		5.5%		41%		4%

Summary of Single Phase Scaling

1. Derived from first principles for:
   a. Steady-State
   b. Transients

2. Preserves:
   a. Volume/Power ratio, Prototype: Model = 500
   b. Real Time (for each component)

3. "Fat and Short" Hot Leg & Cold Legs

   Diameter: 1.6 times geometric scale

   Height: 1/3 of geometric scale

2. Ranges of Important Scaling Parameters - Two-Phase

Parameter	Prototype	MIST*	UMCP 2x4
j_ℓ (fps)	0.0-1.6	0.0-0.4	0.0-1.5
j_g (fps)	3.5	0.93	5.
j (fps)	3.5-5.1	0.0-1.33	5.-6.5
U_{gj} (fps)	0.64	0.64	0.72
D (inch)	36	2.5	3.
p (psia)	600.	600.	200.**
P (kW)	5% of 2800×10^3	170.	200.

Typical Parameter Ranges, Hot Leg

UMCP 2x4 Natural Circulation Loop | 18

*From Ishii's report

**Designed for 300 psi but most runs will be at 200 psi

Parameter	Prototype	MIST	UMCP 2x4
α	0.0-0.6	0.0-0.47	0.0-0.7
β	0.0-0.68	0.0-0.7	0.0-0.77
$Fr\left(=j_g\sqrt{\frac{\rho_g}{g\,d\,\Delta\rho}}\right)$	0.0-0.064	0.0-0.064	0.0-0.15
$N_d\left(=\frac{U_{gj}}{U_0}\right)$	0.18	0.45	0.15
$N_\rho\left(=\frac{\rho_g}{\Delta\rho}\right)$	0.02	0.02	0.01
$N_{sub}\left(=\frac{\Delta H_{sub}}{H_{fg}}\ \frac{\Delta\rho}{\rho}\right)$	3.2	3.2	0.0-10.0
$N_f\left(=\frac{f_\ell}{d}\left\{\frac{1+x\left(\frac{\Delta\rho}{\rho_g}\right)}{\left[1+x\,\frac{\Delta\mu}{\mu_g}\right]^{0.25}}\right\}\left(\frac{a_0}{a_i}\right)^2\right)$	1.5	1.5	1.2

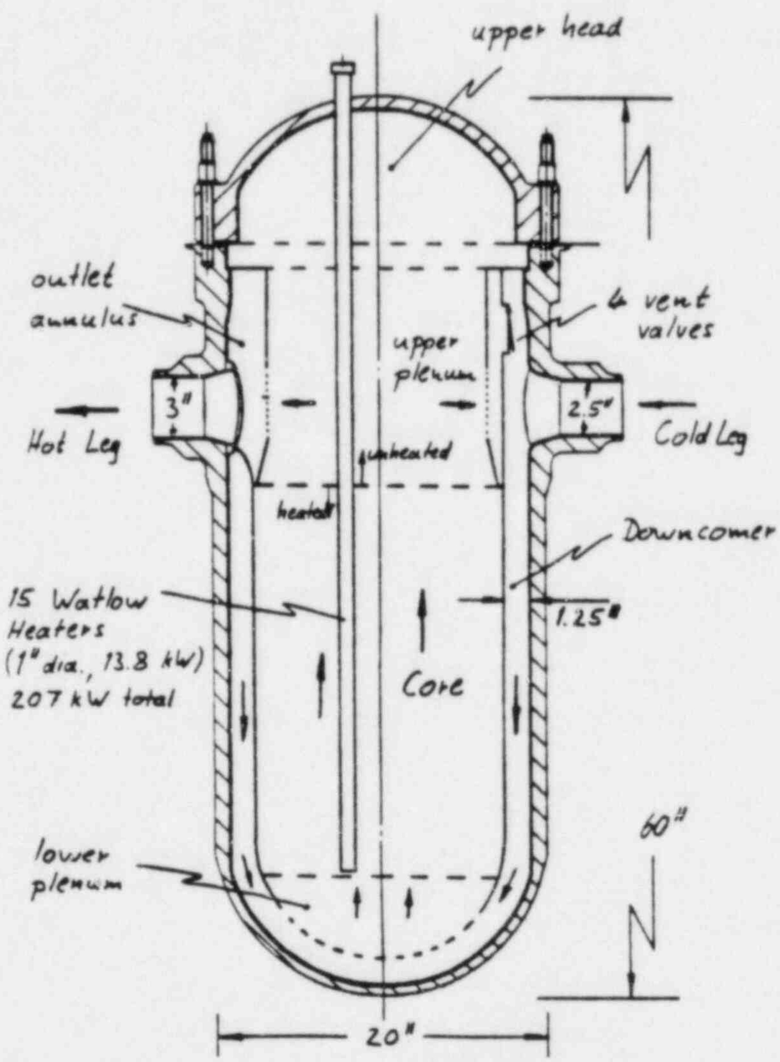
Typical Parameter Ranges, Hot Leg

Two-Phase Flow

1. Most 2-ϕ parameter groups proposed by Ishii are simulated in the same range. Only exceptions are CHF No. and Phase-Change Number which are for core, and are of less concern.

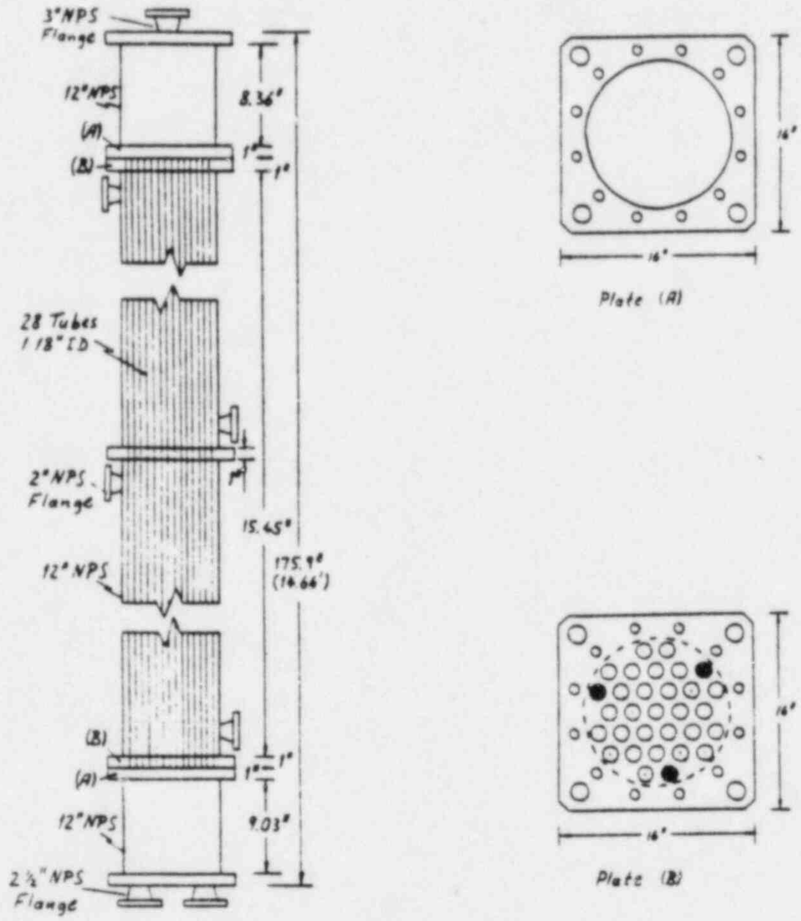
2. For hot leg, the only flow pattern of concern is the bubbly region, which is simulated in model in the same range of Fr and β as in proto-type.

3. Facility Design



Schematic of Model Reactor Vessel

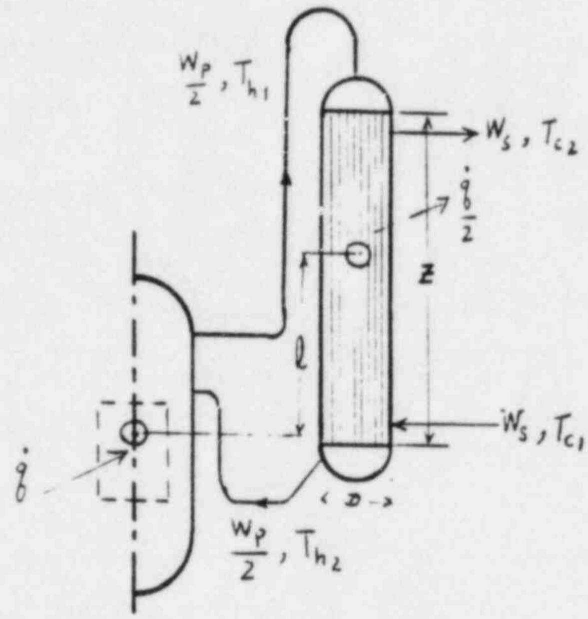
UMCP 2x4 Natural Circulation Loop



Heat Exchanger Design

UMCP 2x4 Natural Circulation Loop

23



1. Preservation of velocity ratio $U_{H.L.}/U_{S.G.(Primary)}$

$$\left(\frac{A_{H.L.}}{A_{S.G.(Primary)}}\right)_{Prototype} = \left(\frac{A_{H.L.}}{A_{S.G.(Primary)}}\right)_{Model}$$

2. Preservation of volume ratio $\frac{500}{1}$

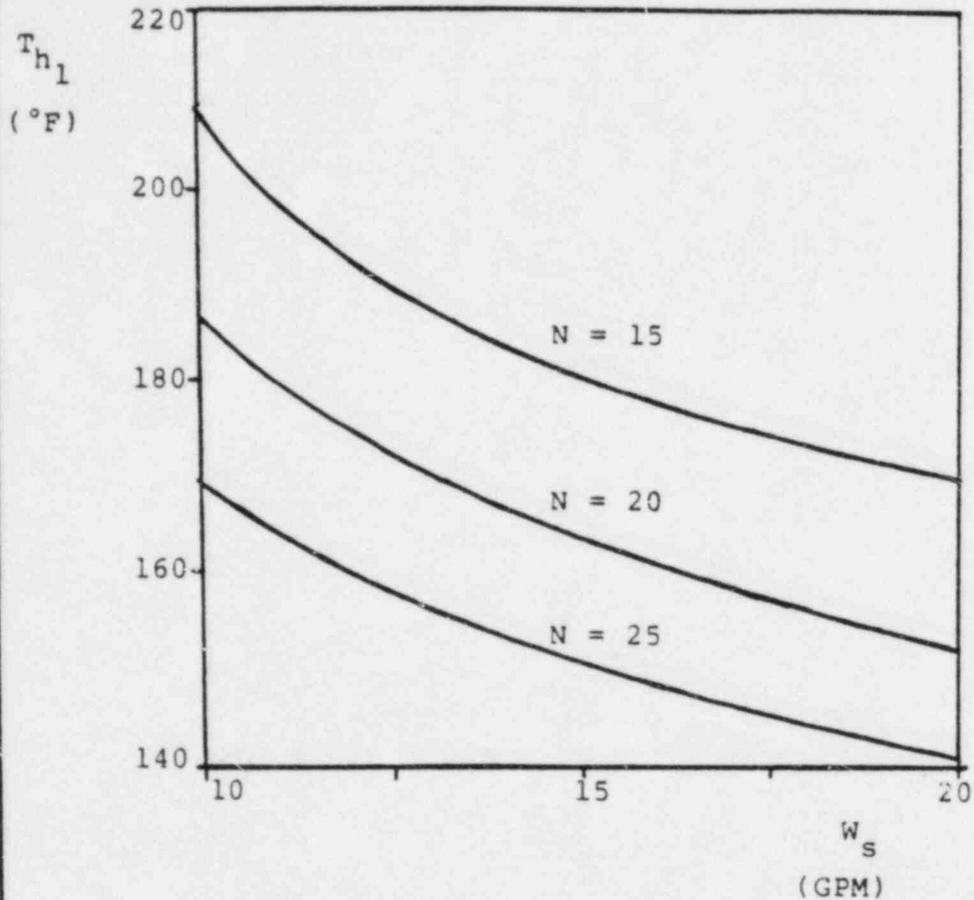
$$\left[\left(\frac{\pi d^2}{4}\right) Z\right] N + \frac{\pi d^3}{6} = \frac{2030}{500} \text{ ft}^3$$

3. Preservation of length ratio for each component

   Z + D = 16.0 ft (Height Limitation)

D ft(in)	1.(12)	1.02(12.25)	1.25(15)	1.5(18)
N_{max}	31	30	27	21

Scaling Principles of Steam Generator



Z = 15 ft

D = 1 ft

d = 1.25 in.

t = 0.25 in.

$\dot{q}$ = 200kW (100 kW/H.X.)

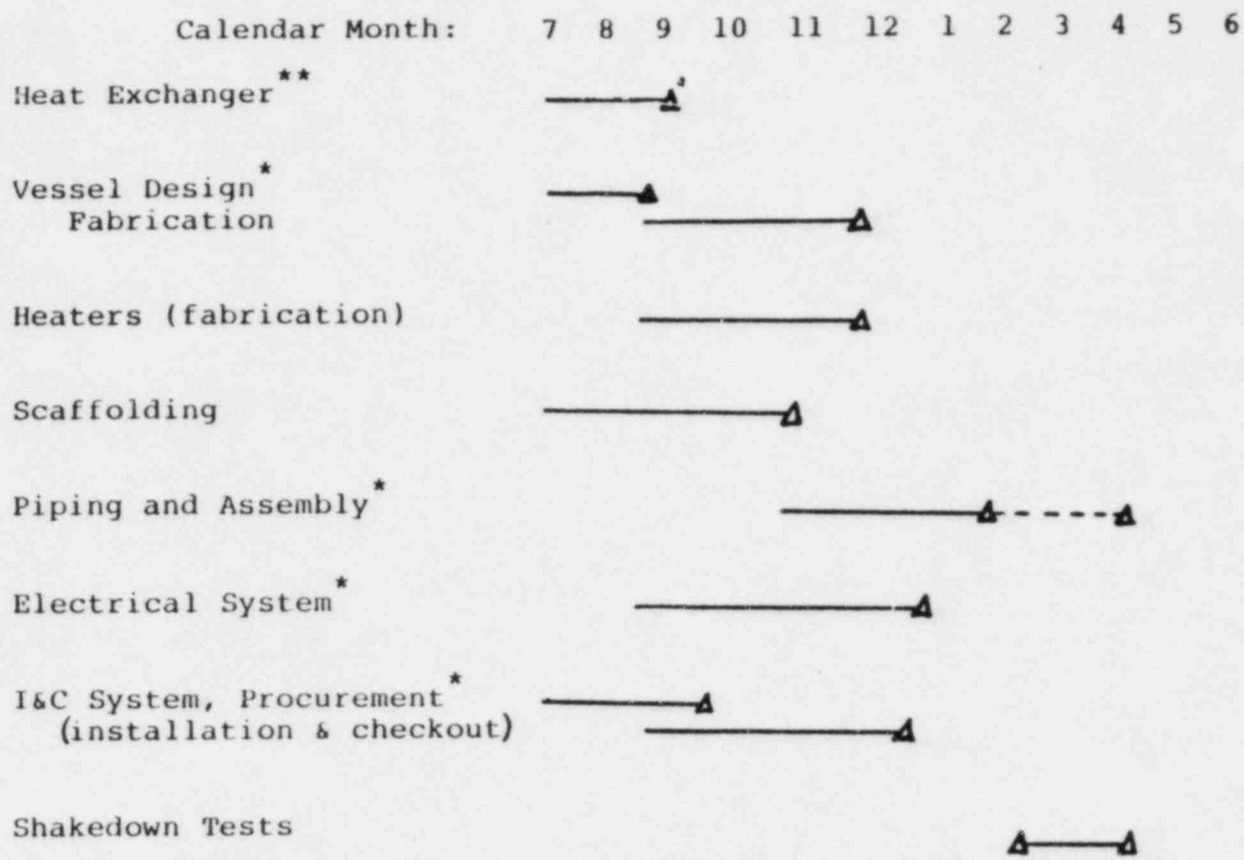
T_{c_1} = 65°F

Core Outlet Temperature Versus Secondary-Side Flow Rate

UMCP 2x4 Natural Circulation Loop	25

4. Schedule

Schedule for Loop Construction



*Partially funded by UMCP, about 45K (+ half man-year of faculty time)

**Funded by BG&E, 20K

5. Test Matrix

Table 4.2

Evaluation of Priority

Issue	Importance	Knowledge	Priority
1. Natural Circulation			
Single Phase	1	3	3
Two Phase	1	2	2
* Boiler Condenser	1	2	2
Hydraulic Stability			
S.G. driven unstable	2	1	2
C.L. oscillations	2	1	2
* Interruption & Reestablishment of N.C.	1	2	2
High Point Vents	2	2	4
Non-condensible Gases	1	1	1
Reactor Vessel Vent Valves	1	2	2
2. SB LOCA			
Break Size	1	3	3
ECCS Operation	1	3	3
RC Pump Operation	2	2	4
Location of Break	2	2	4
Break Isolation	1	2	2
Reactor Vessel Vent Valves	1	2	2
3. Feed & Bleed	2	2	4
4. OTSG Tube Rupture	2	1.5	3

Footnotes

Importance - 1) Related to II.K.3.30
2) NRC need to improve confidence
3) Transients outside II.K.3.30 space

Knowledge - 1) Little known
2) Moderate amount of knowledge
3) Comfortable level of understanding

Priority - 1) Lowest number is higher priority

*Knowledge reflects SRI-1 test results

TEST MATRIX

1. SHAKE-DOWN TESTS

   WATER AND THEN AIR/WATER AND STEAM/WATER

2. COMPONENT CHARACTERIZATION TESTS

   A. LOOP : TO DETERMINE K :

1 x 1 LOOP	8	TESTS
1 x 2 LOOP	2	TESTS
2 x 4 LOOP	3	TESTS

   B. VENT VALVE AND DOWNCOMER : TO DETERMINE K IN CIRCUMFERENTIAL AND AXIAL DIRECTION

   V V AND NEAR COLD LEG

   V V AND FAR COLD LEG

   V V AND BOTH FAR AND NEAR COLD LEGS

   VARIABLES: FLOW RATES, GAP, SET-POINT OF V V

   TOTAL RUNS: ABOUT 20

   C. STEAM GENERATOR --- HEAT TRANSFER OR THERMAL CENTER ELEVATION

   VARIABLES: STEAM ENTHALPY FLUX

   WATER ENTHALPY FLUX

   LEVEL

   TOTAL RUNS: ABOUT 10

3. Separate Effect Tests

	Variable 1	2	3	4	5
Baseline	B	B	B	B	B
Test 1	V	B	B	B	B
2	B	V	B	B	B
3	B	B	V	B	B
...					

A. V.V. Condensation & Mixing

Variables: Steam enthalpy flux (Temp & p)

Water enthalpy (subcooling & flow rate)

Gap

Set-point of V.V. (opening size and timing)

2 Baseline case + 8 parametric runs

B. ∩-bend --- V_X & V_Y as function of location and size

Variables: J_G, J_ℓ

Pipe diameter

Radius of curvature

Non-condensable or steam

Tests: About 10-12 tests

4. System Tests

Phenomena: Non-condensable (top vent, flow interruption)

V.V.

Multi-loop oscillation

Steam generator effect

Variables: Power

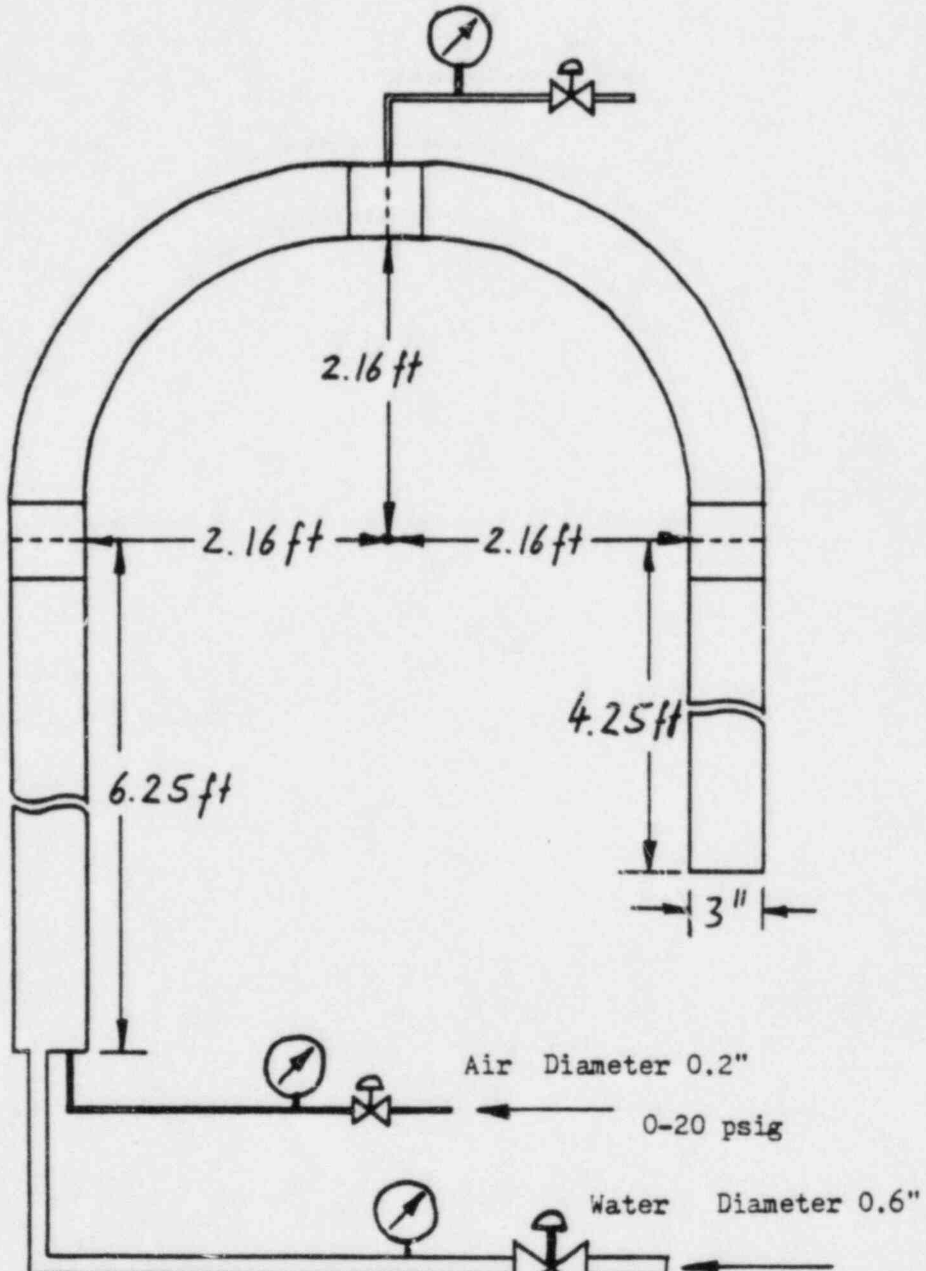
Non-condensable

Steam generator cooling rate

Top venting

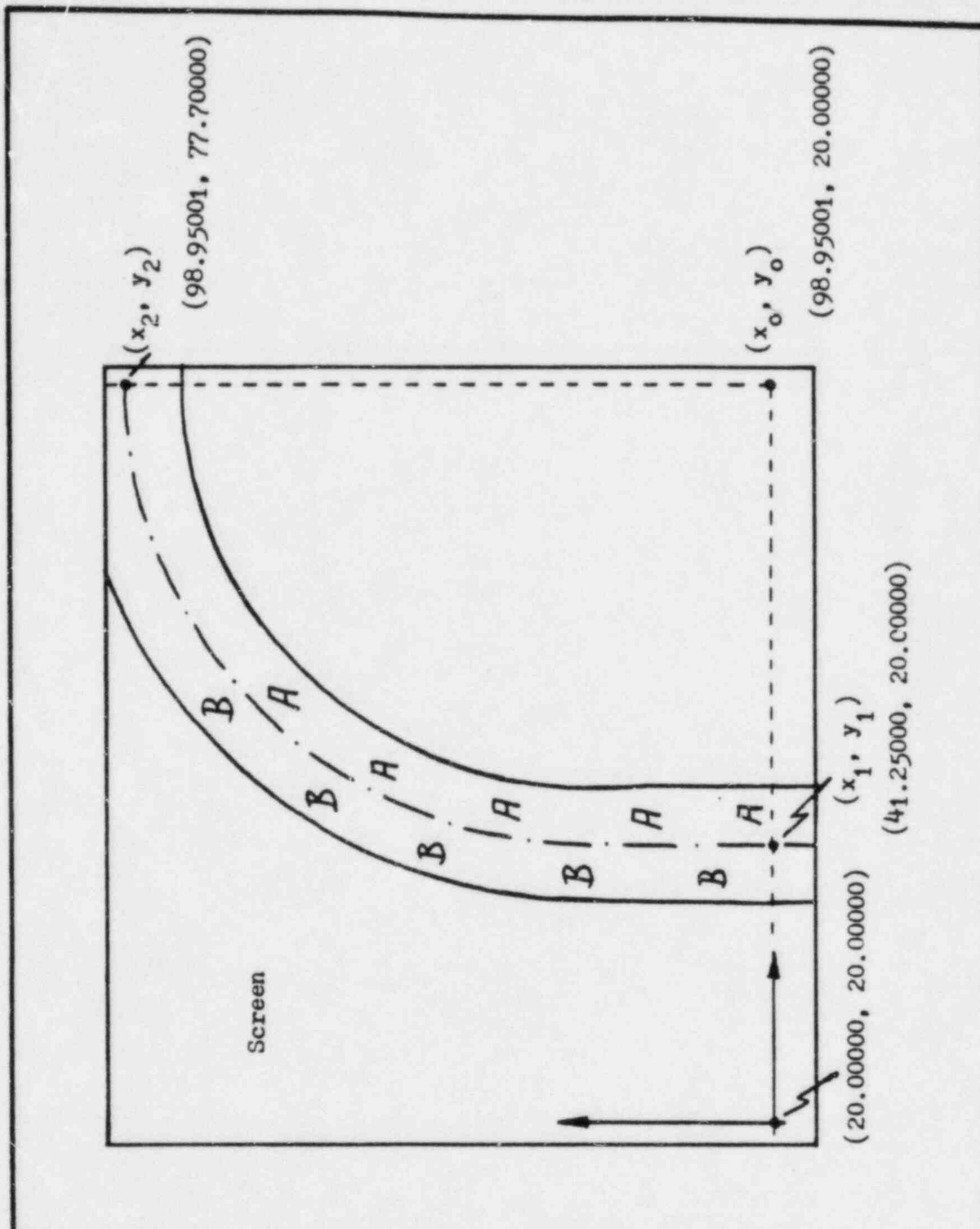
Tests: 3 Baseline case + 8-10 variable cases

6. Test Results - ∩-bend bubble velocity



Candy Cane Facility

UMCP 2x4 Natural Circulation Loop	33



Measurement Conditions for Digital Machine

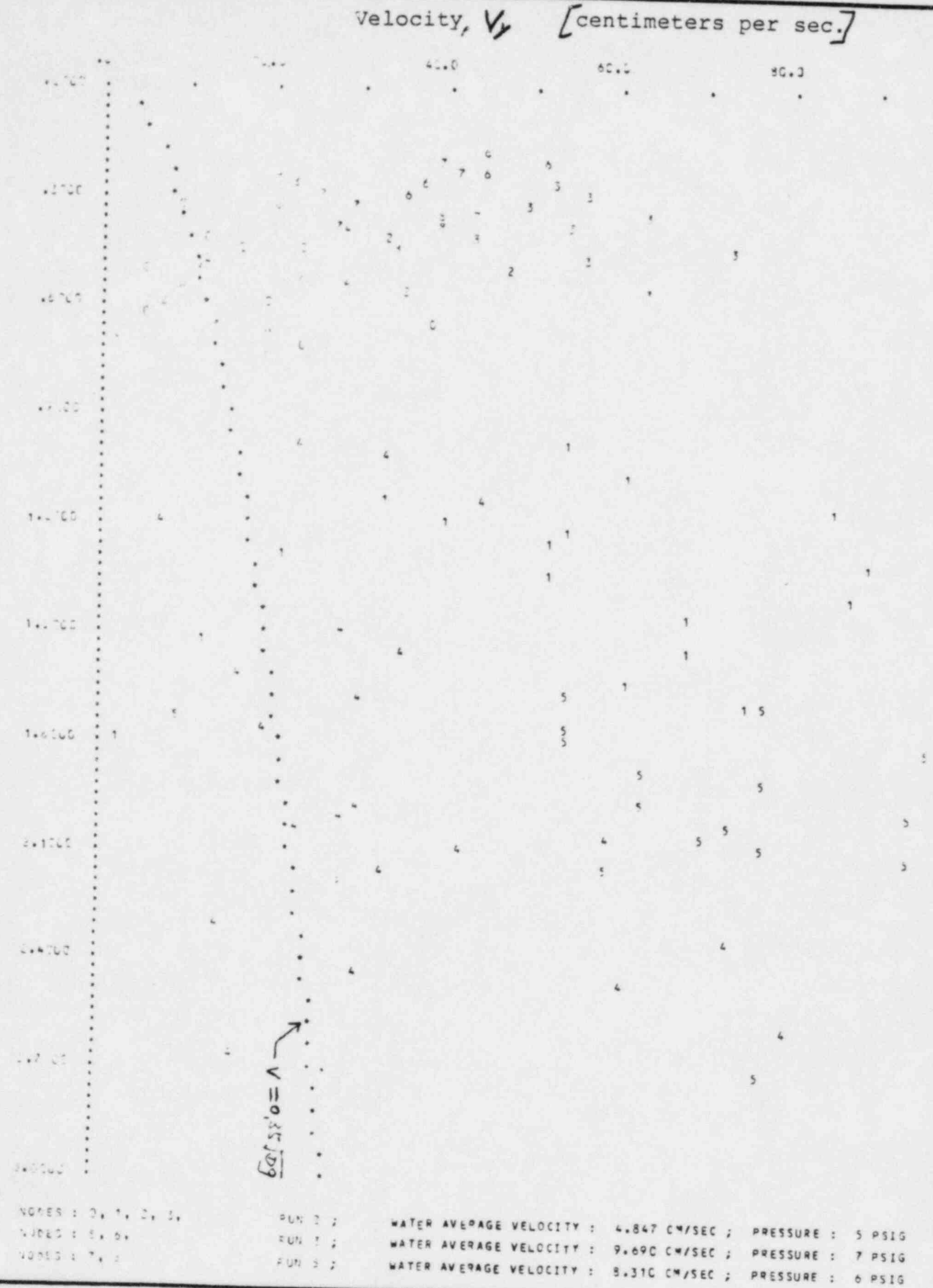
UMCP 2x4 Natural Circulation Loop	34

3" diameter pipe
distance: 2 m
timelight: 10 Hz
frames/sec: 100
exposure: 1/900
air pressure: 0-20 psig
water flow: 0-6.5 gal/min

	Run	Water Flow (gal/min)	Mean Velocity (cm/sec)	Frequency	Air Pressure (psig)
up flow	1	0	0	8	5
	2	3.5	4.847	8	5
	3	7.0	9.69	8	4.2
	4	5.0	6.925	8	5
	5	6.0	8.31	8	10
	6	6.0	8.31	8	15
	7	6.2	8.587	8	15
	8	6.5	9.00	8	15
	9	6.5	9.00	8	18
	10	6.5	9.00	8	10
	11	6.5	9.00	8	11
	12	5.0	6.925	8	2.5
	13	5.0	6.925	8	2.0
	14	4.0	5.54	8	2.0
down flow	15	6.3	8.726	5.6	17
	16	4.2	5.817	5.6	20
	17	5.2	7.20	5.6	18
	18	6.5	9.00	5.6	20

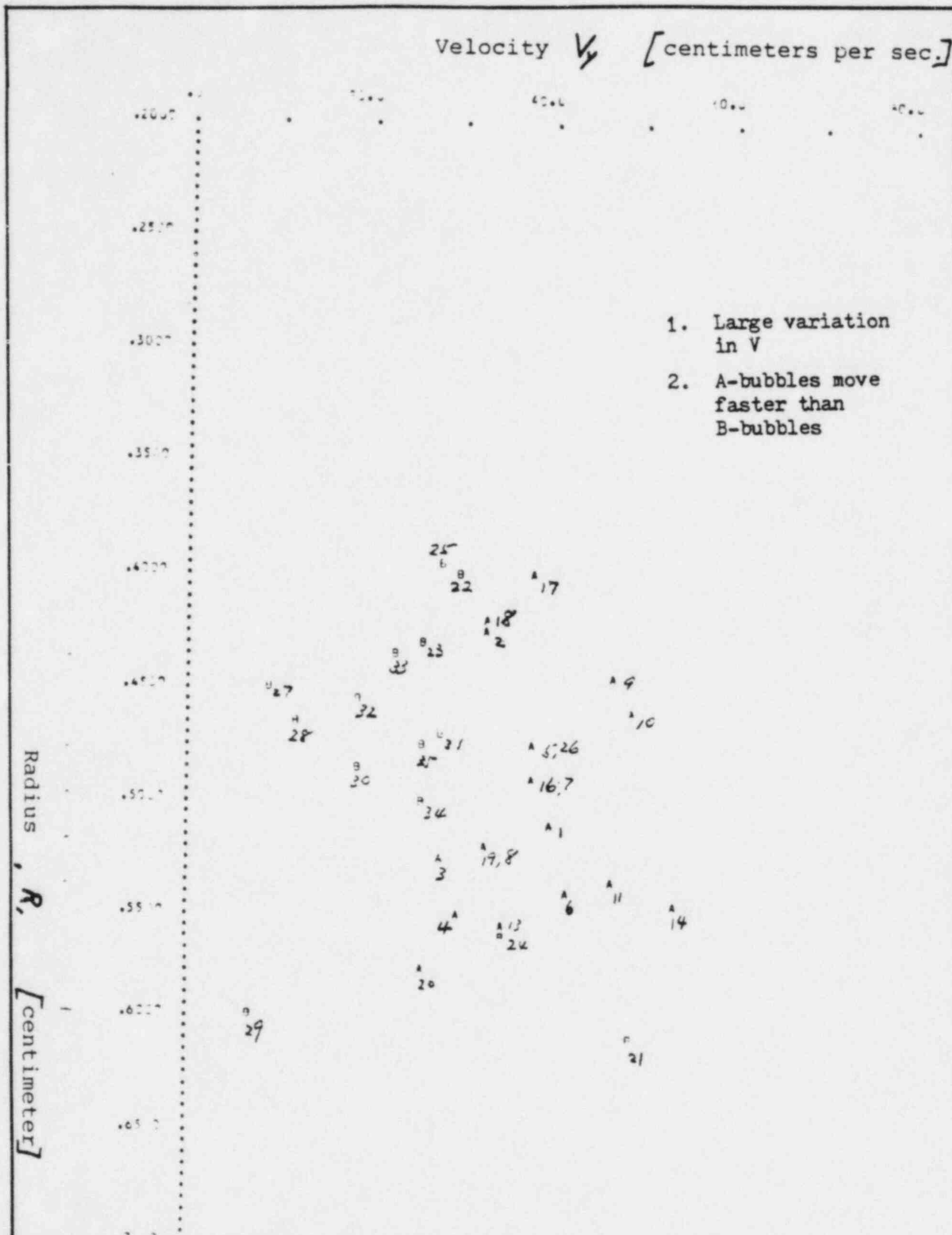
Operating Conditions

UMCP 2x4 Natural Circulation Loop

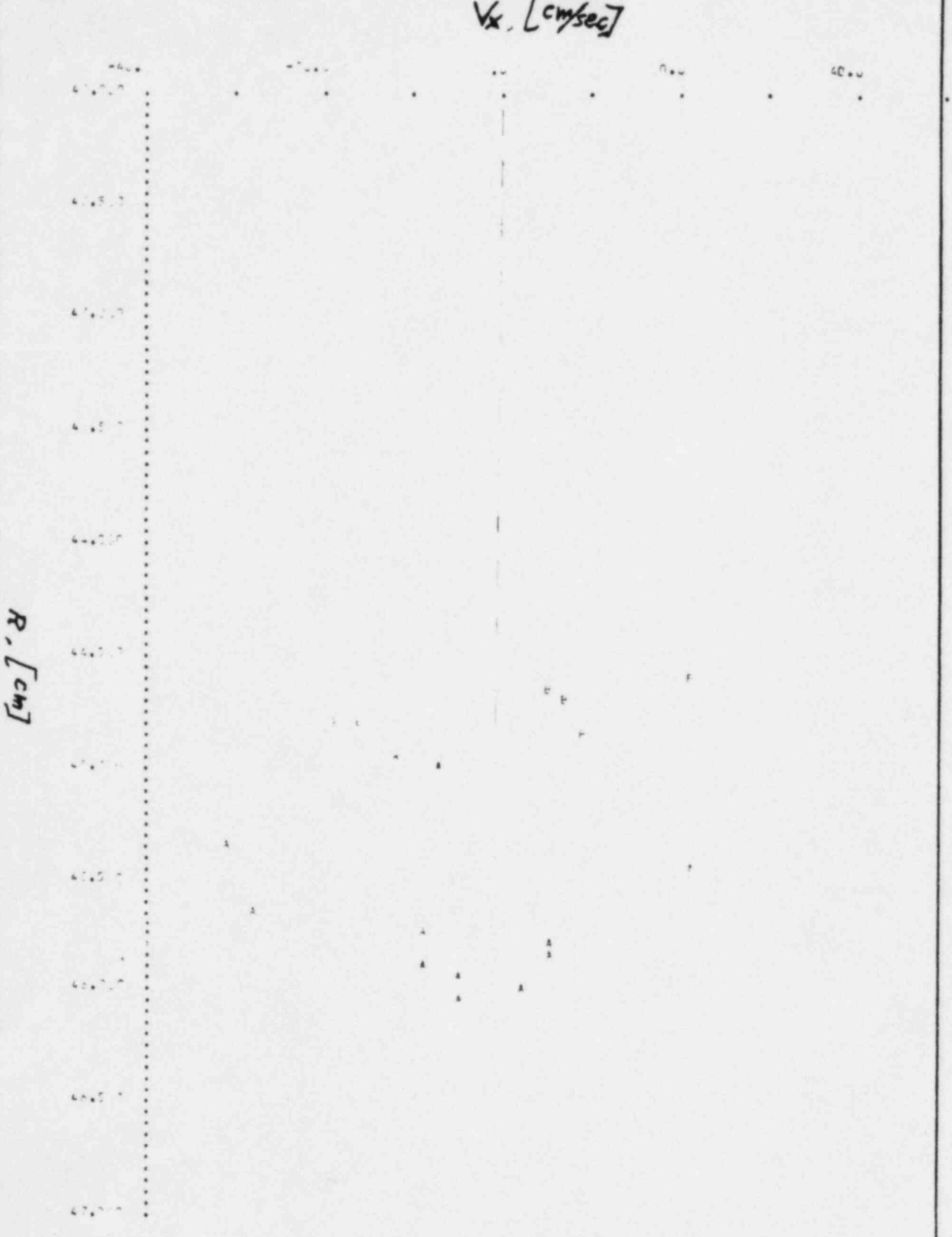


UMCP 2x4 Natural Circulation Loop

UMCP 2x4 Natural Circulation Loop



Velocity V_y [centimeters per sec.]
Radius, R, [centimeter]
1. Large variation in V
2. A-bubbles move faster than B-bubbles



[illegible] INCH DIAMETER PIPE ; RUN [illegible] ; WATER AVERAGE VELOCITY : [illegible] CM/SEC ; AIR PRESSURE :10 PSIG

NRC SUPPORT PROGRAMS FOR MIST/OTIS

- Separate Effects (& System) Tests
- Instrumentation & Data Acquisition
- Analysis
- Consulting

Univ. of Maryland Support

- Separate Effects
  - HLUB
  - RVVV
  - DOWNCOMER
- System Tests
  - MULTI-LOOP OSCILLATIONS
  - STEAM GENERATOR DRIVEN INSTABILITIES
  - HLUB BLOCKAGE & VENTING
  - SBLOCA

Instrumentation & Data Acquisition

- Recommend Advanced Instrumentation (MIST)
  - GAMMA DENSITOMETERS
  - DRAG DISCS
  - Spool Piece
- Review Proposed Instrumentation (type & location)
  - T/C'S (FLUID & METAL)
  - DP CELLS & PRESSURE TRANSDUCERS
  - FLOW METERS
  - CONDUCTIVITY PROBES
  - RTD'S
- Data Acquisition/Qualification
  - REVIEW B&W DAS
  - ADQ SYSTEM IN LOFT

Analysis Support

I. Benchmark code (RELAP5 & TRAC) against GERDA data.

II. Evaluate abilities and limitations of MIST facility and also Univ. of Md facility.

- Plant Model
- MIST Model
- U. of Md Model

III. Perform pre-test analysis

- OTIS
- MIST

CONSULTING SUPPORT

- MIST FACILITY SPECIFICATION
- GERDA MODIFICATIONS
- INSTRUMENTATION
- GERDA DATA
- OTIS & MIST TEST MATRIX

APRIL 14, 1983 SCALING MEETING

COMMENTS

1. PRIMARY GOAL IN DESIGNING THE SYSTEM SHOULD BE TO DISCLOSE PECULIAR STATES AND UNEXPECTED PHENOMENA, RATHER THAN CODE VERIFICATION.
2. DIFFICULT TO SCALE WITHOUT KNOWING PHENOMENA TRYING TO MODEL.
3. USE RELAP5 OR TRAC TO PERFORM SCOPING STUDIES FOR VARIOUS TYPES OF TRANSIENTS FOR EACH FACILITY TYPE.
   BENEFITS: A.) RECOMMEND BEST FACILITY TYPE/TRANSIENT.
   B.) KNOW WHAT TYPES OF PHENOMENA TO EXPECT (AND INSTRU. NEEDED)
   C.) DATA FOR CODE VERIFICATION AND ASSESSMENT.
4. SELECTION OF SCALING PHILOSOPHY - DEPEND UPON WHICH PROVIDED CLOSEST VOID AND VOID DISTRIBUTION PROFILES AROUNG THE LOOP.

RECOMMENDATIONS

5. ENDORSE THE TWO DIFFERENT SCALING APPROACHES REPRESENTED BY B&W AND UNIV. OF MD.
6. B&W AND ISHII SEND DISCRIPTION OF MODEL BASED ON THEIR SCALING APPROACH. CONSULTANTS TO COMMENT ON ADVANTAGES AND DISADVANTAGES OF EACH.

<u>EXPERIMENTAL FACILITIES</u>

• GERDA	(RAISED-LOOP, 1 x 1)	ELEVATION
• OTIS	(RAISED-LOOP, 1 x 1)	ELEVATION
• U of MD	(LOWER LOOP, 2 x 4)	ISHII-MODIFIED
• SRI-I	(LOWER LOOP, 2 x 2)	LINEAR
• SRI-II	(LOWER LOOP, 2 x 4)	ISHII
• MIST	(LOWER LOOP, 2 x 4)	ELEVATION

SUMMARY OF TAG EFFORT

FOUR TASKS:

1. IDENTIFY EXPERIMENTAL DATA NEEDS
2. IDENTIFY OPERATING PLANT AND EXPERIMENTAL DATA AVAILABLE
3. EVALUATE HOW WELL THESE DATA ADDRESS DATA NEEDS
4. PROVIDE RECOMMENDATIONS FOR FUTURE PROGRAMS

LIST OF ISSUES

NATURAL CIRCULATION

- BOILER CONDENSER NATURAL CIRCULATION
- TWO-PHASE NATURAL CIRCULATION
- SINGLE-PHASE NATURAL CIRCULATION
- STEAM GENERATOR-DRIVEN INSTABILITIES
- COLD LEG OSCILLATIONS
- INTERRUPTION/REESTABLISHMENT
- HIGH POINT VENTS
- NON-CONDENSABLE GASES
- REACTOR VESSEL VENT VALVES

SMALL BREAK LOSS-OF-COOLANT ACCIDENT

- BREAK SIZE
- EMERGENCY CORE COOLING SYSTEM OPERATION
- REACTOR COOLANT PUMP OPERATION
- LOCATION OF BREAK
- BREAK ISOLATION
- REACTOR VESSEL VENT VALVES

FEED AND BLEED

ONCE THROUGH STEAM GENERATOR TUBE RUPTURES

SOURCE OF 1ST DATA

1. ACTUAL PLANT TRANSIENT AND TEST DATA

   A. LIMITED RANGE OF FLUID CONDITIONS

   B. LACK OF DETAILED INSTRUMENTATION

2. SRI-II AND UNIVERSITY OF MARYLAND - LOW PRESSURE, 2X4

   - CONCERNS THAT LACK OF FULL ELEVATION WILL AFFECT NATURAL CIRCULATION PHENOMENA

3. GERDA - FULL ELEVATION, HIGH PRESSURE, ONE LOOP

   A. ONE LOOP CANNOT SHOW ASYMMETRIC BEHAVIOR
      - TUBE RUPTURES
      - STEAM GENERATOR DRIVEN INSTABILITIES
      - LOCATION OF BREAK
      - NON CONDENSABLES

   B. LACK OF PUMPS

   C. HIGH POINT VENT VALVES

   D. RAISED LOOP CONFIGURATION

CONCLUSION: A HIGH PRESSURE, FULL ELEVATION 2X4 FACILITY WILL COMPLETE THE EXPERIMENTAL DATA BASE.

SELECTION OF RECOMMENDED 2X4 FACILITY

A. ISSUES WERE WEIGHTED TO:

1. REFLECT IMPORTANCE AS SAFETY AND LICENSING CONCERN

2. REFLECT LEVEL OF KNOWLEDGE EXISTING

B. SEVERAL FACILITY OPTIONS WERE PROPOSED

C. FACILITY OPTIONS WERE EVALUATED IN LIGHT OF ABILITY TO ADDRESS ISSUES AND COST.

MIST FACILITY

1. FULL ELEVATION, 2X4 CONFIGURATION, LOWERED LOOP
2. FOUR PUMPS
3. FULL LENGTH PROTOTYPICAL CORE
4. FULL ECCS CAPABILITY
5. TWO 19-TUBE PROTOTYPICAL STEAM GENERATORS
6. FULL GUARD HEATING, WELDED SYSTEM
7. 10% SCALED POWER
8. VESSEL AND U-BEND HPV
9. ADDITIONAL HOT LEG INSTRUMENTATION

OTIS FACILITY

1. MODIFICATIONS TO GERDA TO MAKE MORE TYPICAL OF DOMESTIC RAISED LOOP PLANTS
2. ADDITIONAL TESTING IN RAISED LOOP CONFIGURATION

V/G #1

LICENSING CONSIDERATIONS

AND NEED FOR A

2 x 4 INTEGRAL SYSTEM TEST FACILITY

BACKGROUND

- RECOGNITION THAT SBLOCA AND OTHER TRANSIENT AND ACCIDENT EVENTS POSED DESIGN-SPECIFIC (I.E., GEOMETRY-DEPENDENT) ANALYTICAL MODELING PROBLEMS
- ABILITY TO MITIGATE ACCIDENTS SHOWN TO REQUIRE A UNIQUE COMBINATION OF SAFETY SYSTEMS AND OPERATOR ACTIONS
- ASSURANCE THAT OPERATORS WILL NOT TAKE INAPPROPRIATE ACTIONS IS BASED ON THE OPERATORS HAVING A GOOD UNDERSTANDING OF PLANT BEHAVIOR UNDER A VARIETY OF POSTULATED TRANSIENT AND ACCIDENT CONDITIONS
- B&W PLANTS ANALYTICALLY EXHIBITED SBLOCA BEHAVIOR PREVIOUSLY NOT CONSIDERED IN REGULATORY REVIEWS
- WHILE ATOG IMPLICITLY CONSIDERS THE EXPANDED UNDERSTANDING OF B&W PLANT BEHAVIOR DEVELOPED SINCE TMI-2, THE CALCULATED PLANT BEHAVIOR HAS NOT BEEN EXPERIMENTALLY CONFIRMED

WHY GERDA

- FOLLOWING IDENTIFICATION OF NEED FOR AN INTEGRAL FACILITY IN 1980, NRC EXAMINED OPTIONS AVAILABLE

FACILITY	FUNDING
NEW 2 x 4	NRC
MODIFY EXISTING FACILITY	INDUSTRY
	JOINT NRC/INDUSTRY

- RES CRITERIA FOR FUNDING OPTIONS INDICATED JOINT NRC/INDUSTRY FUNDING
- STUDIES (INCLUDING 2 x 4 EG&G STUDY) INDICATED MODIFIED GERDA FACILITY WAS MOST COST-BENEFICIAL TO ALL PARTIES

- RECENT SUBCOMMITTEE CONSULTANT COMMENTS INDICATE THERE IS PERCEPTION THAT GERDA/OTIS/MIST FACILITIES MAY NOT EXHIBIT ALL PHENOMENA OF INTEREST
- WE AGREE THERE ARE STILL UNANSWERED QUESTIONS ON EXTENT OF GERDA/OTIS/MIST CAPABILITIES
- COST STUDIES AND FUNDING LIMITATIONS SHOW EXAMINATION OF CERTAIN PHENOMENA MAY HAVE TO BE SACRIFICED
- IF ONE WAITED UNTIL ALL PHENOMENA WERE EXHAUSTIVELY STUDIED WITH RESPECT TO QUANTIFYING THE DEGREE OF COMPROMISE, DATA WOULD PROBABLY NOT BE FORTHCOMING UNTIL THE LATE 1980s AND ATTENDANT FACILITY COSTS WOULD RISE
- PRELIMINARY STUDIES (PRIMARILY EG&G 2 x 4 STUDY) SHOW THAT A 2 x 4 FACILITY, SUCH AS MIST, WILL EXHIBIT MUCH OF THE MAJOR PHENOMENA OF INTEREST

- GERDA/OTIS/MIST IS A MULTISTAGE PROGRAM THAT CAN DRAW ON EXPERIENCE OF EACH SUCCESSIVE TESTING STAGE
- ANY DEFICIENCIES HIGHLIGHTED BY GERDA TESTS CAN BE ADDRESSED EITHER IN OTIS AND/OR MIST
- ANY DEFICIENCIES HIGHLIGHTED BY OTIS CAN BE ADDRESSED IN MIST
- ANY MIST DEFICIENCIES CAN POSSIBLY BE ACCOMMODATED BY A FOLLOW-ON PROGRAM

- WE RECOGNIZE NEED TO CONTINUE STUDYING SCALING COMPROMISES SO THEY ARE UNDERSTANDABLE AND QUANTIFIABLE
- SUCH STUDIES ARE BUDGETED FOR AND SCHEDULED BY RES
- FOCUS OF FUTURE SUBCOMMITTEE REVIEWS SHOULD BE ON SCOPE AND ADEQUACY OF SPECIFIC SUPPORT PROGRAMS NEEDED TO COMPLEMENT INTEGRAL SYSTEMS TEST DATA

EPRI PROJECTS RELATED TO B&W PLANT DESIGN

J-P. SURSOCK

ELECTRIC POWER RESEARCH INSTITUTE

JULY 19, 1983

PRESENTATION TO ACRS SUBCOMMITTEE

EPRI STUDIES RELATED TO B&W PLANT DESIGN

- SRI-1 RESULTS
- SRI-2 PLANS
  - OBJECTIVES
  - DESIGN REQUIREMENTS
  - SCALING CRITERIA
  - TEST MATRIX
  - SCHEDULE/MILESTONES
- PRESSURIZER TESTS
- FLOW REGIME TESTS IN HOT LEG
- ANALYSIS
  - RETRAN-02
  - MMS-02

NATURAL CIRCULATION STUDIES

ON A SCALED MODEL OF TMI-2 (SRI-1)

(SRI - INTERNATIONAL)

OBJECTIVES:

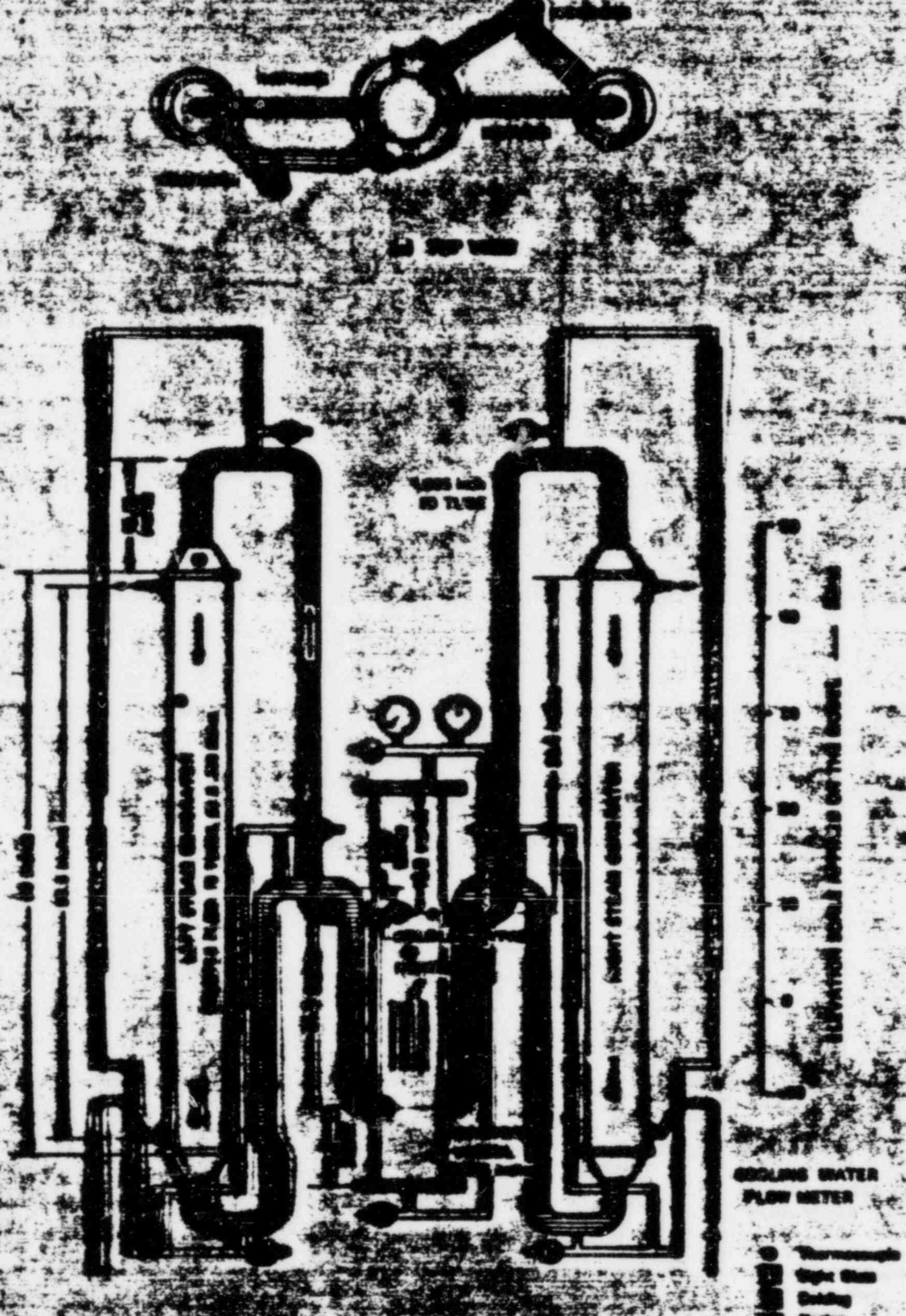
- STUDY NATURAL CIRCULATION MODE TRANSITION
- STUDY EFFECTS OF NON-CONDENSIBLE GASES
- DEMONSTRATE EFFECTIVENESS OF DECAY HEAT REMOVAL IN BOILER CONDENSER MODE

MAJOR RESULTS OF SCALED TMI-2 MODEL

- SYSTEM CAN OPERATE IN STABLE TWO-PHASE FLOW CONDITIONS
- TWO FLOW REGIMES IDENTIFIED (HLU, HLC)
- BOTH REGIMES CAN TOLERATE SUBSTANTIAL CONCENTRATIONS OF NON-CONDENSIBLE GASES
- LOOP RESPONSE IS ANALYTICALLY PREDICTABLE

REFERENCES:

- J. P. SURSOCK AND R. L. KIANG: "TWO-PHASE NATURAL CIRCULATION USING OTSG: ANALYSIS AND EXPERIMENT" - PROCEEDINGS OF ANS SPECIALISTS MEETING ON SMALL BREAK LOCA ANALYSIS IN LWRS-MONTEREY, CALIFORNIA, AUGUST 25-27, 1981
- R. L. KIANG, "TWO-PHASE NATURAL CIRCULATION EXPERIMENTS IN A TEST FACILITY MODELLED AFTER THREE MILE ISLAND UNIT-2" EPRI REPORT NP-2069, OCTOBER 1981.


COOLING WATER
FLOW METER

[illegible]

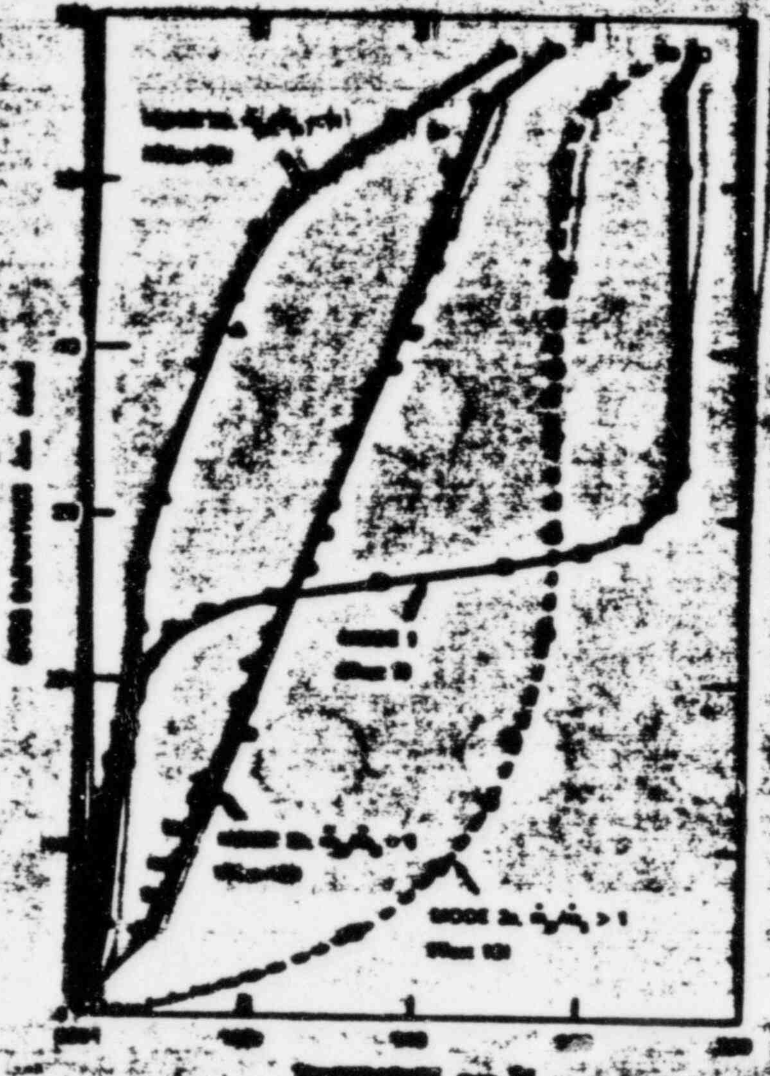


Figure [illegible]. Axial Temperature Profiles of Various Modes

MODE 1 - ALU

MODE 2 - ALC

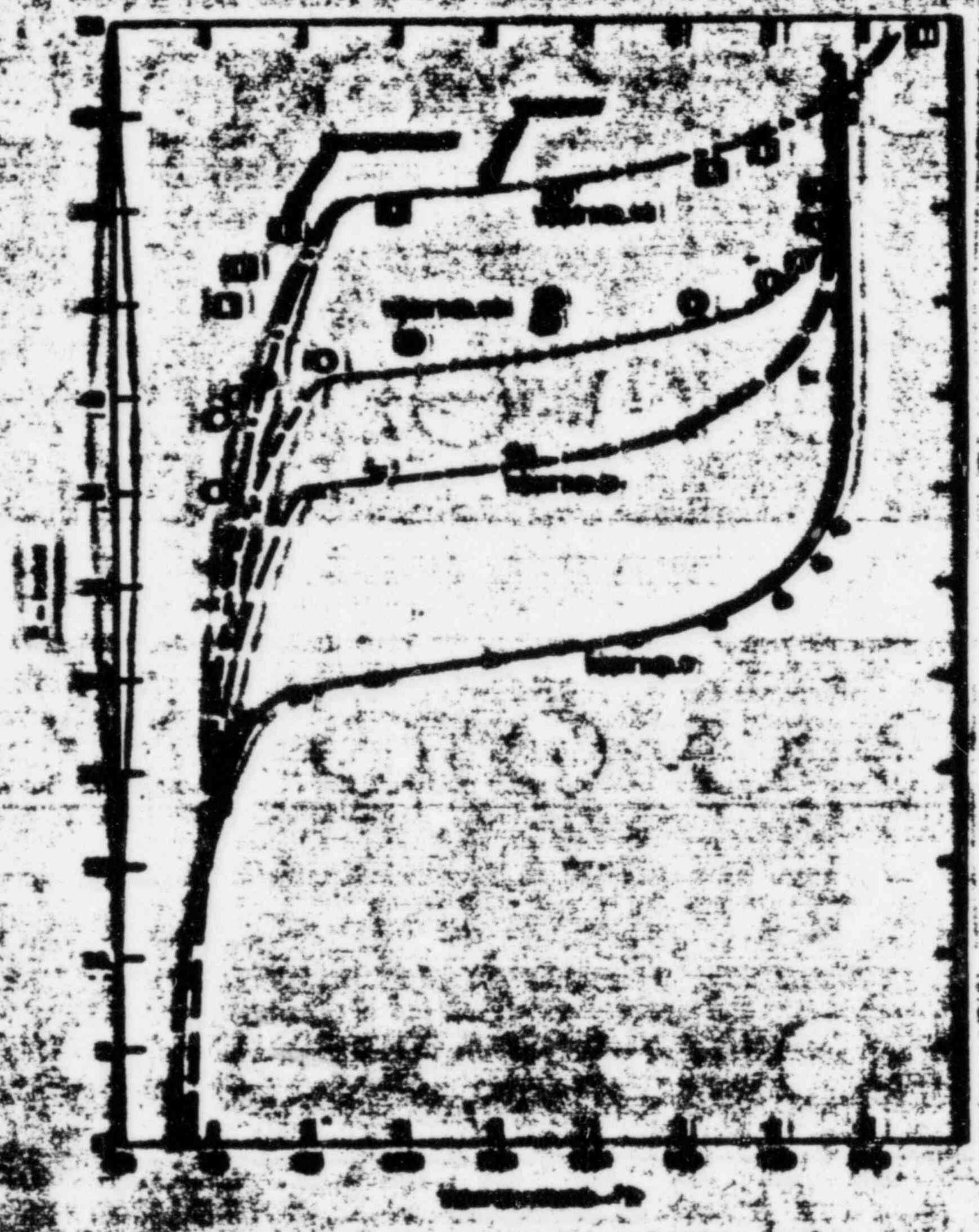
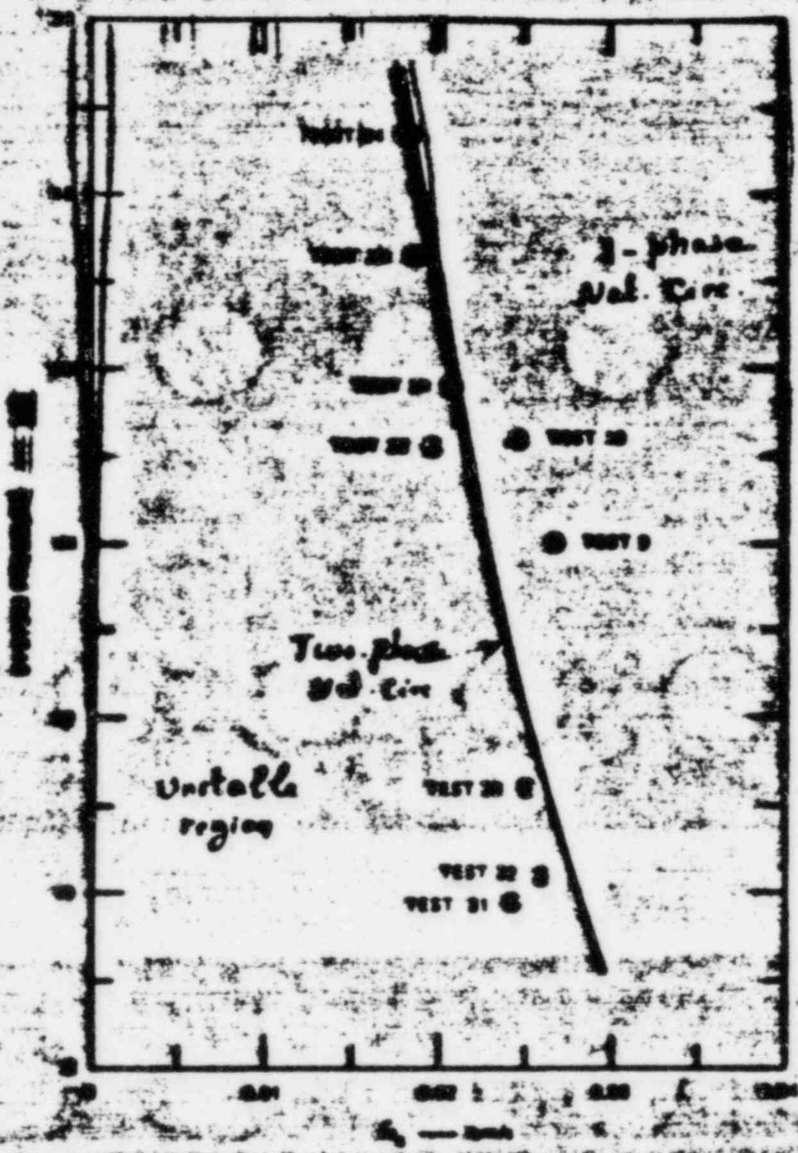


FIGURE 4. EFFECT OF NONCONDENSABLE GAS ON [illegible]



OPERATING MAP FOR SCALED OTSG FACILITY

OBJECTIVES OF SRI-2 TEST PROGRAM

- DEVELOP DATA BASE TO HELP QUALIFY SYSTEM COMPUTER CODES SIMULATING B&W PLANT DESIGN
- SUPPORT THE MIST/OTIS PROGRAM
  - ALTERNATE SCALING APPROACH
  - SCOPING TESTS
  - PHENOMENOLOGICAL STUDIES

DESIGN REQUIREMENTS FOR SRI-2

COMPONENTS	DESIGN REQUIREMENTS
HOT LEGS	• DIFFERENT SIZE CANDY-CANES • VIEWPORTS FOR FLOW REGIMES • HIGH POINT VENTS
REACTOR VESSEL	• POWER UP TO 100KW • EXTERNAL DOWNCOMER • VENT VALVE
COLD LEGS	• 2 COLD LEGS/LOOP • PRIMARY PUMP • HPI PUMP • "BREAK" VALVE
STEAM GENERATOR	• REAL TUBE DIAMETER • AUX-FEED • TUBE BREAK CAPABILITY
PRESSURIZER	• HEATERS • SPRAY • RELIEF VALVE

SCALING CRITERIA FOR SRI-2

PRESERVE:

- TRANSIT TIME NUMBER: $\frac{t\,u_o}{L_o}$
- FROUDE NUMBER: $\frac{u_o^2}{g L_o \langle\alpha\rangle_o} \frac{\Delta\rho}{\rho_\ell}$
- HEAT SOURCE NUMBER: $\dot{q} L_o / \rho_\ell C_p u_o \Delta T_o$
- PHASE CHANGE NUMBER: $\frac{4\dot{q} L_o}{D_o u_o h_{fg} \rho_\ell} \frac{\Delta\rho}{\rho_g}$
- FRICTION/ORIFICE NUMBER: $\frac{fL}{D} + K$

DO NOT PRESERVE:

- DRIFT FLUX PARAMETERS (C_o, V_{gj})
- DENSITY RATIO
- SUBCOOLING/LATENT HEAT
- CHF

RESULTS OF SCALING ANALYSIS

$$L_m / L_p = \delta$$

$$t_m / t_p = 1.04\, \delta^{1/2}$$

$$\dot{q}_m / \dot{q}_p = 0.12\, \delta^{-1/2}$$

$$\Delta T_m / \Delta T_p = 0.13$$

δ = scale factor

NOTES

- SCALING BASED ON ISHII'S ANALYSIS
- 1/4 HEIGHT MODEL (~20 FEET)
- HOT LEG DIAMETER ≈2"
- OPERATING PRESSURE ≈100 PSIG
- CORE POWER = 100KW
- APPROX. 80 DATA CHANNELS

TEST MATRIX FOR SRI-2

- SMALL-BREAK LOCA
- SECONDARY INDUCED TRANSIENTS SUCH AS: LOSS OF FEED AND OVERFEED
- FORCED-TO-NATURAL CIRCULATION TRANSITION
- TRANSITIONS BETWEEN SINGLE- AND TWO-PHASE NATURAL CIRCULATION, AND BETWEEN TWO-PHASE NATURAL CIRCULATION AND BOILER CONDENSER MODE OF HEAT REMOVAL
- FEED AND BLEED MODE OF HEAT REMOVAL
- STEAM GENERATOR TUBE RUPTURE

SRI-II MILESTONES

• FREEZE OF DESIGN	SEPTEMBER 1983
• COMPLETE DESIGN REVIEW	NOVEMBER 1983
• COMPLETE CONSTRUCTION	MARCH 1984
• COMPLETE SHAKEDOWN TESTS	MAY 1984
• START OF TESTING	JUNE 1984
• END OF TESTING	FEBRUARY 1985
• DATA ANALYSIS	MAY 1985
• REPORTING	JULY 1985

PRESSURIZER STUDIES AT DARTMOUTH

(PRS. G. WALLIS & H. RICHTER)

OBJECTIVES:

- DETERMINE MECHANISMS OF HEAT AND MASS TRANSFER IN PRESSURIZER
- GENERATE DATA FOR MODEL VALIDATIONS
- DEVELOP PRESSURIZER MODEL

RESULTS TO DATE:

- COMPLETED FIRST SERIES OF TESTS WITH SCALED PRESSURIZER
- STUDIED SPRAY CONDENSATION PHENOMENA

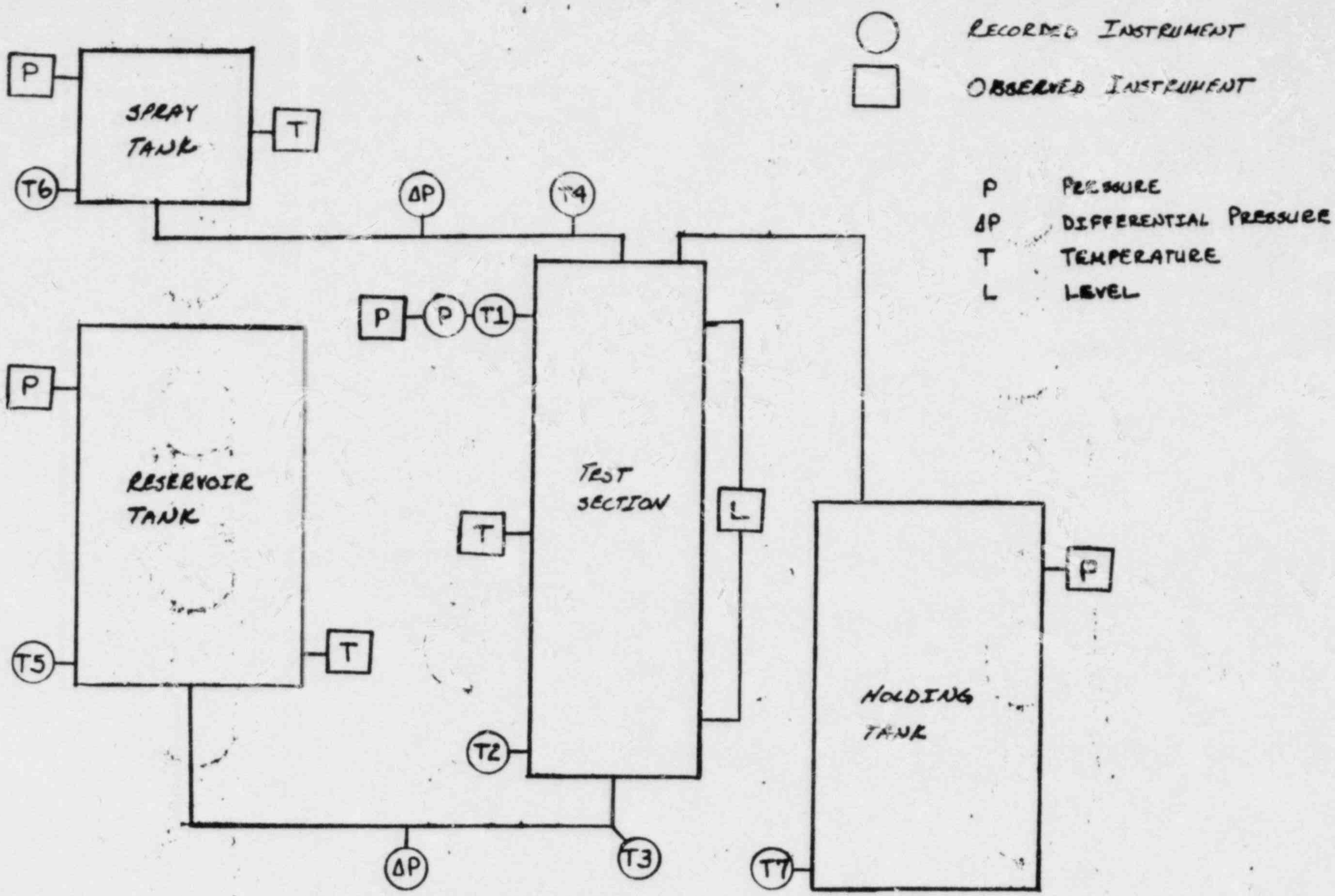


FIGURE 1 : INSTRUMENTATION SCHEMATIC

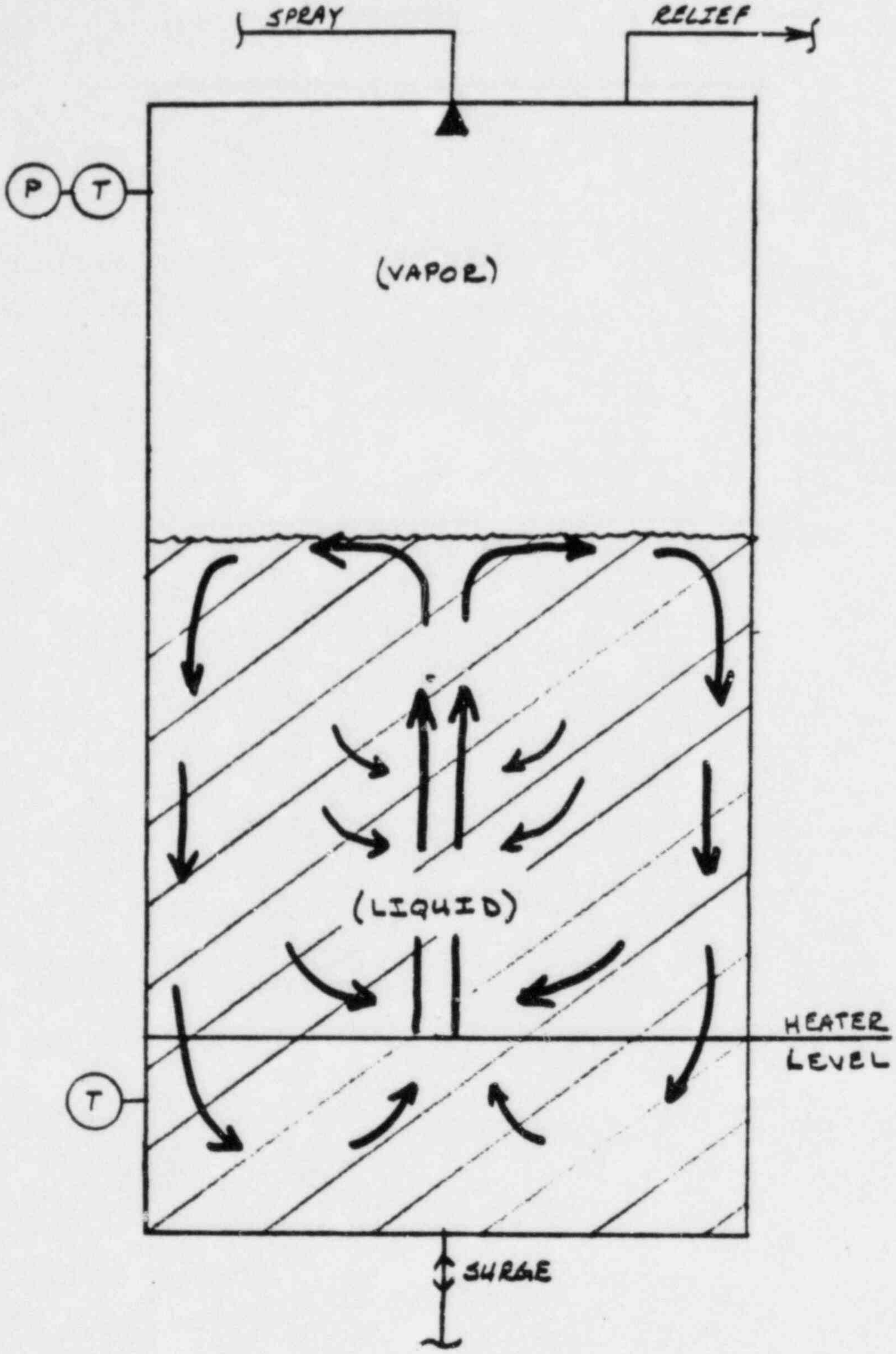


FIGURE 9: CIRCULATION PATHS DURING HEATUP

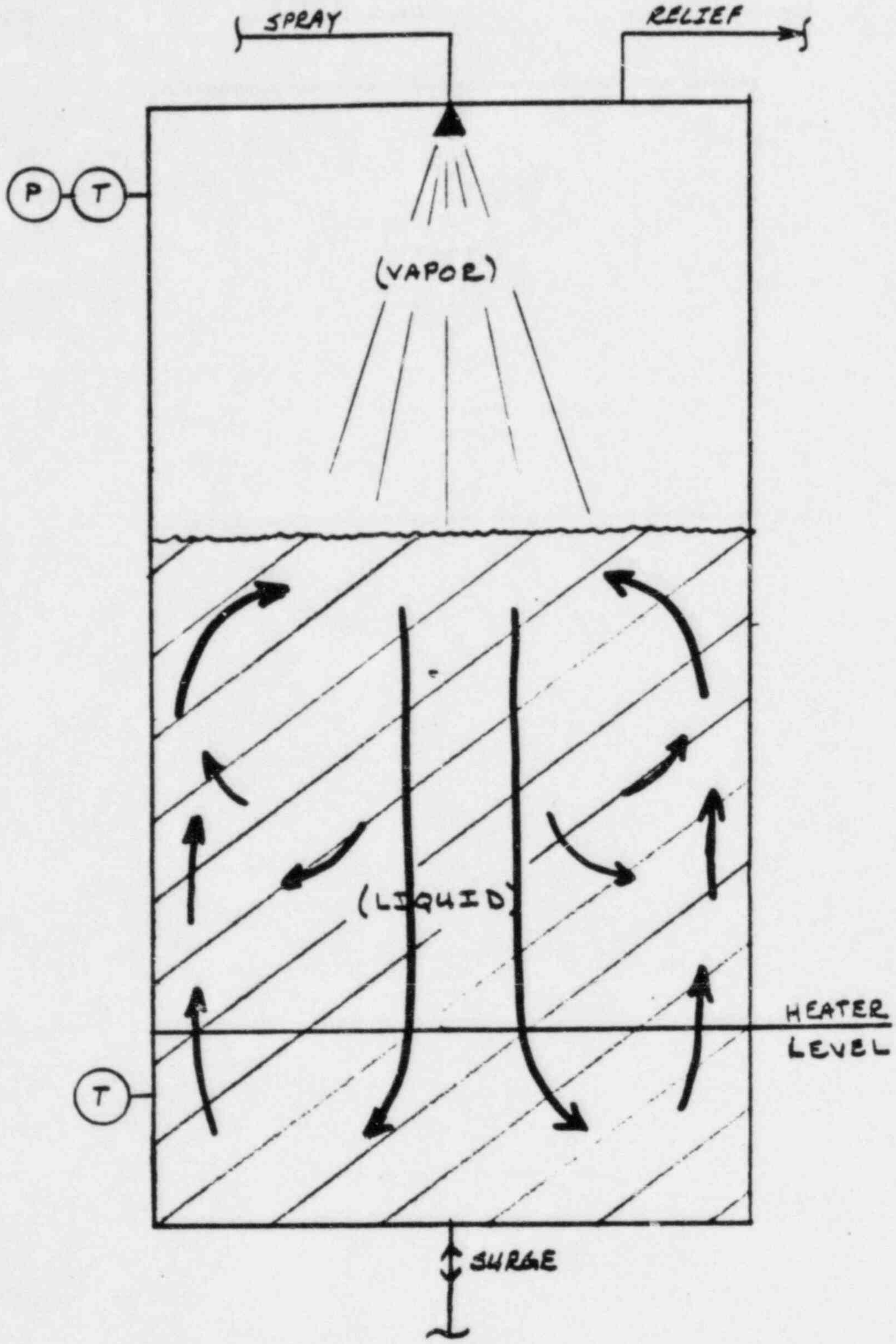


FIGURE 10: CIRCULATION PATHS DURING SPRAY FLOW

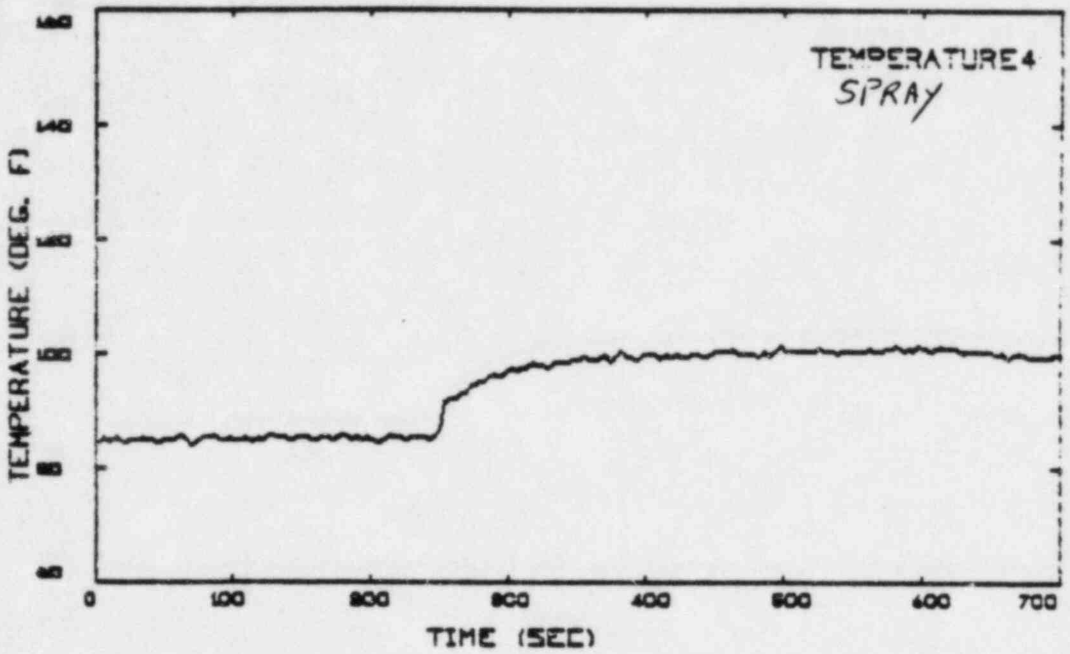


FIGURE 6

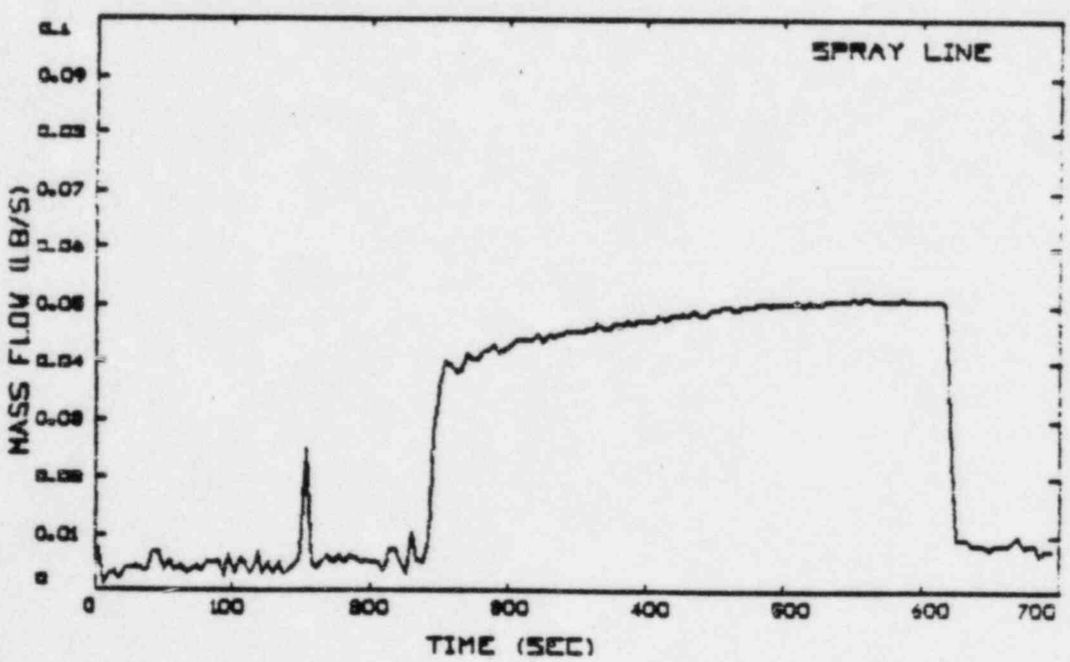


FIGURE 7

TEST C75 run 2

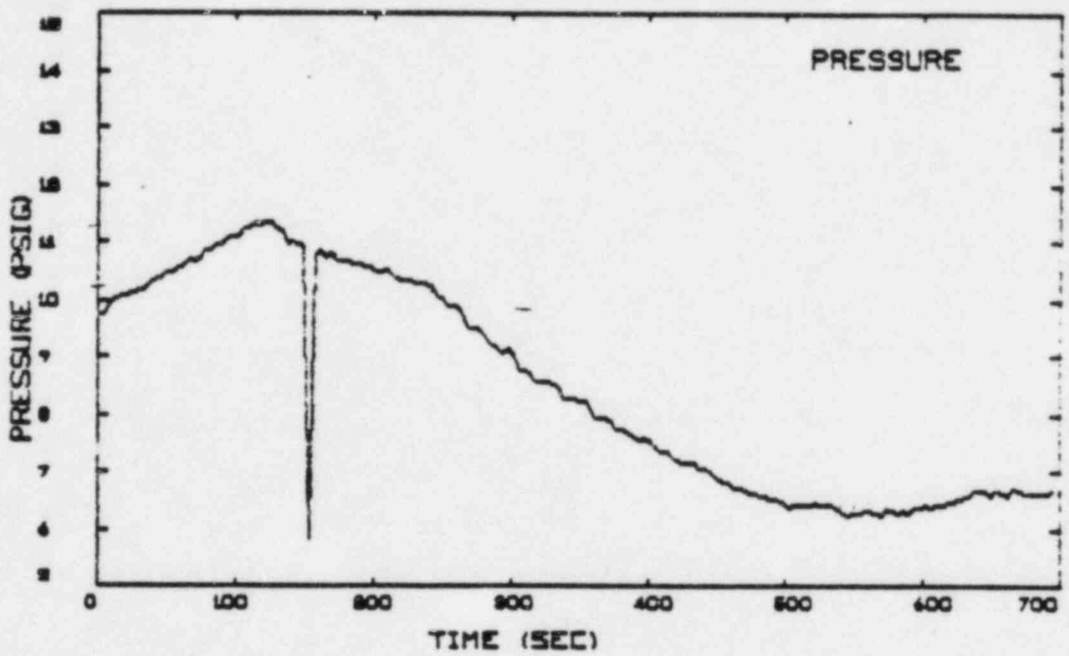


FIGURE 8

UC SANTA BARBARA PROJECT

(PR. S. BANERJEE)

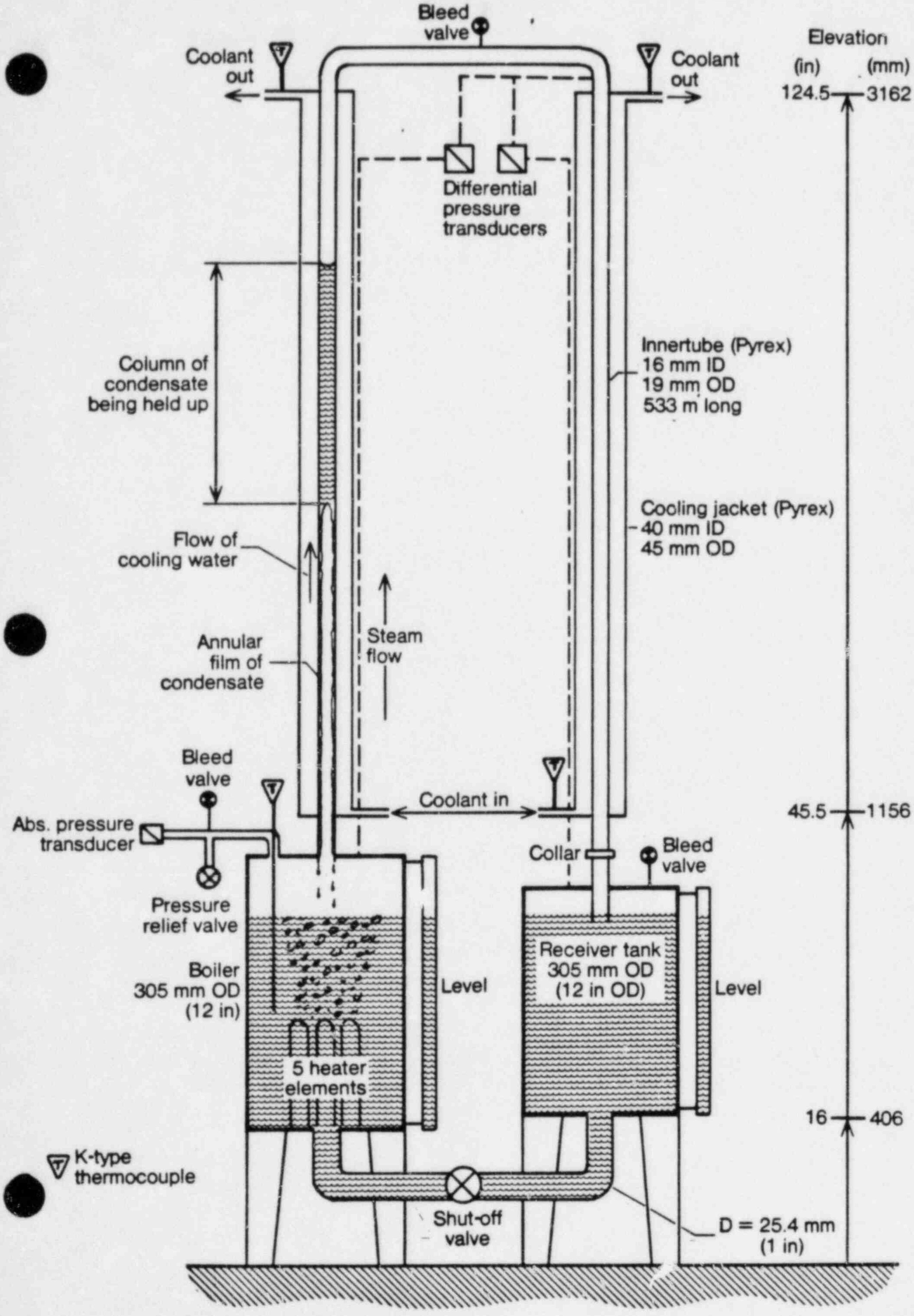
OBJECTIVE:

- STUDY CONDENSATION IN INVERTED U-TUBE GEOMETRIES WITH STEAM/WATER AND FREON
- DETERMINE EFFECTS OF NON-CONDENSIBLE GASES OR CONDENSATION
- DEVELOP AN ANALYTICAL MODEL

RESULTS TO DATE:

- DETERMINATION OF FLOW REGIME TRANSITIONS IN SINGLE AND MULTIPLE TUBE GEOMETRIES
- DEVELOPED SIMPLE MODEL
- TESTS WITH CODING ON DOWNFLOW SIDE OF U-TUBE (B&W)
- EFFECTS OF NON-CONDENSIBLE GASES
- INSTRUMENTATION DEVELOPMENT FOR MEASUREMENT OF NCG CONCENTRATIONS

SCHEMATIC OF TEST FACILITY AT UNIVERSITY OF CALIFORNIA, SANTA BARBARA FOR STUDY OF CONDENSATION MODES IN VERTICAL U-TUBES
(only one of four inverted U-tubes is shown)



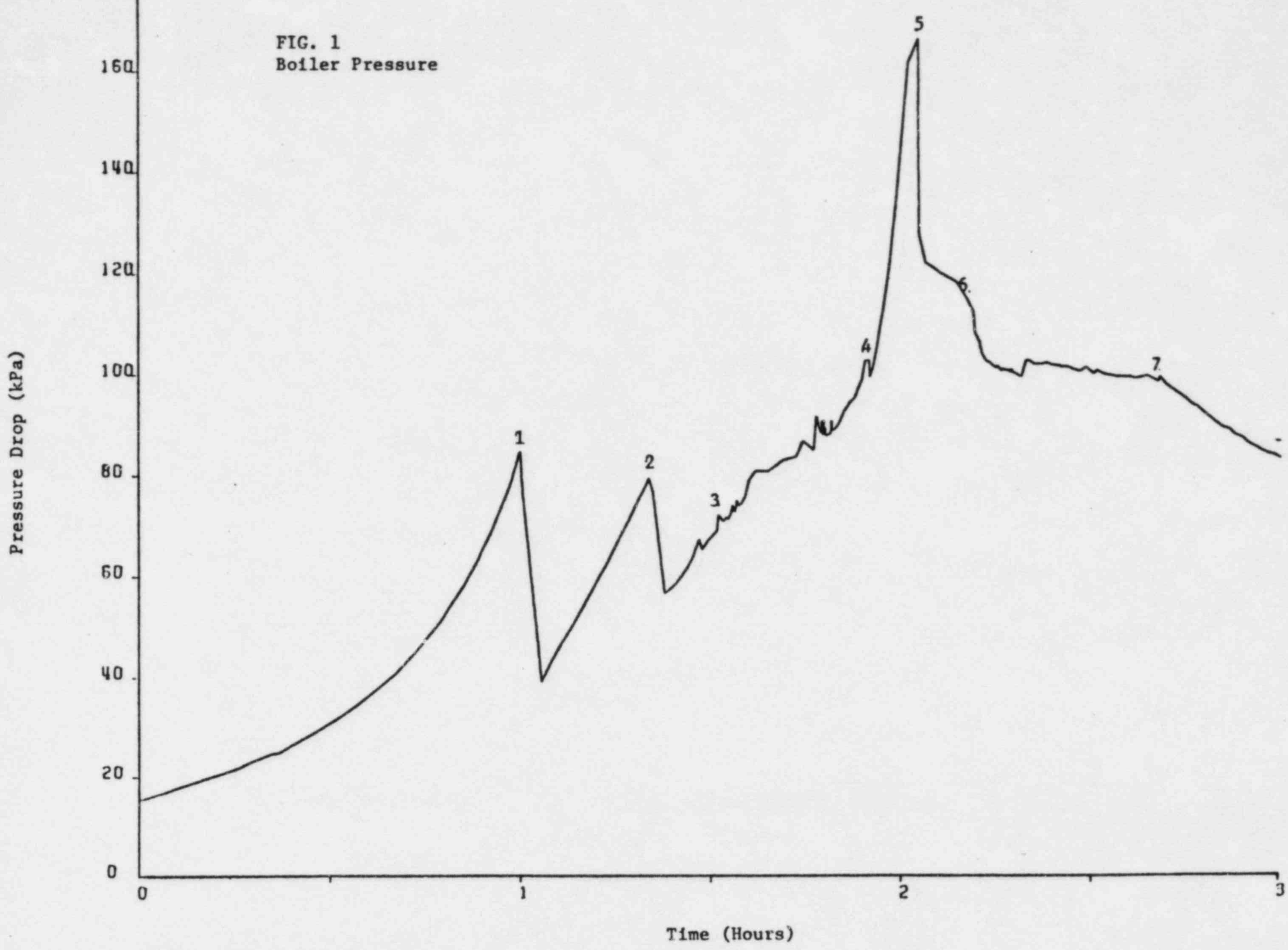


FIG. 1
Boiler Pressure

FIG. 2
Downleg Pressure Drop

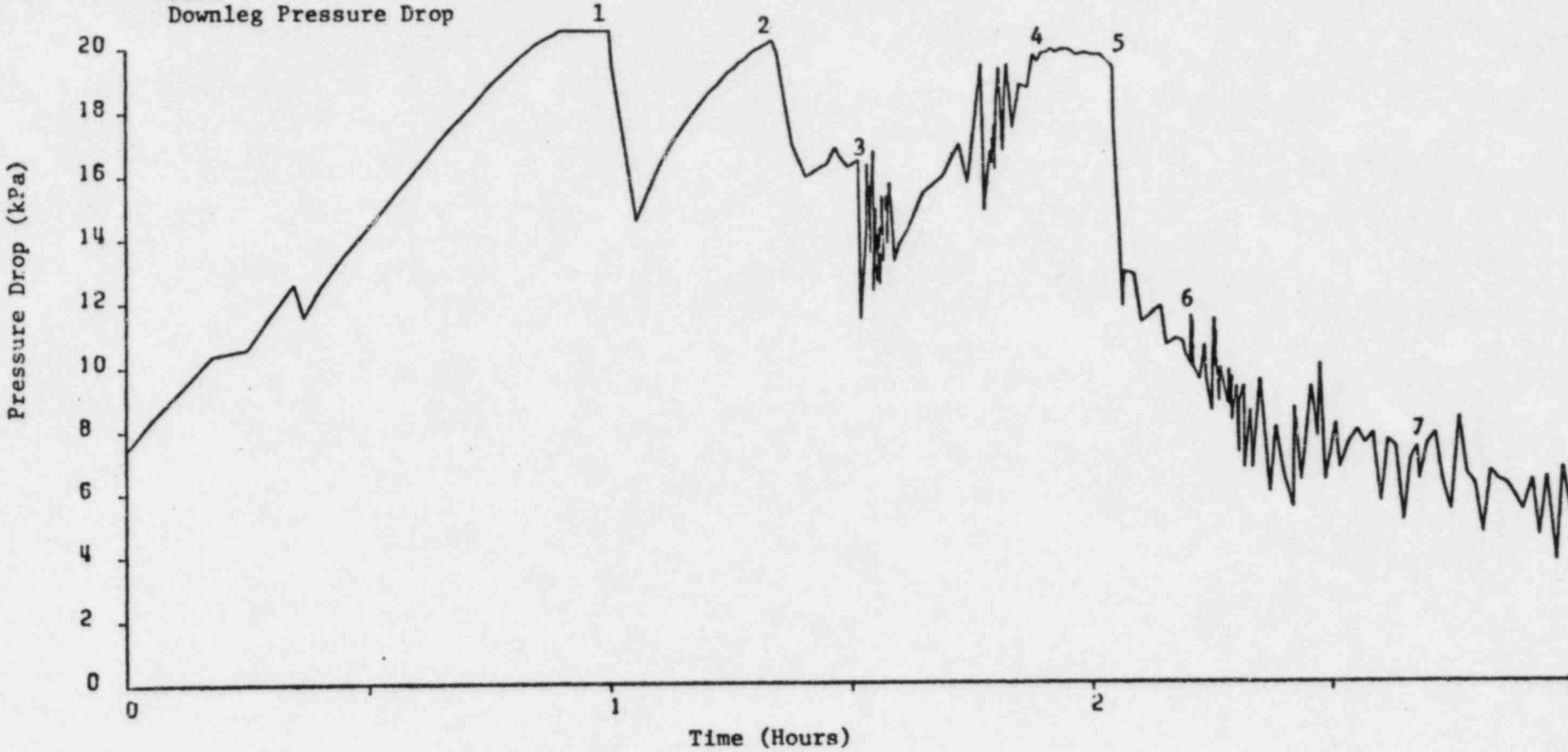


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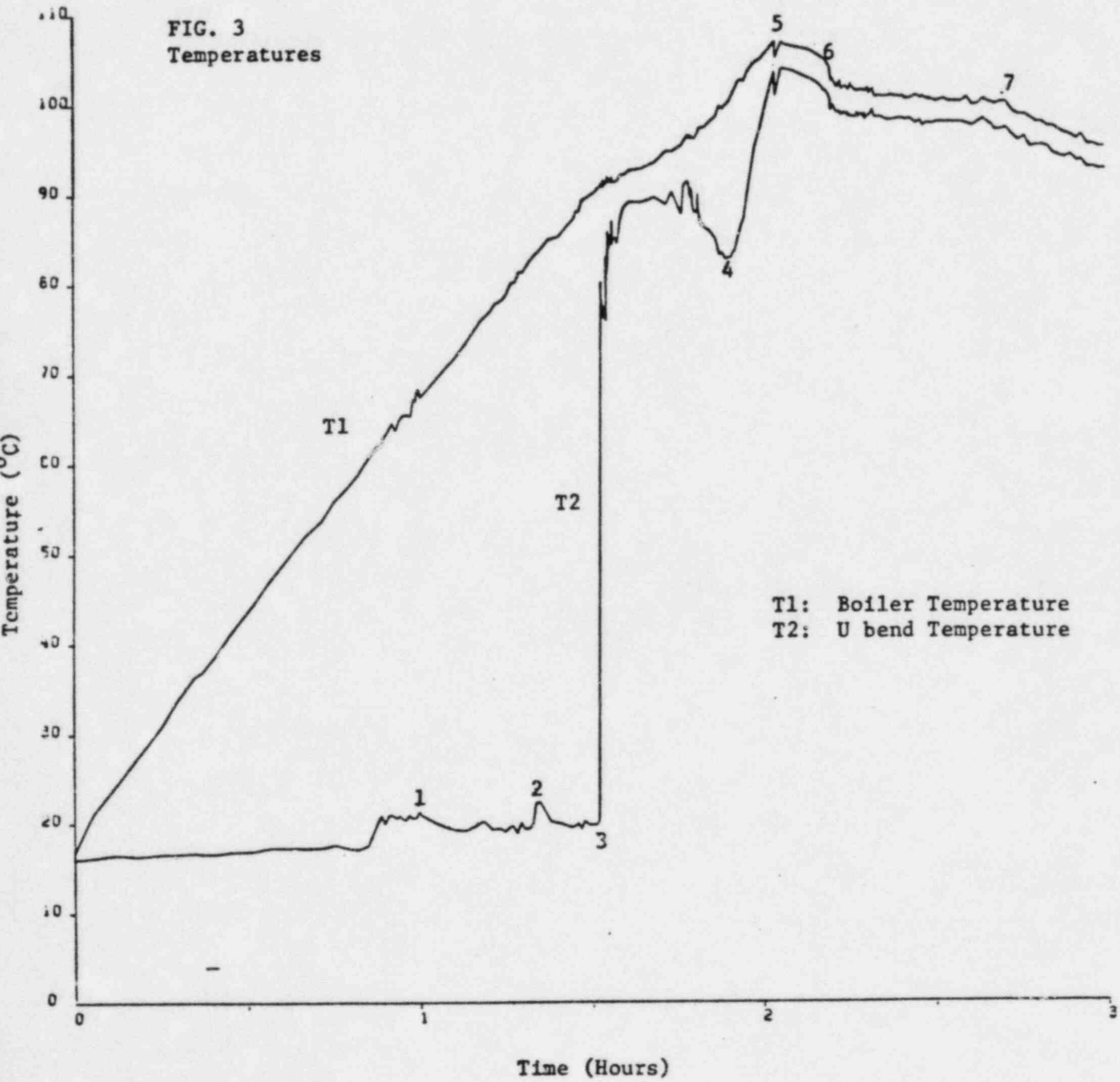
FIG. 3
Temperatures



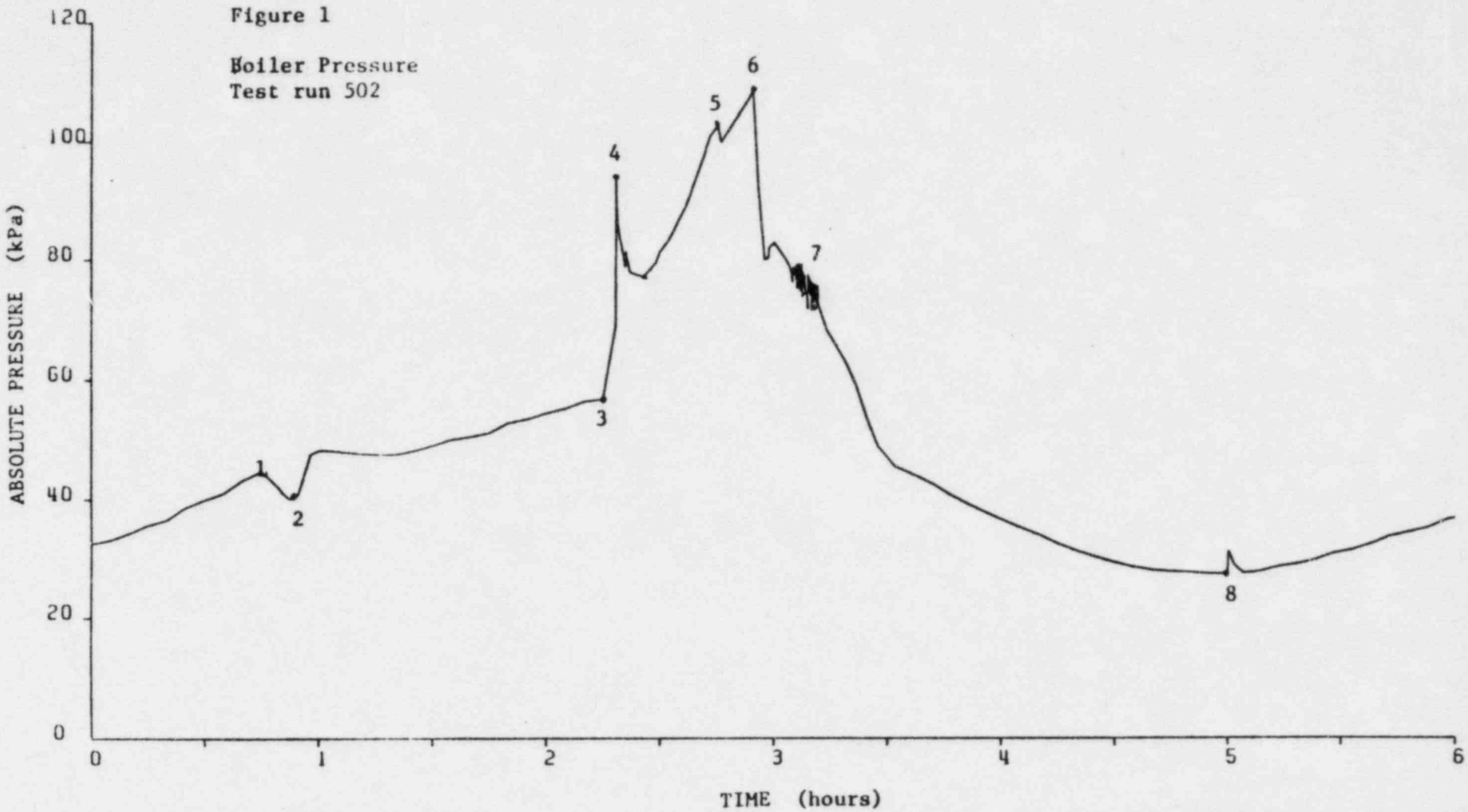
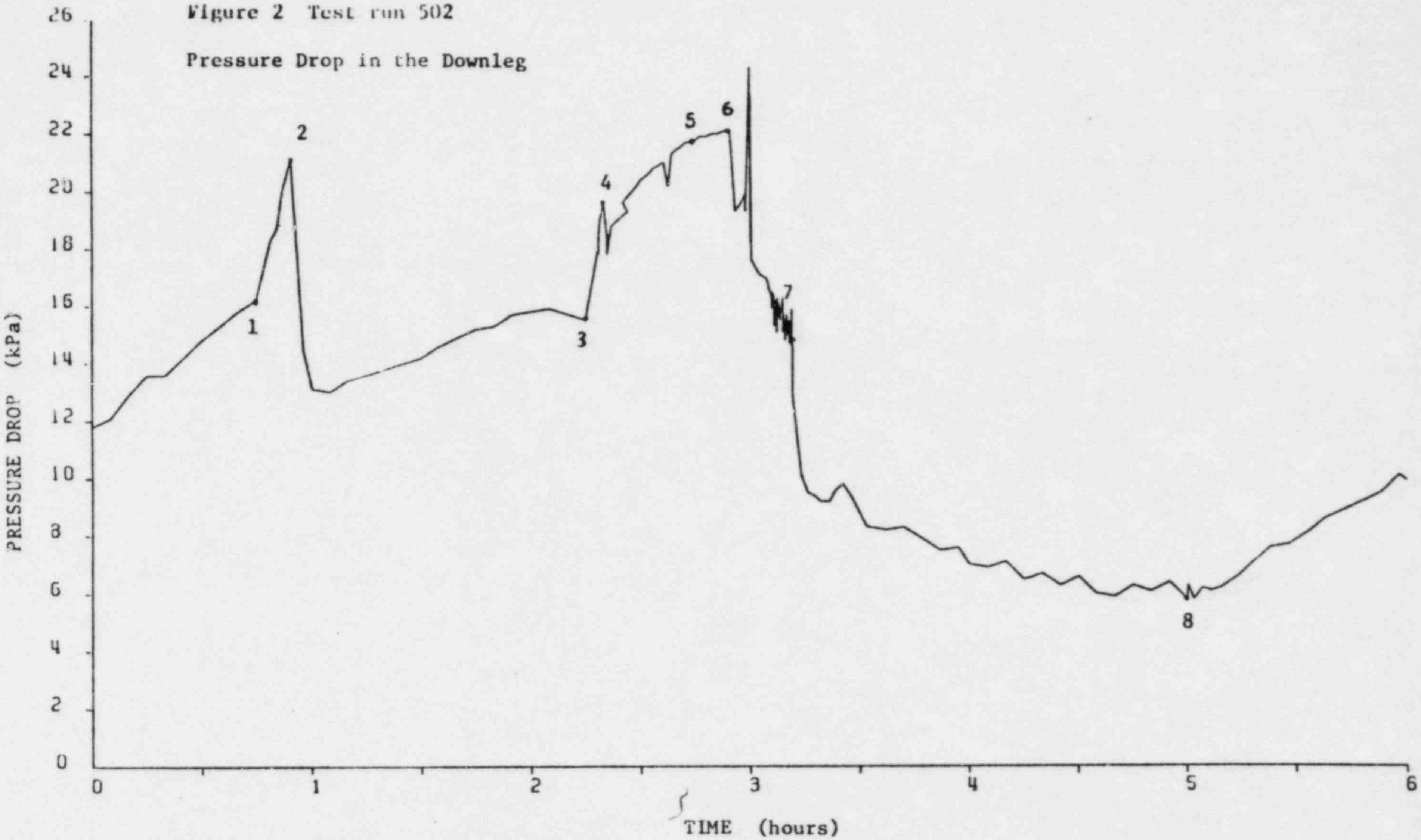


Figure 1
Boiler Pressure
Test run 502
ABSOLUTE PRESSURE (kPa)
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
TIME (hours)

Figure 2 Test run 502

Pressure Drop in the Downleg



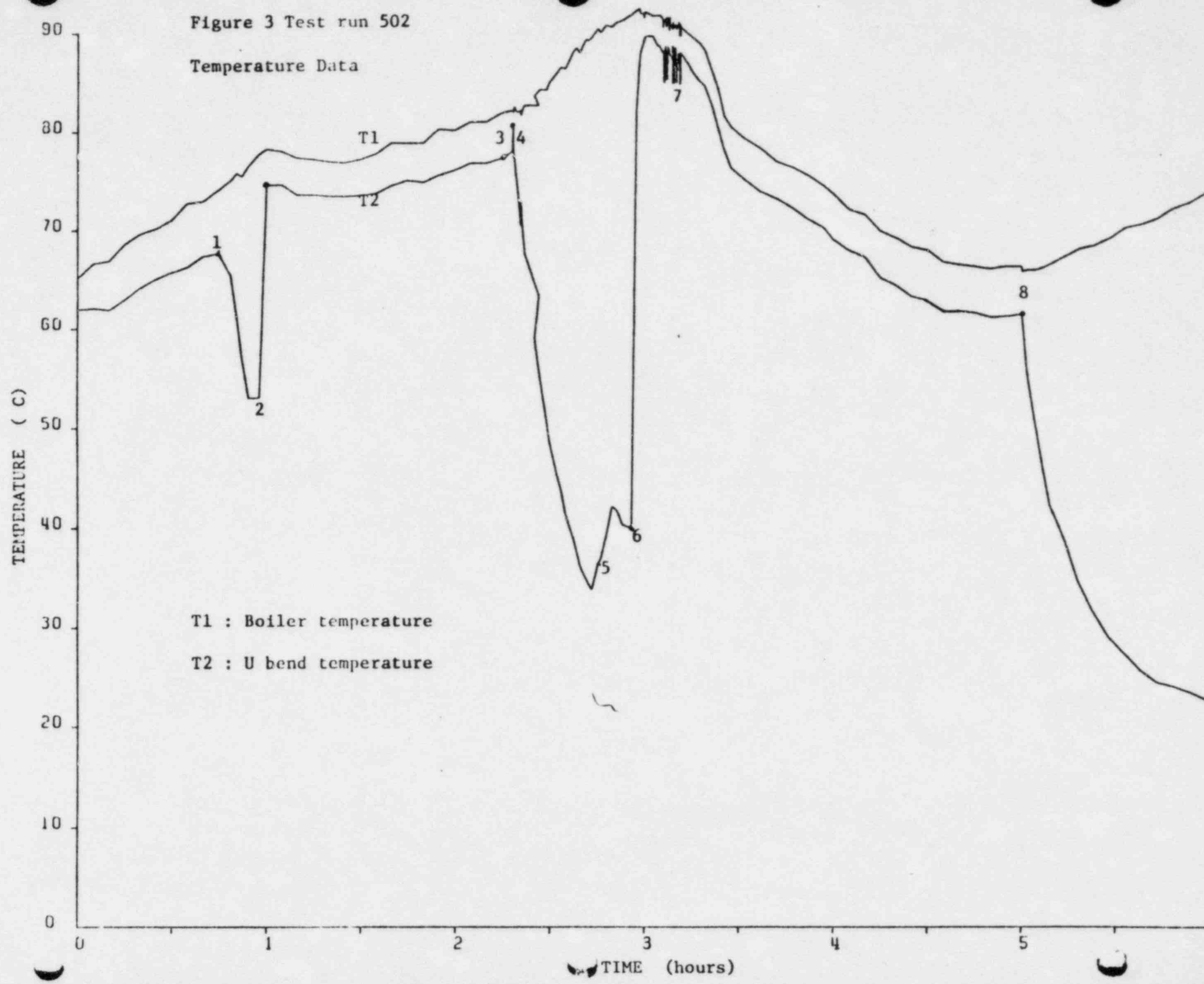


Figure 3 Test run 502
Temperature Data
90
80
70
60
50
40
30
20
10
0
TEMPERATURE (C)
T1
T2
1
2
3
4
5
6
7
8
T1 : Boiler temperature
T2 : U bend temperature
0
1
2
3
4
5
6
TIME (hours)

ANALYSIS EFFORT

OBJECTIVES:

- QUALIFICATION OF RETRAN-02 AND MMS-02 FOR PWR'S WITH OTSG'S
- HELP IN DATA ANALYSIS AND INTERPRETATION

APPROACH

- TWO EPRI CODES WILL BE USED (RETRAN-02 AND MMS-02) AND CROSS-COMPARED
- SEVERAL SCALES WILL BE EXAMINED
  - SRI-2 (SMALL SCALE)
  - MIST/OTIS (LARGE SCALE)
  - PLANT (FULL SCALE)
- MODELING ENHANCEMENTS WILL BE SOUGHT WHERE REQUIRED