NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

IN THE MATTER OF:

SUBCOMMITTEE MEETING

ON

EMERGENCY CORE COOLING SYSTEMS

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

TUESDAY, 19 JUNE 1979

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETING

ON

EMERGENCY CORE COOLING SYSTEMS

Room 1046
Nuclear Regulatory Commission
1717 H Street NW
Washington, D.C.

Tuesday, 19 June, 1979

The ACRS Subcommittee on Emergency Core Cooling Systems met, pursuant to notice, at 8:30 A.M., Dr. Milton S. Plesset, Chairman of the subcommittee, presiding.

BEFORE:

DR. MILTON S. PLESSET, Chairman of the Subcommittee

MR. JESSE EBERSOLE, Member

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P R O C E E D I N G S (8:40 A.M.)

DR. PLESSET: The meeting will now come to order.

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

I am Milton Plesset, Subcommittee Chairman.

Jesse Ebersole is scheduled to join us very soon. He was slightly delayed.

The ACRS consultants present today are Professor Catton, Mr. Garlid, Mr. Lipinski, Mr. Michelson, Mr. Shumway, Mr. Sullivan, Professor Theofanous, Professor Wu, Mr. Zaloudek and last, but not least, Mr. Zudans.

The purpose of the meeting is to review the ECCS model for small breaks in the reactor systems. Tomorrow, the subcommittee will review the proposed Fiscal 1981 budget figures for ECCS-related activities.

The meeting will be conducted in accordance with the provisions of the Federal Advisory Act and the Government and Sunshine Act.

Dr. Andrew Bates is the designated federal employee for the meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register.

A transcript of the meeting is being kept and will be

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made available. It is requested that each speaker first identify himself and speak with sufficient clarity and volume so he can be readily heard.

We have received no written comments or requests for time to make oral statements from members of the public.

We are waiting for not only Mr. Ebersole but his associate is supposed to be here any minute. In the meantime, we can have a free discussion of the consultants.

In particular, you got this morning from Dr. Bates an outline of the budget proposed for safety research, light water safety research. This is of some importance, if you have a chance to look at this, because tomorrow we are going to consider some of the aspects of this research budget.

The ACRS has to prepare a report very shortly for the commissioners regarding this budget and, in the not too distant future, a report to the Congress on the same matter. There have been suggestions that some of our reports haven't been as incisive as they might be and we have a responsibility to be searching in our forthright consideration of the budget. I would like to consider this this evening and be, perhaps, prepared to discuss with the staff tomorrow some of the items that will have to be reported on.

The budget related to ECCS research is the largest part of the safety research budget and is certainly, therefore, looked at with considerable care and a lot of detail. There is

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always a question raised about this: Is it disproportionate? Perhaps it has been in some respects; perhaps it has not been in other respects.

I would appreciate very much if you would be prepared to make frank comments tomorrow. It will assist us in preparing this report, which will have to [illegible] made available within two weeks. That will also go to the Congress, I'm sure. As I mentioned, we will have a longer report then, with a little more time toward the end of the year on this same matter.

I don't need to say again that this part of the budget is looked at with a lot of careful scrutiny and sometimes criticism. I would appreciate your input.

Well, let's go to the regular program, unless you have comments now. We have time if you would like to make some comments regarding today's or tomorrow's agenda.

MR. ZUDANS: Will we have our presentation on the individual items in this budget?

DR. PLESSET: Yes. That's what we will devote tomorrow to.

MR. ZUDANS: This report to the Congress, is that the same report we had the other year?

DR. PLESSET: Yes.

MR. ZUDANS: That's not due in two weeks, is it?

DR. PLESSET: No, but the budget from the staff goes to the commissioners in July and they have requested comments

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from the ACRS so that they can have some use of it in going over the proposal.

DR. BATES: The figures you have went to the NRC budget committee for research, which then goes to the commissioners, and they act on it and then altered figures may go to the government budget office and that goes to Congress.

MR. ZUDANS: The comments that are due in two weeks are for the benefit of the commissioners.

DR. PLESSET: That's right. However, I'm quite sure that this will be looked at by the committee in Congress that is concerned with the budget for the NRC.

MR. ZUDANS: Independent of the other report.

DR. PLESSET: That's right.

PROF. THEOFANOUS: As you know, some of us are involved with another subcommittee, also, which has discussed some of these research items. There is a question of duplication. Do we want to discuss basically some of the things we discussed a week and a half ago or do you want to just give some feedback by some of the consultants' reports given to the subcommittee? What do you suggest is the best way to provide the right feedback?

DR. PLESSET: Well, I think that we will have the responsibility of making the comments on the ECCS program. That is quite independent of what the other subcommittees are doing. Their consultants should give us the information they

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have developed. It might be of value in making that report.

PROF. THEOFANOUS: What I am saying is that those subcommittees basically have a scope that includes the scope of this subcommittee. What we have seen in the total budget, a good part of it is ECCS, which has been discussed also as part of the total. There is duplication, basically, in being here for the same discussion, but if we don't have the discussion, there will be no feedback.

PROF. CATTON: A lot of the detail has been left out.

PROF. THEOFANOUS: If there are any written reports here -- I wrote a report -- we need a chance to [illegible] them so that tomorrow, when we discuss the research, we have the benefit of all this previous work.

DR. PLESSET: There will be some special consideration in the budget of the implications of Three Mile Island. We definitely have to make comments about the systems engineering part of the budget on LOFT and code development. Those programs in LOFT and SEMISCALE, for instance, have been effective for Three Mile Island and they have some added test programs with small breaks.

One question I have in mind is: Are those significant and how important a contribution can be made by the kind of codes that we have concentrated on in the past? I think that is something you can give us some advice on.

Many of the tests don't need elaborate, big code

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programs. To do it that way may be a good exercise but not necessarily very helpful or useful for the code or the users interested in the results. For example, as a possibility, some of the tests may not be too meaningful; others may be.

As you know, there is a large program quite independent of the small break program with the codes and with an international program. The international 2D/3D program is a big program. Our part is $59,000,000, even though we are not involved with any new facilities. I think we can think about that, as well.

Does that help?

PROF. THEOFANOUS: Yes.

MR. GARLID: Is the Fiscal 1981 budget virtually solid and we are looking primarily at Fiscal 1982?

DR. BATES: It is 1981 we are looking at. The 1980 budget is before Congress now. The 1981 will be going to Congress.

PROF. CATTON: Isn't the '80 budget going with the huge supplement for Three Mile Island? We will probably have to look at that.

DR. BATES: Yes. There is a paper being duplicated which is supplemental to this.

DR. PLESSET: We can't look at that now because we don't even have it.

PROF. CATTON: The supplement is $30,000,000, I

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believe.

PROF. THEOFANOUS: Under 1980, one of the columns says 68. The next said amended 197. That's the additional money they want for that.

DR. BATES: The amended 1980 budget --

PROF. THEOFANOUS: Includes this $30,000,000.

DR. PLESSET: Yes. That's the amendment. There is $20,000,000 in the second and third column increase. Okay, I was just looking at the first part of it, right; $30,000,000.

Any other comments?

PROF. CATTON: There are a couple of things I would like to hopefully hear about today. One is this generator model. I would hope we co[illegible] hear from the staff on what they think of the method. It looks extremely crude.

Basically, they take the heat flux from the primary side to the secondary side at time zero and set up a ratio and multiply this by some time-dependent modifier. That is the steam generator model, in essence. I find that an oversimplification in the description when you consider the various things involved. I would like to hear something about that.

I would also like to hear a bit about how they calculate the rate at which the bubble grows at the top of the candy cane, and also why I should not expect the bubble to start growing there about the same time it starts to grow in the upper plenum of the vessel. It is not clear to me why you

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can't generate the bubble there simultaneously. You only need 50 cubic feet to block the candy cane. Why not block it before you clear the head?

I will pursue it at the appropriate time.

DR. PLESSET: Any other comments? If not, then we will proceed to the staff.

I might say it is a little unfortunate that Babcock & Wilcox couldn't send somebody down. They are being visited by the President's investigative committee this week. They could not spare anybody, which is unfortunate.

Is there somebody here?

MR. CUDLIN: There are two of us here today and we are expecting a third. I apologize we are not in full strength but we mustered up some.

DR. PLESSET: Will you make a presentation?

MR. CUDLIN: No, sir; we had not planned on a presentation.

DR. PLESSET: Fine. Thanks for being here. Do you want to begin with the regular agenda?

MR. ROSZTCOZY: Yes. Our subject today is the B&W small break loss of coolant accident analysis. Following the TMI-2 incident, the NRC staff reviewed the B&W small break analysis. Their review is now almost complete.

Based on the review and based on the present status of the review which we have looked at in the Oconee and the

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Arkansas plants safety evaluations, a repo t of the generic evaluation of the B&W small break review will be issued by the end of this month. Similar reviews for other operating pressurized water reactors are also on their way.

We have met with the Westinghouse owners group and Westinghouse three times during the past two weeks and we have met with the Combustion owners group and Combustion twice during the past week. These meetings initiated the review we have already completed for B&W. The Westinghouse submittal is expected at the end of this month and our evaluation will be completed in July. Combustion is expected in July and our evaluation will be completed a few weeks later. Discussion with the General Electric Company and operators of boiling water reactor plants will start next week.

The scope of the review is not yet defined. There are significant design differences and we are presently trying to evaluate the appropriate extent of the boiling water reactor review.

The purpose of the B&W review was to ascertain that there is a sufficient understanding of the small break so that plant responses in cases like this can be correctly predicted. This has been analyzed but most of the small break analysis was limited to break sizes that resulted in a complete depressurization; complete depressurization meaning the high pressure safety injection system, safety injection tanks and low pressure

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safety injection system were initiated in the appropriate sequence.

If one continues the small break spectrum down to smaller sized breaks, then depressurization doesn't necessarily happen and other possibilities exist, like the pressure can hang up at an intermediate level, maybe close to the secondary pressure, or repressurization can happen when the pressure turns around and rises again.

It was also the purpose of the review to see to it that proper guidelines are being prepared for emergency procedures. also followed up with a review of the emergency procedures and operator retraining based on the new information.

As I mentioned earlier, the analysis review was limited to the small breal LOCA including small break loss of coolant accident caused by other means initiated by transient and then resulting in a stuck-open valve. Strict compliance with Appendix K and 10 CFR 50.46 was not required in this step. Instead, the review concentrated on information needed for the preparation of emergency procedures and the information needed for the training of operators.

DR. PLESSET: Could you clarify one thing? How does Appendix K read; is it required to use 1.2 ANS for small breaks here?

MR. ROSZTCOZY: Yes. Appendix K does not differentiate between small and large breaks. The requirements

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specified in Appendix K apply to small breaks the same as large breaks. The 1.2 multiplier is required. It is important to keep in mind that many of the restrictions specified in Appendix K represent significant conservatism for large breaks but might be relatively ineffective for small breaks.

Some of those were devised purposefully for large breaks. The 1.2 multiplier is a significant conservatism in the small break analysis.

DR. PLESSET: So that's the one I thought would be the most important one for small breaks. That is required according to the wording of the appendix just as it is for large breaks, to use the 1.2.

MR. ROSZTCOZY: That is correct.

MR. SHUMWAY: You talked about retraining of operators based on new information.

MR. ROSZTCOZY: Yes.

MR. SHUMWAY: What new information?

MR. ROSZTCOZY: New information is basically the plant response in the case of small breaks, the plant response with the design changes which have been introduced in these plants.

MR. ZUDANS: Those findings are based on the analysis of small breaks.

MR. ROSZTCOZY: Based on the evaluation of small breaks, thinking about them -- what can happen, how, so on --

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and the suppliers of nuclear plants prepared guidelines for the preparation of emergency procedures. Those guidelines are provided to the individual utilities. Each of the utilities are responsible for the preparation of the emergency procedures so they devised emergency procedures based on these guidelines, taking into account any other knowledge they gained from Three Mile Island and since Three Mile Island, and the operators were retrained based on the new emergency procedures, which are significantly more detailed and complex than they have been in the past.

MR. SHUMWAY: So it is new emergency procedures you talk about; not necessarily new thermal hydraulic information.

MR. ROSZTCOZY: The new procedures were based on a careful evaluation and review of all the various possibilities that can happen in terms of plant response should you have a small break.

MR. SHUMWAY: Do you feel there are some new thermal hydraulic information?

MR. ROSZTCOZY: New in the sense we have seen analyses of break sizes which result from depressurization, we have seen analysis of break sizes which hang up at intermediate pressures. Some information of this sort was available but it was rather limited.

Routinely, if you look at the safety analysis report of these plants -- for example, the operating plants -- they

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did not have this information.

DR. PLESSET: Have the operators of the pressurized water plants -- have there been any negative responses to the new setpoint conditions for reactor trip and the like? Have they all found them acceptable and desireable?

That's a general question. I thought I saw some responses that indicated some reservations.

MR. ROSZTCOZY: Let me answer the question based on my knowledge. This afternoon, we are going to have people here who have worked individually with the individual utilities in the preparation of the emergency procedures for each utility. They are the people more aware of what discussions went on and what concerns might have been expressed.

My understanding is that there were no major concerns in terms of the setpoint changes. The two changes in the setpoints were: In the past, B&W plants had a relief valve set at the lower pressure than the reactor trip initiated from high pressure so that in the normal course of events, if there was say a feedline transient, the normal course was the pressure started to rise. This opened the relief valve.

If the relief valve was able to hold the pressure, there was no reactor trip. If the pressure rose further up another 100 psi or so, then the reactor trip was initiated from the pressure and the reactor was tripped.

The advantage of this type of design philosophy is

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that you exercise the relief valves quite a bit. As you probably know, during the 30 reactor years of operation of B&W plants, there were 148 occasions when the v ves were exercised.

Based on studies which were done completely independently -- I believe there is a reactor safety study where they just looked at valve behavior -- they arrived at the conclusion the probability of the valve not closing once it was lifted is two times ten to the minus two. If you compare that number to the three occasions out of the 148 trips when the B&W valves did not close, you get almost exactly the same number of one in 50. This is a disadvantage of design.

Now what is the design change? It is that they reversed the order of these two setpoints. They lowered the setpoint on the reactor trip and increased the setpoint of the relief valve. In the new design, if there is a transient and the pressure starts to increase as a result of that, first you reach the reactor trip and you would reach a valve opening only if the pressure started to continue and rise higher.

In addition to these design changes -- the design changes on the setpoints -- there were also new reactor trips installed; two new re   r trips. One is loss of feedwater. The second is on turbin trip. With these two new reactor trips and the new setpoints, the expectation is that most of these transients will not result anymore in lifting of the relief valve.

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Along these lines, I am not aware of any serious concerns. There were a few other items in the bulletins and some of these are being discussed in a lot more detail. One of them that got quite a bit of attention -- and there is kind of a spectrum of opinion on this; not everybody is of the same opinion -- is the question of the reactor coolant pumps.

When you have a small LOCA, what should be the emergency procedure? Should they tell the operator he should turn off the reactor coolant pump or run the reactor coolant pumps even if they tripped out? Maybe start them up and try to run them.

The opinion on that question seemed to be evenly distributed. Some advocate one and some the other. Later on, we will discuss the various analyses performed and maybe that will be a good time to comment on that.

Again, we do not see a completely clear black and white choice. There is some advantage of doing it one way and there is some disadvantage coming with it. If you do it the other way, again, you will have some advantages and some disadvantages.

DR. PLESSET: I was thinking not only of B&W plants but other pressurized water reactor systems, and I thought there might be some concern from the operator that you will get more spurious trips of the reactor with the new arrangements. We will come back to that later today, as you say.

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MR. ROSZTCOZY: These last few comments I made were general comments applying to all PWRs. For example, one vendor is recommending one and another vendor is recommending the other one on the trip.

In terms of the setpoint changes which I described, Combustion always had them the other way. They had what is considered the new B&W design. I believe most of the Westinghouse plants are the other way, too, but they have plants in both categories.

MR. ZUDANS: My question was the one you phrased. I assume we will hear later the philosophy why this switchover of setpoints is such a good thing. Is it easier to, say, replace the relief valve after 100 operations or so?

MR. ROSZTCOZY: I'm sorry if I mislead you but I do not believe we will discuss that part today. We will discuss the analysis part but we are not planning to address that part. If you have any questions on that, I can respond to it now.

MR. ZUDANS: It appeared to me kind of very sudden, talking about a switchover from one system to the other. Instead of offering a relief valve, because it will fail to close after, say, 100 operations, you trip the reactor. With the trip points suggested, are you allowing the pressure to go higher than it would go before you trip the reactor now or what?

MR. ROSZTCOZY: That was not the original purpose. Why is the relief valve there? It doesn't really have any

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safety purpose for this type of transient. It might have one for other occasions, but those are not automatic openings of the relief valve.

For example, you might use the relief valve to avoid something, but those are not automatic actions. They would be manual. The automatic action is not a safety consideration; it is just an operating convenience.

When you go to the reactor trip, to trip the reactor under certain circumstances, that is a safety consideration.

The main reason for the change was the very high probability -- or the very high frequency -- of occurrences of these cases. If you look at the B&W plants, their 30 years of experience, there have been four small loss of coolant accidents because this valve was open. There were cases where the valve was lifted as a result of a transient and didn't close. One was the result of an electrical malfunction which opened the valve for an extended period of time. Four of these in 30 years gave you a probability of 0.13 approximately.

In all our considerations, when we have been working with the loss of coolant accident -- for example, when the criteria were derived -- probabilities of much lower than this have been considered. Over a risk that a given accident represented is a combination of the two -- a combination of the probability of occurrence and the consequence of the event -- there are two ways you can enforce a certain criterian.

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You can have a risk criterian -- or establish criteria -- for each of them, the probability of occurrence. The way our regulations are set up, we are following the second route. We don't have an overall criteria but we have a requirement on the probability of the events and consequences.

If both of those are met you have an acceptable consequence. If one is met and the other is not, the risk can be unacceptably high. The main purpose was to reduce this very unusual and very high occurrence of small break blowdown.

MR. ZUDANS: That would be fine, but to clarify this in my mind, it doesn't mean they will now be making more reactor trips. Or does it mean that? If so, isn't the reactor trip more damaging than just a relief valve?

There are many other things coming into action. What I am concerned about is not to see as many trips as there would be the other way. In other words, you are paying with a reactor trip for elimination of a relief valve. I am wondering what the mechanical consequences are in either case. I would certainly not want to trip the reactor to save the relief valve.

MR. ROSZTCOZY: What the design change has done is reverse this, too, so should the design be the same in the past as it is now, then you would have seen 148 reactor trips.

MR. ZUDANS: The reactor is not designed for that. You cannot take it. There are components that suffer from this trip.

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MR. ROSZTCOZY: There is quite an effort going on to try to reduce the number of reactor trips. Large portions of this were initiated by feedwater transients, initiated from the feedwater systems.

Parrallel with the analysis review, what we have performed, there have been systems reviews of these plants, and one of the main objectives of the systems review was the feedwater system of this plant. Various things have been discussed and I assume consideration has been given to improve the feedwater system in such a manner that the frequency of feedwater transients in the future would be lower than it has been in the past.

I have not been involved in that part of the review and I cannot give you the exact conclusions of the review, but there is a definite effort to do this.

MR. ZUDANS: In other words, some other group of people will look at the total number of such trips and make sure they are not more than the plant is designed for.

DR. PLESSET: I think that was well-stated. What I was concerned about, at least, changes. I would be surprised if there were not responses of operators of PWRs in this context. Maybe we will have more on this later today.

Rex also wanted to comment.

MR. SHUMWAY: How many reactor trips occurred when you had these 148 incidents?

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MR. ROSZTCOZY: I don't know the answer to that. Additional information has been requested on those. We haven't seen an itemized list of all of those yet. Once we have the information, I assume the answer to your question will be there.

DR. PLESSET: We would like to see that.

MR. SHUMWAY: If we had 148 reactor trips, anyway, then it means this change will just result in fewer small breaks.

MR. ZUDANS: The plant is not designed for 148 reactor trips.

PROF. CATTON: Some small fraction.

MR. ROSZTCOZY: Since the B&W people are present, they offered to comment on any areas where they might be able to help. Let me check with them on whether they have answers to some of these questions. Maybe they can provide a little bit more insight about how many of these transients resulted in reactor trips.

DR. PLESSET: Fine.

MR. KANE: Ed Kan, B&W.

I don't have the specific number of incidences that lefted the relief valve that will now cause a reactor trip. I believe, in our presentation last Friday, there was a slide presented which indicated the number of successful turbin trip runbacks, loss of single reactor coolant or loss of single feed-water pump runbacks at the B&W plants.

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On one particular plant that I recall over a five-year period, I think the number of additional trips was expected to be about 30.

MR. ZUDANS: That's 30 too many, I assume.

DR. PLESSET: Thank you. We will get some more.

Yes, Karl.

MR. MICHELSON: Have you considered the possibility of an automatic -- but delayed -- closure of the block valve after the actuation of the relief valve in lieu of some of these other possible changes, keeping in mind, of course, the operator would then have to manually reopen the block valve after the transient was over?

MR. ROSZTCOZY: This possibility has been discussed in our various considerations but I am not aware of any case when any of the utilities would have operated to follow up on that; at least, not in the short-term.

There are also various things we considered the long-term. I believe there is one that is being looked at.

MR. MICHELSON: It would appear to alleviate the concern about the valve sticking open because it would back up that possible single failure by automatic closing of that route for loss of coolant. It appears in many respects like a more favorable direction to go than to start juggling around set-points.

MR. ROSZTCOZY: Recommendation has been made by some

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members of the staff that these should be kept closed for these plants for the timebeing. The probability of failure is being evaluated. That recommendation was considered. It is my understanding that a number of the utilities are keeping the valve closed on their own initiative.

Shortly after the Three Mile Island incident, they decided to keep the valve closed and are operating in that mode. That is an accepted operating mode and has always been an accepted operating mode. The fuel can follow that.

MR. MICHELSON: Would it be a more attractive alternative to require a mandatory operation to close the block valve after each activation of the relief valve until the transient was over with? This could also be done but you would count on operator action. It, again, appears better to do than to start juggling the setpoints as they have been juggled.

MR. ROSZTCOZY: No; the last item -- mandatory closing of the block valve -- would contradict some of the present emergency procedures. Emergency procedures in some cases -- not on the permit -- require the manual opening of the valve, so the valve is being used to relieve pressure for some of the transients.

MR. MICHELSON: I thought you assured us there was no safety significance to the operation of the relief valve. There are no requirements to open that valve. Some desired time, but no required time.

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MR. ROSZTCOZY: No requirement for ultimately opening the relief valve. It is there and some of the emergency procedures ask the operator to open the valve if repressurization occurred. Usually, the instruction is given in terms of a certain pressure level. If the pressure rises to a certain level, then the operator is asked to open the valve to maintain the pressure or reduce it, so the valve is being used as a result of operator action.

PROF. CATTON: Is it a concern for operators doing the wrong thing? How much of a role does that play?

MR. ROSZTCOZY: I didn't hear the question.

PROF. CATTON: How much of a concern is there about the operator doing the right or wrong thing? How much concern is there in these procedures?

MR. ROSZTCOZY: It played a very important role in the process of generating the procedures. Questions have been continuously asked during those dicussions: What happens if the operator doesn't follow some of these instructions?

The purpose is to try to be kept at a minimum and at relatively basic steps. This would be a type of thing where the operator learned this, and since the main steps of the procedures are relatively simple, he certainly would try to follow those.

PROF. CATTON: If operator education were considered, maybe one could back out of some of these procedures in the

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future. Can you teach the operator to do it right?

MR. ROSZTCOZY: Yes, I assume so. We can do that.

DR. PLESSET: I would not encourage discussion of this point. Perhaps Mr. Rosztcozy is not too prepared to go into all of this.

MR. ROSZTCOZY: A different group of people -- system people and specialty people -- who are in our operator training branch were the ones who followed up the emergency procedures. Those people will be here this afternoon giving a presentation to you. The questions on how the operator responds to that, how they are being trained, how emergency procedures are being prepared, thos questions probably should be kept for the afternoon session.

PROF. CATTON: I was trying to fet a feel for this.

DR. PLESSET: Our concern is: Have we really improved the situation or not? I'm not sure, but this may have been done in some haste. We will find out more this afternoon.

Harold?

MR. SULLIVAN: Zoltan, do find it to be a conflict -- you say the valve is not safety related, but the actuation of that valve, how it is used, is definitely controlling how the transient goes -- or the effect on the transient. Yet, you don't require it to be in any one position. Do you find that to be a conflict?

MR. ROSZTCOZY: First, let me see if I understand

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your assumption. The valve is definitely safety related in the sense that it is part of the primary system pressure bundling and we have a very strict requirement for that. There is no question it is safety related.

My remarks were that automatic opening of the valve is not a safety related action. We have pressurized water reactor plants which do not have this valve at all. It is not a necessity and doesn't have to be on the system.

All the new Combustion designs don't have this valve there. In that sense, automatic actuation of the valve is not a safety related action. If you did that, then there are various circumstances when you probably would use the valve, and it is to your advantage to use the valve in those circumstances. Recognize that there is no restriction at the present time on the use of the valve.

MR. SULLIVAN: It indirectly affects how the transient goes, whether it is automatic or not, or whether it works or not, is that correct?

DR. PLESSET: We know that.

MR. SULLIVAN: In its operation, it looks like it would be part of the review of a safety issue whether it was automatic or not.

MR. ROSZTCOZY: Let's take a simple case. Take the same plant. In one case, it is operating with the block valve open. In the other case, the same plant is operating with the

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block valve in a closed position. What is the difference between the two? The difference with the new setpoint, for most of the transients there is no difference. For those where the valve would open, the difference is that should the valve open, it would try to maintain the pressure and it might prevent the lifting of the safety valves. If the valve cannot prevent that, then the safety valves will operate.

The second case is when you have the valve closed. In that case, the pressure rise would just continue to the safety valve. It reaches the safety valve. The only difference is that the safety valve is a somewhat higher pressure and different design.

If it can be shown the safety valves are more reliable than keeping the valve closed, that is probably the safer mode of operation. The real fact is if they are more reliable than the safety valve, then the best operation is the keep the valve open and operate with the relief valve.

MR. ZUDANS: Is the safety valve on the same line or a separate line?

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

DR. PLESSET: Separate line.

MR. ZUDANS: Those setpoints are in accordance with the code?

MR. ROSZTCOZY: Yes; typically 2500 psi and the relief setpoint is 2400 psi.

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MR. ZUDANS: The safety valve setpoint would be way beyond the reactor trip setpoint.

MR. ROSZTCOZY: With the new setpoints now, the trip is approximately 2300. Next is 2400. The safety valve setpoint is 2500 psi.

DR. PLESSET: Maybe we should go on. We will be talking more about this later. Go back to your set program.

MR. ROSZTCOZY: Yes.

I had a few more sentences in my introduction. It turns out, I believe, these questions have already asked for those responses so we are ready to start our presentation.

We have three presentations this morning. The first will be by Brian Sheron, who will discuss the items relating to the Michelson concerns.

The second presentation will be by Mr. Audette, who will discuss the small break analysis that B&W performed during the past month.

The third presentation, which is not on your sheet, will be given by Norm Lauben. He will discuss other calculations we have performed for the B&W case. Originally, when this program was prepared, we assumed Mr. Audette would do that presentation, also, so we had one item there. It now splits into two. Audette will do part and Lauben will do part.

We will try to complete those in the morning and spend the afternoon on the guidelines and emergency procedures

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and operator training.

DR. PLESSET: Fine.

MR. ROSZTCOZY: Brian, would you please start?

MR. SHERON: Good morning.

(Slide)

What I will be speaking to you about this morning deals with natural circulation in the B&W plants. Specifically, I will be addressing the concerns of Mr. Michelson that he raised in a draft report written on B&W raised loop plants.

Just for history, for those not familiar with it, a draft report -- handwritten report, I guess -- that we obtained in early April of this year by Mr. Michelson was written expressing what was considered to be about six major concerns on 205 fuel assembly plants. This was in reference to the Bellefonte application, I think.

These concerns were transmitted formally from TVA to Babcock & Wilcox in a letter of April 26th of last year. B&W evaluated the concerns in this letter and responded in a letter to TVA on January 3rd of this year.

I would feel it fair to say, as I understand informally from B&W, they spent about a month or two evaluating the letter. They did not feel there were any significant safety concerns. As I understand, that is why there is a big time delay between April and January here.

In April -- around the 14th, the first or second week

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of the month -- a copy of the report was received, at least in the analysis branch, and that was when we were asked to review it and to provide our evaluation on it.

On May 7th B&W came in with a report on small break analysis of their plants. This is the big blue report. In it, they devoted one appendix to more detailed evaluation of the concerns of Mr. Michelson.

(Slide)

DR. PLESSET: Is that the first time you were aware of this analysis?

MR. SHERON: It was the first time I was aware of the report. I think it was the first time most of the staff was. There was an internal memo from Darryl Eisenhut to a number of office directors, I believe it was, dated around April 14th and it said here was a report he received from Mr. Michelson and he was passing it out for our information.

I called Darryl and, as I understand, this was received by him from Mr. Michelson. It was, I think, at the site. At least, that's what he told me up at Three Mile Island. I read in the Post what everybody else did, that there was a possibility the staff might have had a copy prior to the Three Mile Island event. I do not know who got it or what the actual circumstances were.

DR. PLESSET: Okay.

MR. MICHELSON: I think it is fair to say that the

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staff did have handwritten copies of this material at least on 10-21-77, since that was the date the handcopy returns were returned to Jesse.

MR. ROSZTCOZY: My understanding is that one member of the staff received a copy of this from a member of ACRS, I believe. I'm not sure of the date; somewhere along the line Mr. Michelson indicated. That copy was not circulated within the staff. The people who are here today and the people who have been involved in these reviews have seen the report for the first time following the TMI-2 incident..

MR. SHERON: In reviewing the report, there appear to be six major concerns that were addressed with regard to the natural circulation phenomena in B&W plants following a small break accident in which the steam generators were required to remove the decay heat.

In addition, there was an additional report written by Mr. Michelson. I think he referred to it as more or less handwritten notes. This addressed one other item. This was for a CE System 80 plant. This was the effect of non-condensable gasses. I intend to address that this morning, also, as part of this. It was not specifically pointed out in the B&W report.

The seven items were: Acceptability of intermittent natural circulation.

Time delay in transitioning from natural circulation

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to pool boiling mode, or reflux boiling.

Item three, the pressurized level is not necessarily a correct indication of water level in the core.

The consequences of if an IFA small break is isolated, what happens?

Another was the pressure boundary damage due to bubble collapse, like a waterhammer effect.

The fact that the energy leaving the break is not necessarily the energy that is being generated and exiting the core.

Okay, so when one talks about if the break carried away the decay heat, one must take into account what goes out the break is not what comes out the core.

The last item was the effect of non-condensable gasses, on which we do not have any formal information submittal from B&W at this time.

What I will be talking to you about are some staff estimates that we have put together.

(Slide)

With regard to the intermittant natural circulation, which we have come to call the "Michelson Effect," that is, what happens is you get steam bubbles. As the system depressurizes, you would start to flash the hot leg in the core, steam bubbles are formed and can accumulate at the high points in the system, be it the upper head or top of the candy cane, and if they do

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accumulate at the top of the candy cane, this is the hot leg U-bend, and when the steam volume exceeds the volume of the U-bend, then I have broken my natural circulation path and the natural circulation will cease.

What happens is that because I have now lost the ability to remove decay heat, the system will start to re-pressurize. When it does, what happens is that you will condense out some of the steam up in this candy cane and you will reestablish natural circulation. Restore the heat sink and the pressure starts to come down. You generate voids, then. These voids accumulate in the top of the candy cane. You break the natural circulation. You would expect to see some cyclic re-pressurization.

(Slide)

Just to refresh some memories, this is Three Mile Island. This is the lowered loop plant. This is the candy cane I am talking about. When the volume above this lower part of the U-bend here becomes filled with steam, there is no longer a flow path for liquid here.

PROF. CATTON: What is the radius here of the candy cane?

MR. SHERON: About four and a half feet.

PROF. CATTON: The rise to the top of the candy cane.

MR. SHERON: It looks like about 50.

PROF. CATTON: What is the diameter of the pipe?

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MR. SHERON: 36 inches on the hot leg.

PROF. CATTON: The distance between the centerline of the rise and the top of the steam generator -- centerline of the steam generator to the centerline of the pipe.

MR. ZUDANS: Ten feet.

MR. SHERON: I would say the radius was about four and a half, so from here to here is nine.

PROF. CATTON: Thank you.

DR. PLESSET: You assume that the system is capable of repressurizing sufficiently in this discussion so that you get condensation of the steam again and you start over, is that correct?

MR. SHERON: The actual analysis would determine whether you have a sufficient repressurization there to condense the steam.

DR. PLESSET: Do you see that?

MR. SHERON: The calculations by B&W have shown in the lowered loop plants that this phenomena doesn't occur. It is the raised loop plants where they predict this. This cyclic repressurization does occur in the raised loop plants. It was not predicted to occur in the lowered loop plants based on the B&W analyses they submitted.

MR. ZUDANS: The pressure goes up faster than the corresponding saturation temperature in the reactor. The pressure would then go up faster than the temperature.

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MR. SHERON: Yes, in order to condense the steam.

MR. ZUDANS: It is a very sensitive situation there.

PROF. CATTON: What is the difference between the two? Is it because the pressure rises faster with time, one over the other?

MR. SHERON: Yes. I checked. As I understand, there is no clear-cut geometrical difference one can atribute to why one sees repressurization in a raised loop and not in a lowered loop.

I know Bob Jones is here. He performed the analysis. I might ask him to explain.

MR. JONES: Well --

PROF. CATTON: Could you repeat the differences again for me?

MR. SHERON: The other geometry would be this raised loop design, which is the steam generators being just essential to shift it up.

(Slide)

PROF. CATTON: The raised loop goes back into natural circulation faster than the other.

MR. SHERON: The raised loop exhibits repressurization. In other words, the interrupting of solid liquid natural circulation, okay? And then you see a repressurization, which then condenses the steam at the top of the candy cane and re-establishes liquid flow and you get the liquid natural

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circulation again, which, in turn, reduces the pressure and allows the steam to form and to break the natural circulation flow.

PROF. CATTON: So it burps. It sort of burps along.

DR. PLESSET: The lowered loop plant doesn't do this.

MR. SHERON: That was not calculated to do this intermittant repressurization.

DR. PLESSET: Is this affected by the rate of high pressure injection, for example, or is that quite independent? Is that not supposed to be functioning?

MR. SHERON: Mr. Jones can help us here.

MR. JONES: Bob Jones of B&W.

Both plants exhibit this phenomena. The Davis-Besse exhibits a somewhat cyclic behavior. At present, we are now attributing it to basically a larger column of cold water in the steam generator on the raised loop arrangement, which gives you a greater potential to reestablish natural circulation.

DR. PLESSET: So you have a somewhat more effective heat sink is what you are saying, if I understand.

MR. JONES: Basically, it is not the heat sink per se here. With the lowered loop arrangement, you only have a driving head from about the midpoint in the generator up for natural circulation. You have the whole generator column.

DR. PLESSET: What other assumptions go into the calculation that are important? Can you say? Do you assume

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you have a break?

MR. JONES: Yes.

DR. PLESSET: It doesn't matter where it is?

MR. JONES: If the break is in the top of the hot leg, you --

DR. PLESSET: It would be quite different from, say, a stuck-open valve.

MR. JONES: It would be somewhat different. It is break-size dependent.

DR. PLESSET: In addition, you have break location.

MR. JONES: As long as it is in the cold leg piping, you would see roughly the same phenomena occur with the same break size, whether it's in the pump discharge piping or the suction piping.

If it is in the hot leg, it is possible you might see a system repressurization dependent on the break-size, but it should not go as high because of the ability to vent steam directly out the break.

DR. PLESSET: How sensitive is it to the rate of injection? What assumption is made there?

MR. JONES: The analysis assumed the availability of only one of the high pressure injection systems.

DR. PLESSET: Fully operating?

MR. JONES: Fully operating.

In the case of the analysis, since we put the break

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in the pump discharge piping, we are losing some portion of the HPI fluid through the break directly. The amount of the repressurization would be somewhat dependent on the injection flow because, if you have more injection, you will possibly not even see the repressurization because you would match the leak rate earlier.

DR. PLESSET: I think Harold had a comment.

MR. SULLIVAN: Wouldn't you say the effect is calculating the level and that height is very important on how this affects the circulation?

MR. JONES: I wouldn't want to characterize it as very important. It does, however, control the phenomena.

As far as its impact on the actual calculation, if you had a faster bubble rise, you would interrupt the circulation somewhat earlier and start the repressurization. From roughly the same point the system is already down to 1200 psi and you would repressurize until you drain sufficient volume from the system to establish a condensing surface in the generator.

The actual dynamics of the slip model, as long as it is reasonable, will give you roughly the repressurization you should see.

MR. SULLIVAN: Let me rephrase that. Had B&W checked their bubble rise model against any data to see how well it might calculate the two-stage level?

MR. JONES: Our bubble rise model has been checked within the vessel region. We used the Wilson bubble rise model. We have checked it versus some level swell tests that have been performed by Westinghouse on GE-Hitachi data.

MR. SULLIVAN: Now you use it in the pipe, is that right?

MR. JONES: Correct.

DR. PLESSET: I think you had a question.

MR. ZUDANS: I would like to understand this completely. In this configuration, there is a greater tendency of cyclic behavior than in the other configuration, and if so, does this cyclic behavior exhibit stable appearance or unstable appearance? Does it grow in amplitudes or reduce in amplitudes here? How do you get out of it?

MR. SHERON: I have a couple of slides on that.

DR. PLESSET: All right, I think Ivan and then Harold next.

PROF. CATTON: Does solid water occur before you return to natural circulation or do you have to condense all the steam out of the candy cane and steam generator before you can return the natural circulation?

MR. JONES: I don't really understand your question. If you mean within the very short time that these analyses have been performed, for over the first hour you do not return to a solid configuration?

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PROF. CATTON: That's the answer I was looking for. I am wondering how you initiate the natural circulation process when you have a lot of void in your system, particularly if the top of the candy cane is voided. If you don't condense that bubble out, how do you start it?

MR. JONES: Basically, this is a terminology problem. I was warned not to call it natural circulation and I messed up there.

PROF. CATTON: I'm not bothered by you calling it natural circulation.

MR. JONES: What happens is when you get the bubble in the U-bend in the hot legs, you interrupt the heat removal from the generator. We can use that term. As you drain the system because of the break, you will slowly decrease the level in both the generator and hot leg. At some point in time in the transient, you will uncover the auxiliary feedwater injection nozzles or you will bring steam in contact -- steam will be in the tubes of the generator at an elevation where the auxiliary feedwater is injecting and then you would start to condense steam. This is what we are calling the natural circulation as an end-phase in the reflux boiler mode.

PROF. CATTON: You don't mean going back into natural circulation as we normally mean. You mean initiate condensation. Your cyclic behavior is going from condensation to no condensation.

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MR. JONES: The cyclic behavior that is exhibited for Davis-Besse is of two forms. The first repressurization that occurs is stopped due to a two-phase mixture being built up in the hot leg due to steam being created in the core and then into the hot leg and raising the mixture. That overflows into the generator, establishing the generator again as a heat sink and brings the system pressure down.

Later into the transient, we are no longer able to support the columnar mixture in the hot leg up above the U-bend and we create the bubble again, start repressurization, and we come out of that repressurization in the condensation mode. We go into a condensation heat transfer at the end of that repressurization.

PROF. CATTON: I followed about one-tenth of that.

MR. ROSZTCOZY: Maybe a little background is needed. The so-called cyclic repressurizations do not represent a large number of repressurizations occurring. In one case, the lowered loop case, it goes through a single repressurization and then depressurizes again.

In the raised loop case, I believe it goes through on two, and that's all.

(Slide)

PROF. CATTON: How important is the steam generator to all of this?

MR. ROSZTCOZY: That is the normal mode of decay heat

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removal during a small break accident so it plays an important role. Calculations have been performed as to what would be the case if it was not available for any reason, and in that case there are other ways to remove the heat.

PROF. CATTON: So the steam generator doesn't matter, then.

MR. ROSZTCOZY: No, I didn't say that. I said the steam generator is the normal mode, and that's what you would like to have.

If you don't have that, then you can remove the heat by other modes, which is maybe not the favorite mode, and there may be a time limit before something has to be done.

PROF. CATTON: We want to stick with the most favored mode, using the steam generator. How sensitive are the results to the ability of the steam generator to remove the heat? In other words, if I take and decrease the present efficiency that would result, from looking at the B&W analysis, in about 50%, is that a lot or a little?

MR. ROSZTCOZY: A steam generator is more than adequate to remove all the heat, so it is no problem in terms of removing the heat if auxiliary feedwater is available.

PROF. CATTON: So you don't have to be very careful here --

MR. ROSZTCOZY: It matters to the extent there are certain physical phenomena going on here. Unless you are careful, you can completely mask that. For example, the interruption of the natural circulation mentioned here does not show up if you use the steam generator carefully. You have to be careful to the extent that you are modeling the actual physical phenomena. Beyond that, exactly how much heat you remove will alter somewhat the course of the transient.

It seems to have relatively little effect on the final conclusion, which is measured in terms of water level available in the vessel having covered the core.

PROF. CATTON: At present, as far as I can tell, there are two models of the steam generator used by B&W. Both of them are, in my view, extremely simplistic. I don't see how they could represent much physical phenomena. Do you think they are adequate?

MR. ROSZTCOZY: Each of these have been described up to now as being arrived at in physically thinking about the system, seeing what could happen. The calculations were performed. The calculations for one of those models you are referring to confirmed each of these and followed reasonably closely their expected behavior.

These are also the same physical phenomena that have been described in Dr. Michelson's report two years ago. So, independently, which one are we following? Our own thinking, Dr. Michelson's work, or the calculations?

The conclusions seem to be the same. Based on that,

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our judgment is that the present calculations are pretty good, representing the basic phenomena.

I mentioned in this review we didn't stick to the exact requirements of Appendix K. Before we would consider this matter an approved matter, we required more sensitive studies on the representation and noding of the steam generator and, after that, gave our approval for this model. We expect more work on it.

PROF. CATTON: I gather the physical processes of the steam generator are not important. You said the B&W model gave adequate results. That's a two-node, single-heat transfer coefficient, single-temperature kind of model.

If that gives good predictions of what behavior should be, the rest is probably not important.

MR. ROSZTCOZY: Let me start again.

PROF. CATTON: That's okay, I heard you.

MR. ROSZTCOZY: Certain physical phenomena, the model has to be sufficiently detailed for those. One of the B&W models you are referring to did not predict an interruption of the natural circulation. That was not sufficient.

PROF. CATTON: Which one was that?

MR. ROSZTCOZY: The one which did not have an extra node on the top of the candy cane in the upper plenum area. When the extra node was inserted, the physical phenomena was predicted from there on, and we believed we had a reasonable

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answer. Questions still exist in our mind how much difference would be introduced in the calculations if the model is further detailed.

Our present judgment is that it will make some difference but we are not seeing any significant difference, neither in the physical phenomena nor the final result, which is the water level in the vessel. You need a certain amount of detail once you arrive at an acceptable level and further refinement from there would make relatively small changes.

PROF. CATTON: That would be fine but it has to do with the piping system tube of the steam generator and not the details of the steam generator, itself.

MR. ROSZTCOZY: The interruption is due to the bubble formation at the top. This has to be correct at the location where it could form. It has to permit it.

As mentioned earlier, the heat transfer area of the steam generator is a lot more than what was needed for this purpose. There are some differences in how you model the heat transfer.

PROF. THEOFANOUS: The way I understand your response, Zoltan, is that you more or less decided beforehand -- before you did the calculations -- what you really wanted to get out of this, what you expected to happen, and used that as a criterian to justify whether the calculation was correct or not. That strikes me as puzzling.

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In view of the fact you have all kinds of capability to run calculations -- detailed models -- why can't you use some of those to do a reasonable job instead of pre-judging things on a model judgment and then running out a very crude calculation and saying: "That's what I expect, that's what I get, and everything is fine."

MR. ROSZTCOZY: The first step of evaluating in one's mind what you expect -- what kind of response you expect -- from a system is, I believe, a very important step. It is just as important as doing the actual analysis.

As it turned out in this case, that was done for a different reason. The reason was, simply, time. It wasn't done by us; it was done basically by B&W.

In order for them to be able to arrive at guidelines on the time schedule they set out for themselves, they put together a task force -- a relatively large-sized task force -- including people of various disciplines; including some people from the analysis area, including people with system design experience, people with operating experience and so on.

This group was working in the preparation of the guidelines. They did not have the time to wait for the completion of the analysis method in order to start their work.

PROF. THEOFANOUS: I think you are giving a very prolonged answer -- which I am not very much interested in -- with all the details. In the interest of time, I recognize this but

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I'm sure you can do them, or people working for NRC can do these calculations. In view of the urgency of the problem, why don't you do something about it?

MR. ROSZTCOZY: You will hear later in the presentation what we have done. We have used for our calculations the most advanced version of the code that was available. That will be presented later today. That's Norm's presentation.

In terms of what can be done by other codes, like the TRAC code, I believe they are trying to do a calculation for the Three Mile Island case. We have requested a calculation for similar type things, not related to this. It is related to one of the other problems we ran into last summer. They requested a calculation to be done by the TRAC code in October or November of last year. It is still not complete.

Some of these complex codes, in terms of producing results when needed, are not necessarily at the point where you could get those results from one week to another.

MR. ZUDANS: Along the same line, I understand that you expect certain things to happen, and it is nice to be able to confirm it by whatever analysis model you use, but what physical actual experiments or actual behavior in power plants do you have information on that indicates the actual behavior in response to what you expect it to do?

MR. ROSZTCOZY: Each of these models are being built up from -- let's call it submodels. Normally, there is

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experimental evidence available to check on the individual submodels. Mr. Jones was referring to some of those in connection with bubble rise and so on. In addition to trying to check each of the submodels, there is emphasis on integral tests once you tie together all the submodels and try to check this against available experimental evidence.

The one that was used here was Three Mile Island. I believe we will see some of those curves here today. The other integral experimental program where data is available is the SEMISCALE experiments. There was one SEMISCALE experiment run a few years ago, which was selected as a standard program for small breaks.

Comparisons were made between that test and the calculations. We learned a number of things, which were encouraging. There were some negative aspects in those comparisons. Because of that, additional tests were requested for small breaks.

New small break tests were run last winter. At this time, it was a required calculation. We required each of those who have approved evaluation models to perform a calculation for the small break test design. Because of some other complications, like the LOFT test scheduled, and then TMI-2, the schedule of this calculation has been somewhat delayed. The schedule was to be finished by early July and each of the PWR vendors are performing these calculations -- blind calculations --

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since then.

I believe some of them indicated some delay, so it might not be available early July, but I think definitely during the summer we will have these calculations and we will compare them against the data.

MR. ZUDANS: I understand. That's very nice. My question was mainly directed to this: Remember, you mentioned there had been five small breaks, essentially, that have occurred -- five small breaks in actual power plants.

MR. ROSZTCOZY: Four.

MR. ZUDANS: Okay.

Of these four, how many of them have been recorded adequately enough to be useful to evaluate these calculations?

MR. ROSZTCOZY: As far as I know, only one is what would be useful for this type of thing. That's Three Mile Island 2. That is the one that has been used for this purpose. Some of the others happened at low power but there had been another case like Three Mile Island, and that was electrical failure, but that was during startup tests when the reactor wasn't at power yet. The second case was nine percent power. It was a very low power case.

Therefore, the consequences and the information available from that is not challenging here. The only one that is a challenging type set of events would be the Three Mile Island 2 event.

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MR. ZUDANS: Even in Three Mile Island, I guess you would not have detailed enough information to make any judgment with respect to whether --

MR. ROSZTCOZY: Three Mile Island 2 wasn't an experiment and you don't have all the information you would like to have. This creates certain difficulties.

Nevertheless, there are a number of things you can learn from Three Mile Island. Looking at the beginning, you can check whether you are reasonably indicating the depressurization. In another aspect, the pumps were running relatively long -- one and a half hours or so -- and then the pumps were turned off. One item would be looking forward to seeing whether these codes can correctly predict for times shortly after the time the pumps were turned off.

We tend to use as part of our review the calculations to be done in the near future to evaluate the benefit of running the pump or not running the pump.

PROF. CATTON: One more question. I heard from several people statements about the need for these and how the process is basically a quasi-study process. You can do a series of calculations and get reasonably good results. If that's the case, why the devotion to the big codes, which may have their own problems as far as the small break is concerned? Would you care to comment on that?

MR. ROSZTCOZY: The main reason why we are going to

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the big codes is to have a tool available for us that represents all phenomena that would play a role. By using this code, we could evaluate problems that they are faced with. Every time they are faced with some unusual situation, either from calculations or experimental evidence, we could use this code to really understand that.

We have such a code. If such a code has been verified against data in the future, that code could be used as our standard. When we go to simplified codes like the one we are using here -- or hand calculations, if you wish -- those simplified calculations can be checked against the more elaborate codes and verified by the more elaborate codes. That's the main reason we need elaborate codes.

We also need them for a second reason. That is simply to supplement experimental programs. I am sure you are familiar with our experimental programs. By not being able to run full scale tests in this area on the complete system, the experimental program combines together various sets of tests. This necessitates the use of the computer code. That's a second use of it.

These are probably the two main reasons for the complex code.

PROF. CATTON: My concern is the use of codes rather than thinking.

DR. PLESSET: I think you asked more directly: Could

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one do this with very simple analyses, get the answers to the small break failure with very simple analyses rather than with large codes? That was the question.

The answer was yes or no?

MR. ROSZTCOZY: We can do calculations with simple analysis. We have done it. When we compare it against experimental data, we are getting relatively large uncertainties.

With the standard problem I mentioned -- I believe it was Standard Problem 6 -- a report issued approximately a year ago shows even the depressurization rate is not correctly predicted by most of the calculations. As soon as cold water is introduced into the system, a learge amount of ECCS water coming into the system, the code behavior doesn't match up with the data. There is need for improvements. Activities have to be modeled in these simpler codes.

DR. PLESSET: You are saying the codes don't predict the behavior correctly. What about simplified analyses? Would they do as well?

MR. ROSZTCOZY: That has the same problem.

DR. PLESSET: Are they better or worse?

MR. ROSZTCOZY: Well, the subject now touches a little on this. Dr. Michelson, by doing the simplified analyses, it was sufficient to pinpoint the various physical phenomena you expect to play a role, but it was not sufficient to predict the transient behavior of a given system for this case.

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The analysis was steady state of each point. It just didn't have the capability to follow exactly through on a transient.

B&W, when they addressed this problem, did that second step, the only difference being they did it with a computer code as opposed to the simplified calculations. They were able to carry it one step further.

It could be carried one other step further by using the complex code. One day, we hope to do that. Right now, we don't have the capability to do it in a short time.

PROF. CATTON: At the outset, they found there was no problem. This demonstrated there could be a problem. I'm afraid with huge, big codes you get caught up in these and you lose sight of the forest for the trees.

MR. ROSZTCOZY: The complex code has not yet been used for this purpose so there is no result from the complex code. We don't know what it would predict. That hasn't been done.

PROF. CATTON: Relative to what Dr. Michelson --

PROF. THEOFANOUS: This is a very important subject. I would like to make my views known.

DR. PLESSET: I think so, too. That's why I'm letting you all ramble on.

(Laughter)

PROF. THEOFANOUS: I think there is no substitute for physical insight. On the other hand, it is oversimplification to think we can do very well just by simple hand calculations. It is useful to do these things, but my feeling is that as the break size decreases, the need for a detailed, very well-based system calculations increases and becomes much more difficult. It is much more difficult to calculate a small break than a large break.

Of course, where things settle down, there, of course, everything is very quiet, but even in that case I'm not sure you can do a difficult job by simple means. I am in favor of well - founded system calculations.

DR. PLESSET: I don't think anybody would be against a well-founded calculation but I would like to italicize that "well-founded." This is a concern. One doesn't care very much if the calculations take a week if they are going to give you good results. If they take a week and give you questionable results, you have wasted a week's time.

PROF. THEOFANOUS: The point is what can do the job. I feel, short of a very detailed calculation, you just can't do the job at all, except to just scrub it out by hand calculations as you would with -- you have to deal with severe phenomena, severe mixing effects. If you do a small scale experiment and try to calculate that, unless you do a very good job in portraying those effects, you will come very much off. You cannot get credibility by just saying I think that's the way it will go and here is a simple calculation. I think that's inadequate.

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PROF. CATTON: On the other hand, the small break becomes, of course, much more dependent on operator action. If you don't appropriate operator action into the scheme of things, your small break analysis -- independent of the kind of code you use -- is open to question. Incorporating the two will be a very difficult task unless the program is simple.

I feel that properly incorporating operator action with a reasonably simple code will give you more believable answers that are probably closer to what occurs than if you have an extremely complex code that runs by itself.

PROF. THEOFANOUS: I don't agree with that. As I said here in the TMI-2 meeting ten days ago, it is crucial that you make these codes -- you can't just run through it. You incorporate the action and sit down and think about the results and try to do small hand calculations. However, you can't integrate all those things in your head. You will miss the point completely. If you can't put the phenomena there, you can't tell the operator what to expect.

DR. PLESSET: Any other comment in this area?

MR. ZUDANS: Just one comment. You can put up an interaction in any code; no problem at all.

DR. PLESSET: The question is whether it still has meaning.

MR. ZUDANS: I don't think there is a reason to believe that both kinds of codes are mutually exclusive. They

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are both needed.

MR. SHUMWAY: Dr. Michelson had predicted, by hand calculations or his own intuition, the pressurizer being full of water. Well, the core was uncovered and the SEMISCALE data showed that this, indeed, could happen. I was wondering, have these codes predicted this phenomena?

DR. PLESSET: I think, if you have that type loop, you don't need to make any calculations at all. You could say you have a situation like what occurred at TMI, put that on the board and look at it, and see if you can get this kind of lack of connection between water level and the core, and water level in the pressurizer. You don't need SEMISCALE for that, either. It didn't show that.

MR. SHUMWAY: Do the codes show it?

DR. PLESSET: That's a good question. I think it should.

MR. ROSZTCOZY: These were the ones I used for small break LOCA analysis. They have just one surge line representation and counter-current flow is normally not permitted in the surge line. As soon as you put the break into the pressurizer, like opening up the relief valve, then the flow will be in the direction of the break and the pressurizer is not going to drain in the calculation.

MR. MICHELSON: What happens if the break is in the cold leg?

MR. ROSZTCOZY: Then the pressurizer is going to drain in your calculations.

MR. MICHELSON: Do you really believe that?

MR. ROSZTCOZY: Then you have to go to the actual design to see just exactly what is the pressure distribution in the system. If you have a U-shaped type of surge line, the pressure condensation will determine how much drainage you have. It will be calculated both in the pressurizer mode and also interconnected into the system.

The second complication that comes in is how detailed the representation of the surge line is and whether this U-type of arrangement has been modeled in the calculations. My recollection is, in the past, it was not modeled. There wasn't another one to show the U-tube type.

MR. MICHELSON: The question was: Did your codes, in the past, show this effect -- in particular, for a cold leg break -- and I guess your answer is that they did not, is that correct?

MR. ROSZTCOZY: For a cold leg break, the pressurizer is expected to drain.

MR. MICHELSON: The code calculation showed that it drained.

MR. ROSZTCOZY: Yes.

MR. MICHELSON: I heard several minutes of explanation which said that, depending on how you do all this, it

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might or might not drain. I am totally confused by your answer at this point.

MR. ROSZTCOZY: Let's take the case when you have the break in the hot leg, say; in that case, these codes do not drain the pressurizer. There are some calculations on the record, which have been performed for that case, which show that the pressurizer didn't drain.

When you take the case of having the break in the cold leg, then the pressurizer does drain, both in the code and also in the real situation.

The only question in this case can be whether the drainage of the pressurizer occurred in the right time sequence. Since we don't have actual data available, we clearly can't compare it to anything. The only possibilities may be in SEMISCALE.

MR. MICHELSON: Your answer is what the code told you. Have you thought through the process and determined that, yes, indeed, the pressurizer should drain if the break is in the cold leg?

MR. ROSZTCOZY: Yes.

MR. MICHELSON: You are satisfied that that is the situation, then. I am a little concerned that that's the correct answer if you properly account for heat losses in the pressurizer, this sort of thing, but it appears entirely possible to continue to support a column of water there with

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the steam pressure on the U-tube, so the real physical phenomena is present there to support the water column, and only under idealized circumstances could you probably dump it.

MR. ROSZTCOZY: As I mentioned earlier, in this calculation, number one, the U-tube doesn't exist in most of the designs; only in some designs. My recollection is that, for those cases where the U-tube did exist in the design, the small break model wasn't sufficiently detailed to have the U-tube there.

If the U-tube is not modeled, obviously, you don't expect to see that.

However, I think the code has the capability to handle it provided it is properly modeled.

MR. MICHELSON: I think we are getting close to the an wer now. I have been confused. I think you cleared it up. What you are saying is that you never modeled the loop seal into the calculation. Therefore, that would be what you would then expect. But the answer, then, is that your codes didn't predict it because you had not correctly modeled the piping configuration into the code, is that right?

MR. ROSZTCOZY: For the small break in the cold leg, yes.

Now let me go to Bob, who wanted earlier to say something.

DR. PLESSET: Theo wanted to make a comment. It will

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be short.

PROF. THEOFANOUS: This is a good example of the need for detail. I want to bring out two possible complications.

One is the model of the flow into the pressurizer and the relative velocity between the steam and the water. Your flow is going this way and, presumably, at some point you will be pushing the flow in there. I would like, later on, to see how you will be dealing with that.

Also, another item which maybe you can tell me something about: I heard from somebody that apparently there is an idea that there were three-dimensional effects in the core at TMI-2, that this is an indication that was obtained from different instruments. If it is true, it points to rather severe complications that can result from a low flow small break.

I hear people saying they think three-dimensional effects were developed along the axis of the core very homogeneously, like fingers going into the core with the flow being diverted because of the pressure requirements. These are some of the real complications I envision. I am sure there are many more that can result from this kind of situation where very simple means cannot give you the answer. You have to model them well.

DR. PLESSET: Did you want to make a short comment?

MR. JONES: I will make it short.

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DR. PLESSET: We are progressing backwards in time schedule-wise.

MR. JONES: I would like to just get in two comments on the pressurizer drain during the cold leg break. I believe, for most breaks, it will not exhibit the repressurization due to the interruption of circulation. You will drain the pressurizer completely.

Now in these breaks which have a repressurization, initially the pressurizer does drain, but during the repressurization, we do see a filling up of the pressurizer and the pressurizer level, in fact, is almost an indicator of the system pressure transient. It is the shape that it takes. I think that is physically the real situation.

MR. MICHELSON: The only point I would make on that is that this is the likely model by which the pressurizer gets refilled. Now the subsequent and final draining of that pressurizer, as the level slowly drops down to the top of the core, has to follow some other kind of story. The pressurizer has now cooled off. It has no heat input to it.

DR. PLESSET: All right, let's take a ten minute break and collect our thought.

(Recess)

DR. PLESSET: All right, would you continue?

MR. SHERON: Sure.

(Slide)

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I was going to say one thing. The staff does do hand calculations. I just want to say that. I spent many hours checking B&W's analyses on their small break and how much mass you can get out of the system. Most of it is done to check on a very quantitative basis the results that we get from the large codes, and many times you don't see those calculations.

DR. PLESSET: Don't say too much. You might get into trouble again.

(Laughter)

MR. SHERON: I just wanted to make that point.

B&W performed some analyses reported in the big blue book for .01 square foot and .005 square foot breaks for both 177 fuel assembly lowered loop and 177 fuel assembly raised loop plants. They used a CRAFT code running calculations to 3000 seconds.

For the lowered loop plants, no cyclic repressurization was observed. Once natural circulation was initially lost, the hot leg U-bend did not refill and they went over to a reflux mode of heat removal.

For the raised loop plants, the cyclic repressurization was calculated to occur -- and I think, as has been previously said, it occurred three times in their calculation -- and finally, at the end, they transitioned over to the reflux boiling. The core uncovery was not calculated to occur.

MR. MICHELSON: What do you think would be the effect

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of, instead of spraying the tube bundle from the top, you flood the tube bundle from the bottom? Will you discuss that later?

MR. SHERON: I can point it out quickly.

(Slide)

With the lowered loop plant, where the auxiliary feedwater is sprayed in, if you will note a level here in the core that -- in other words, it's down around here. I think the normal operating level for these steam generators is down in this area. With the pumps off -- let's see if I get this right now -- the auxiliary feedwater comes on at this level and goes down to one-half of its normal operating level.

What would happen is that you would still have your sprays coming in and you would have a condensing surface available before the core would ever uncover. Remember, there is pressure equalization here and here because of the vent valves.

MR. MICHELSON: I was thinking mostly in terms of the cyclic repressurization effect, the idea being that you have to wait a while to get down to condense at the lower part of the steam generator. You have to drain quite a bit of fluid from the system before that would be possible. Does this show up on the calculations as more cycles or what?

MR. SHERON: I don't believe it does. I don't think it exhibited any massive repressurization.

MR. JONES: The cyclic repressurization, if feeding from the bottom of the genrator -- the auxiliary feed to the bottom of the generator -- would probably not show up because of the time required to refill and get a large cold driver head to try to repush that across the hot leg.

MR. MICHELSON: It repressurizes and holds there?

MR. JONES: It would repressurize, probably a little higher, and when you got the condensation surface established again, you would come back down to pressure.

MR. SHERON: This is the calculation of the core pressure versus time for the raised loop small break. You will note that you get repressurizations here, here, here and a small one here.

(Slide)

This is the intact loop hot leg mixture level versus time. If you will note, you will see a line here which shows the natural circulation point. This is the lower point on the U-bend.

(Slide)

If you overlay these -- let me line these up properly here -- you can see that you get the repressurization phenomenon. The pressure starts increasing every time the hot leg mexture level drops below the natural circulation point or below the U-bend.

At this point here, you would see repressurization where it drops and right here, where the pressure -- here it is above. So you get depressurization.

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Now here is where the level drops below this U-bend. You start to repressurize. You get a level recovery which drops it again. You get another point where it drops. You get re-pressurization. Finally, you get into a reflux boiling mode and the pressure remains essentially constant.

MR. MICHELSON: Do you have curves indicating what the bubble size or growth might be in the top of the reactor vessel during this corresponding period of time?

MR. SHERON: I don't have any curves.

MR. MICHELSON: Do your calculations show the growth of the bubble during this period of time? When you stop the natural circulation, it will rise rapidly and the bubble at the top of the vessel will expand rapidly.

MR. SHERON: The calculations were performed by B&W and their report did not contain actual curves of the bubble and its behavior versus time in the upper head. I don't have those curves with me.

MR. MICHELSON: I guess B&W might want to elucidate a bit. I assume there is a bubble oscillating in the top of the head corresponding to these oscillations.

MR. SHERON: Oh, we have a curve; okay.

(Slide)

This is inner vessel mixture height versus time. Let me see if I can overlay that pressure trace. Is this the same break? All right.

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(Slide)

This darker one here was the system pressure. Here was the vessel heigth.

MR. MICHELSON: Could we get a copy of that?

MR. SHERON: Yes. Mr. Audette has copies of all of his.

PROF. CATTON: What is that level relative to?

MR. SHERON: The relative elevation here?

PROF. CATTON: It shows 7.4 feet natural circulation point. Not this graph.

MR. SHERON: I'm sorry, you mean on the vessel?

(Slide)

PROF. CATTON: Where is this level?

MR. SHERON: This is in the top of the candy cane.

PROF. CATTON: When it reaches that top point, that means the candy cane is full?

MR. SHERON: No.

PROF. CATTON: Where is the top of the candy cane?

MR. JONES: When it reaches the flat portion, it is not saying the candy cane is filled with liquid, but by a two-phase mixture. It is really a mixture level in feet.

MR. SHERON: You are talking about this point as the natural circulation point.

PROF. CATTON: The elevation of that flat spot is at the bottom of the uppermost point.

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MR. JONES: It will be actually at the top. The natural circulation point is the bottom of the bend.

PROFESSOR CATTON: So your bubble rise model would shift this curve around quite a bit.

MR. JONES: Yes.

PROFESSOR CATTON: If you changed your noding to have two nodes up there, it might change it a bit. If the horizontal node was much broader to allow more of the vapor to come out of solution, that would shift that. Would that be important if it shifted?

MR. SHERON: I don't believe so. We will get into that.

This is the next item. This is the time delay.

(Slide)

In other words, wha can happen if I don't have decay heat removal while the steam generator is draining. This is the second item, by the way, on the second viewgraph. Once natural circulation is lost, the steam generator level is going to drop below the secondary level in order to commence with reflux boiling.

In other words, the break is eventually going to drain that level down until you expose a condensing surface and then you can start the reflux boiling process. During this time while you are still draining and you haven't established this condensing surface, the question is: Would repressurization

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which will occur -- or possibly occur -- during this period increase the break flow and lead to faster core uncovery?

If the pressure is coming up, then the break flow is coming up and you would think mass might be leaving the system faster, in which case you could drop the level. Repressurization in a generic sense -- in other words, if I stop the heat removal process and start to repressurize the system, I repressurize up to a new balance point which balances the steam being generated in the core and the steam being relieved by the break, or, rather, I should say the mass being relieved by the break -- I'm sorry, the volume being relieved by the break.

For decreasing break size, the mass flow out the break decreases and, therefore, the maximum repressurization -- in other words, that new pressure I would be going up to -- would increase. However, the steam volume in the core that is generated in the core will decrease with increasing pressure.

So this, in turn, says that, number one, as I go to a smaller break and as I repressurize, the mass coming out of the system is going to decrease. I have a curve; I will explain that in a second.

One other point, too, is for the raised loop plants I must establish a condensing surface before I can ever have the liquid level drop below the core. In other words, I will have a condensing surface in the steam generator that is exposed, in which case the elevation of the liquid in the steam generator

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and the elevation of the liquid in the vessel will both be above the core and I will have a condensing surface established here. I have vent valves in the system and this is because I get the pressure equalization and the level stays the same.

For the lowered loop plants, as I explained previously, their auxiliary feedwater enters from the top of the steam generator and the auxiliary feedwater started when the secondary side level drops below one-half normal operating level with the pumps not running. If they are running, if it drops below three feet.

It is a bit tighter if you look at the relative elevations with the lowered loop plants from the standpoint that vessel level comes closer to the top of the core before you get a sufficient condensing surface for the lowered loop plant.

In a-- case, you do establish a condensing surface so you can start the reflux boiling process prior to ever starting to uncover the core.

MR. EBERSOLE: I don't understand that third statement. Suppose there is no water in the secondary at all. You will never get a condensing surface. Can you handle it then?

MR. SHERON: Postulating no auxiliary feedwater?

MR. EBERSOLE: Yes.

MR. SHERON: That's right.

MR. EBERSOLE: You will never get a condensing surface then.

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MR. SHERON: This is premised on the assumption that I have auxiliary feedwater. I am not addressing a case of not having that.

MR. EBERSOLE: Will you address the other case?

MR. SHERON: I am not.

MR. ROSZTCOZY: I believe Mr. Audette is going to address that case.

MR. EBERSOLE: Thank you.

PROF. CATTON: Before you take that off, can you track those levels well enough in the steam generator? I have two questions. I wonder how well you can track the levels to know when you have the condensing surface, and second, how is it implimented? I looked at the B&W models of the steam generator and there is a factor code M sub T and it indicates this is a time-dependent modifier and multiplies some kind of constant. How is that implimented?

That number will take on a range of values going from zero to big numbers to negative numbers. Is there something in the system that calculates that?

MR. SHERON: I am not familiar with the details of the CRAFT model, especially in the steam generator. I don't know whether Mr. Audette plans to address it. B&W is here; they might be able to address it. I, for one, am not that familiar with it.

PROF. CATTON: Do you know what I am referring to?

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MR. SHERON: I think I understand that.

PROF. CATTON: It is called the time-dependent modifier and covers all the physics of the whole process. I am wondering what it looks like.

MR. JONES: It is just set to one and held there.

PROF. CATTON: That means it can't handle Item 3, then, the condensing surface, because if it is just set to one and held there, then, basically, all you are operating on is a Delta K, period.

MR. JONES: That's correct. We model it by separating the steam for this analysis. We separated the steam out so that you have to drop the levels into the generator before you can condense steam. When the steam enters the generator, the heat removal will then condense the steam and give you essentially the same effect as having a condensing surface.

MR. EBERSOLE: Under full power conditions with this superheat boiler, you don't have a discrete level on the secondary side; you have a variable up the tubes and you have to operate in some simple mode like this since you can't see a physical level, is that correct?

MR. JONES: Initially, at full power, that's correct.

MR. EBERSOLE: When you drop to very low power and shut down, do you step-wise change to an entirely different mode? When you are not doing superheat.

MR. JONES: Essentially, that's correct.

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MR. EBERSOLE: Does this suggest something to you, Ivan? When they are running flat out, they don't have this discrete level.

PROF. CATTON: True, but as I understand your model -- and I may be interpreting your CRAFT report incorrectly; I already think I was looking at this a little incorrectly -- you are using Steam Generator Model 2 for this case.

MR. JONES: That's correct.

PROF. CATTON: It, in essence, has control only for the level and the Delta T, and it has two nodes, a level on each node. I am frankly confused. You have two nodes stacked on top of one another. I am really confused.

MR. MICHELSON: Let's not leave this yet. I wanted to mention to Jesse: Jesse, this steam generator arrangement for the 177 plant uses spray spargers at the top of the tube bundles and that's where the heat transfer basically is taking place; not at the bottom with whatever water might be left.

In the case of TMI, they didn't have any significant amount of water laying in the bottom of the generator for half an hour.

In the case of Bellefonte, for instance, it is a flooder. There, the water level is indicative of the heat transfer situation.

MR. EBERSOLE: Even in that model, at full power I don't think they had a water level --

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MR. MICHELSON: Not at full power. There was no way to measure it.

I had two questions but I don't want to interrupt the train of thought.

MR. JONES: I guess I'm not sure what the question was.

PROF. CATTON: It says the raised loop plant's condensing surface must be established before core uncovery. I look at your steam generator model and it eludes me how you establish anything because of its simplicity. I don't see how you are going to get that kind of information out of it.

MR. JONES: I don't think the comment necessarily applies to what is being predicted by the model.

PROF. CATTON: I was afraid of that.

MR. JONES: Let me back up on that in a minute and try to answer that concern.

I believe Brian is talking of the generic raised loop plant situation where you have a condensing surface before core uncovery.

For the operating units like Davis-Besse 1, it has the sparger up in the high auxiliary feedwater injection. You are not talking about a level per se for condensation.

PROF. CATTON: I hear about two kinds of steam generators. Basically, one will cool early at the bottom and the other at the top when the auxiliary feed is on. Looking at

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the equations in your model, I can't see how that gets in there.

MR. JONES: You take care of it via the node.

PROF. CATTON: Your steam generator model has one node on the secondary side and two nodes on the primary side. Looking at the equations, I don't see it. I don't know if this should be pursued or not.

DR. PLESSET: I don't think we should just leave it hanging either.

PROF. CATTON: Maybe they need time to pull it together. I won't let it drop.

DR. PLESSET: Well, why don't you go on?

MR. MICHELSON: I have one question. Maybe Brian can answer it. For Davis-Besse, it has a considerably lower HPI injection than for the other B&W plants of the 177 variety. What effect does the lower HPI injection have on any of these results?

DR. PLESSET: Did the B&W people want to make any comment? Otherwise, we will --

MR. JONES: We are still working on it.

DR. PLESSET: Good. I don't think we will want to drop it.

MR. MICHELSON: I would like to hear their opinion relative to the HPI head also, since Davis-Besse is the one exception. Their pumps are about 1600 or so pounds as opposed to 2400 or so.

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MR. SHERON: The first thing that comes to mind is for any small break that could be perhaps isolated, the pumps will not repressurize the system up to any PORV setpoints.

The second would be that for the plants with small breaks which repressurize, the HPSI flow into the system will be reduced from other analyses with the higher head pumps. This would probably lead to somewhat of a lower inventory in the system, I would envision.

MR. MICHELSON: Haven't the calculations been done for Davis-Besse -- will they be done -- with the lower head pumps? Have they been done? Yes?

MR. ROSZTCOZY: The lower head pumps, one of the main questions is: How do you cool the system if auxiliary feedwater is not available? That will be discussed in the other presentation.

MR. MICHELSON: What does it do with auxiliary feedwater available? My question was simple. Does it have any real effect on any of these answers; the lower head pump?

MR. ROSZTCOZY: In terms of the thing Brian is discussing, the lower head pump will affect the transient but will not affect the conclusion.

MR. MICHELSON: Well, it does affect the transient. Will we discuss it with auxiliary feedwater available? Are there any curves available?

MR. ROSZTCOZY: I believe we have one calculation

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with auxiliary feedwater available. That will be discussed in the next presentation.

MR. MICHELSON: All right.

MR. JONES: Let me get back to the steam generator question, if you wish.

By noding up the steam generator, you can account for the effect of the differences in the two heat transfer modes. In these calculations done for the raised and lowered loop plants, we broke up the steam generator model such that you have not had any steam come into contact with the -- you will not have the potential for heat removal from the steam until you drop the level below the auxiliary feedwater injection nozzles; therefore, simulating the condensation effect when steam enters into or below that elevation.

For the flooding situation, the auxiliary feedwater essentially feeds from the bottom. You would model the nodes in a similar fashion, except your bottom node would be set up so that the control level on auxiliary feedwater would set what the bottom half of the steam generator would be at, and then you would ramp down the heat transfer in the upper half of the steam generator very early in the transient.

PROF. CATTON: This sounds a bit different than what is in your written descriptions of your steam generator model, particularly your implimentation of the model. There are things like an MC bar that take care of heat flow direction,

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ratios of liquid levels in both the upper node on the primary side and the lower node on the primary side, all these different things. What I read in the one-paragraph description sounds different from what you tell me. Could you put together something that describes your steam generator model as used for this problem so I could look at it and understand it?

MR. JONES: Yes, that would be possible.

PROF. CATTON: Would that be appropriate?

DR. PLESSET: Definitely. They promised to do it.

PROF. CATTON: That would be better than pursuing it here. Sometimes I don't know whether I don't understand his answers or he doesn't understand my questions.

DR. PLESSET: I think they will do it.

MR. JONES: Let me rephrase it to make sure I have it since you say I may not have understood the question. Now, basically, what you want is an explanation as to how we modeled the steam generator heat removal during the small breaks.

PROF. CATTON: That's correct; particularly in order to get answers about time, you have to be able to address questions like the condensing surface, where it is located and so forth.

MR. JONES: Okay.

PROF. CATTON: I would like to know what your model is that you have in the code for small breaks.

MR. JONES: Okay, I have it.

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DR. PLESSET: I think it is back to you.

MR. SHERON: Briefly, let me explain one statement.

(Slide)

As maximum repressurization would increase as the break size decreases, you can tell this from a simple volume balance. Over here, I have drawn schematically the core steam generation rate as a function of system pressure for a given power level. It would decrease with increasing pressure.

The steam break flow, however, as the steam pressure increases, would increase, which is shown by these curves for different break areas. As you can see, as a break area increases for a given pressure, the steam break flow would have to increase.

As I go to a smaller break, I would be moving from .1 to .3 and, by moving down, you can see, for the smaller break, the equilibrium system pressure would have to increase and also my steam break flow would have to decrease. Therefore, I would not get as much mass out of the system for that type of repressurization.

MR. EBERSOLE: In view of the fact they are told to ignore the pressurized level and let the pressurizer fill, that break will be handling some kind of two-phase mixture. I don't understand about sticking strictly to the topic of steam flow rather than to the topic of energetic flow out the break, which may be quite different, depending on the quality of the

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fluid.

MR. SHERON: I agree this is a very simplistic explanation.

DR. PLESSET: I think the point is that it is wrong; not simplistic. That would be simple. It is just wrong.

MR. SHERON: I don't think it is wrong from the standpoint of --

MR. EBERSOLE: The trouble is that you say steam flow over there. I don't know that that is the case.

MR. SHERON: This could just as well be mass flow.

PROF. CATTON: That won't suffice. It should be btu flow.

MR. SHERON: I agree there is an energy balance but one must look at a volume balance to determine what the system pressure would be.

MR. EBERSOLE: You have to look at the btu balance, too. Just a volume basis confuses things.

MR. ROSZTCOZY: I think this would be meaningful in the case where the steam generator is available. There, you don't really have an energy problem. Whatever excess heat is left, but not removed through the break, can be removed through the steam generator, so that takes care of the energy part.

MR. EBERSOLE: As long as you sustain macroconvection.

MR. ROSZTCOZY: How far it would go, or where the primary system pressure would settle, are these other parameters.

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With those limitations, I think this chart is useful.

MR. ZUDANS: Qualitatively, this is incorrect. That is not happening. That's qualitatively; there is no quantitative information on this slide.

DR. PLESSET: But the implications are what we are concerned about.

MR. ZUDANS: There are other things but this just supports one of the things he described.

MR. MICHELSON: I think the point here that needs to be considered, though, is that what one is concerned with is a loss of mass from the system. That's how a core got uncovered. I look at all these charts in terms of predicting whether or not I will be left with mass enough from the system to cover the core. I don't care about volume. I am concerned about the mass I lose.

MR. SHERON: There is one basic over-riding point -- perhaps that graph should not even have been put up -- and that was the fact I established a condensing surface and reestablished my heat removal. I stopped repressurizing before the level comes down to uncover the core.

MR. MICHELSON: But I don't know that from looking at this graph.

MR. SHERON: That was --

MR. MICHELSON: There was no quantity on here.

MR. SHERON: I realize that. It was on this graph

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right here. I pointed out that the condensing surface must be established.

MR. EBERSOLE: You have another exit.

MR. MICHELSON: I think all we are trying to do is to predict whether or not we will get core uncovery before we get the condensing surface established.

MR. SHERON: Geometrically, I don't see how that can happen.

MR MICHELSON: The calculation you make is centered on the idea of whether or not I will lose too much mass before I get to this, and get in trouble as a result. So, mass is the thing that I am worried about; not necessarily volume.

MR. SHERON: You agree I ha[illegible]ent valve between the upper plenum/upper head area and t[illegible]egs, so I get pressure equalization, so I can't get massive pressure buildup in the upper head here.

MR. MICHELSON: What do you mean you can't get a mass pressure buildup? The upper head is creating a system pressure.

MR. SHERON: I am saying any pressure buildup significantly different than the pressure in the cold leg upper annulus, the vent valves open and the steam will flow into that and condense.

MR. MICHELSON: It is not quite that simple but, yes, the vent valves, indeed, will open and tend to equalize the elevations of the two legs, except for the density difference.

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MR. SHERON: If I have a level in the vessel, say, at this point here, okay -- or let me put it down here -- then the level on the primary side of the steam generator, it can't be up here because I have too much pressure imbalance. If the level is down here, I have auxiliary feedwater. I, by definition, have a condensing surface.

MR. MICHELSON: I don't think anyone doubts that. How fast do you get that? How much mass have you lost? You continue to lose mass before you get the event turned around. Do you get it turned around before significant core uncovery?

MR. SHERON: Just from this physical description, it appears that there is no problem. B&W performed the calculations. Their calculations -- I know there are questions on their steam generator model -- have shown you establish a condensing surface and establish decay heat removal before the core is uncovered. I guess the evidence shows that there isn't any problem we can envision. Do you see anything additional?

MR. MICHELSON: No; I just wanted to make sure I understood what your model was and this idea of volume balance, which has always been confusing to me, anyhow.

MR. EBERSOLE: That's Davis-Besse, isn't it?

MR. SHERON: Yes.

MR. EBERSOLE: 1600 psi?

MR. SHERON: Yes.

MR. EBERSOLE: The system would tend to rise if you

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closed it at 2200. Does this mean you must deliberately hold pressure down to below 1600 for HPSI injection? You can hold stable, can't you, with almost no inventory change because it is reflux?

MR. SHERON: Reflux boiling, right.

MR. ZUDANS: Can you point out where those vent valves are located?

MR. SHERON: Right above the hot legs.

MR. ZUDANS: Inside the vessel?

MR. SHERON: Yes. It is like the upper plenum and the upper annulus; cold leg inlet upper annulus. I think they open about a eighth of a psi. Very small pressure difference will cause them to open.

MR. ROSZTCOZY: From the previous comments, it seems to me you are wondering what is the importance or value of what has been mentioned by Brian. We are in full agreement with you the final product is the level of the vessel when uncovering the core.

If you look at Davis-Besse and the high safety injection very strongly sepends on the pressure of the system, the volume balance will decide what the system pressure is. In that sense, it can influence the mass discharge from the system and also the safety injection influences the final results.

MR. MICHELSON: I agree with you.

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One thing might be a little misleading here, which you don't want to lose sight of. Just because the steam generator can take out all the decay heat doesn't mean the water level in the core isn't still dropping. The hole has been established. It is still there. It is taking a certain mass out. It is varying with pressure, but all the steam generator does is help enhance the rate of depreciation. Mass is still being lost and it takes a calculation to show you can turn this around. It doesn't magically turn around because the steam generator is now a condenser; only when your mass input is greater than the mass removed from the system.

MR. EBERSOLE: When you repressurize above 1600, where will you get your make-up water from?

DR. PLESSET: Repressurizing to above 1600 psi, where does the water come from?

MR. ROSZTCOZY: In the Davis-Besse case, you can use the make up pump for some but you are limited to that, and that is a relatively low capacity. Sooner or later --

DR. PLESSET: Not safety grade, as well.

That's not something we should lean on, it seems to me, too much.

MR. ROSZTCOZY: That's correct. Sooner or later in that case, you have to recover the auxiliary feedwater and special steps are being made in that case to be sure the auxiliary feedwater will be available.

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MR. EBERSOLE: As an alternate to that, could it be pressurized and could you be sure you could do it?

MR. ROSZTCOZY: That can be done but in such a way that, in the meantime, you have sufficient mass in the system.

MR. EBERSOLE: Most of it is not safety grade at the moment, is it; the depressurization pumping deliberately?

MR. ROSZTCOZY: Talking about opening the relief valve; the relief valve, itself, is not a safety grade valve, no, sir.

MR. EBERSOLE: It is a hybrid, really.

MR. ROSZTCOZY: That's correct.

DR. PLESSET: Well --

PROF. CATTON: In the reflux mode, there is a possibility of inert gasses. Do you have any kind of estimate on what the volume is of those pressures?

MR. SHERON: I have slides later on on non-condensables.

DR. PLESSET: Go ahead.

MR. SHERON: Okay.

(Slide)

The third item was the pressurizer is not a very good indicator -- or may not be -- of actual system inventory for certain breaks. This was evidenced by Three Mile Island. I don't want to harp on it.

What is being done is we understand now that for

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pressurizer breaks, we would get flow into the pressurizers. We could see a flooding phenomenon occurring there. We could actually see perhaps some entrainment of the liquid being carried back into the pressurizer with any steam flow, as well as the fact there is some manometer effect due to the loop seal so we understand that the pressurizer liquid inventory would not reflect the system inventory for pressurized breaks.

For cold leg breaks, as pointed out before, we expect to see the pressurizer drain, and I believe experiments in SEMISCALE have shown us previously --

MR. MICHELSON: How do we know it drains? The model was not modeled with the loop seal but you say we know it will drain. On what basis do we know it will drain. I am going back to the question I asked sometime back and I am getting confused again.

It will drain if there was no loop seal, but with one I gathered you had not really done the calculation, is that the case?

MR. SHERON: By draining -- in other words, with a loop seal -- well, let me find a picture.

(Slide)

Just from a static head balance, one can see you would get draining at least down in this level.

MR. MICHELSON: I would disagree. The top of the pressurizer is not vented to anywhere and it has a trapped

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volume of steam in it which is eventually cooling off, plus the fact you might have gone through a cycle of drainage and refill so the temperature is unknown.

It only takes a little higher temperature into the core to provide all the pressure it takes to support that column of water. You have to go through the arithmetic of knowing exactly what the temperature is in your pressurizer.

You also have to worry about the transfer capability out of the pressurizer and so forth in order to predict what the water level will be in the pressurizer, and it can refill until such time, at least, as the surge line is uncovered.

You know, if you wait a while, the thing cools down and it will refill all by itself if there is water in the surge line entrance.

MR. EBERSOLE: Will you flash your first slide up there again?

(Slide)

This just refutes that flat out. TMI was a pressurizer break.

MR. SHERON: Yes, okay; that's what I said.

MR. EBERSOLE: Pressurizer liquid inventory was not maintained.

MR. MICHELSON: How come, after you closed the relief valve at TMI, the water stayed in the pressuirzer even though the loop was empty? The answer is obvious. That's what it's

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supposed to do. There is enough pressure there to more than support the column of water.

After you closed the relief valve at the top of the pressurizer, you had no break there. You still had some amount of steam -- perhaps not. Why didn't the pressurizer proceed to drain then at that time? The surge line was uncovered. It simply drained the water out, given a bit of time, at least.

MR. SHERON: I would say we will have to wait for the analyses.

MR. MICHELSON: It doesn't take much analysis to show what pressure it takes on a U-bend to support a column of water 30-40 feet. It takes roughly 15 pounds. Under these conditions it is a couple of degrees hotter water in the core than in the pressurizer. That's what you had; a lot more than that, probably.

MR. ROSZTCOZY: The TMI case is different in respect to talking about the TMI case when they closed and there was no break left in the system. Since the heat loss was in the core, the high pressure side was on this side and that can keep the water from the pressurizer.

The other case we are discussing is the small break in the core over here and there is a hole somewhere else in the system, so that low pressure point is somewhere else in the system and that can influence the case.

But I second your comments in the sense that I

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believe there is a need to look at some of these small items with a more detailed representation of the surge line.

MR. MICHELSON: If you look at the situation, you will find the top of the vessel is the pressurizer for the whole system. You have a vapor pressure at the top of the vessel controlling the behavior in the system. That vapor pressure is more than sufficient to support the column of water in the pressurizer unless you put heat input into the pressurizer. We are assuming you don't do that.

Therefore, it takes only about two degrees to support that column of water; maybe three or four degrees, depending on the particular combination of circumstances you want to talk about.

MR. ROSZTCOZY: Well, you have to be careful. This could apply in some conditions. For example, if the system is highly voided -- that's what we are talking about; the possibility of uncovering the core -- then there would be steam not only inside the vessel head area but there would be steam also at the top. Now the vent barrier would prevent any pressure difference between the two. The vent barrier would equalize the pressure and, therefore, you would not have the excess pressure needed to support the large water column.

MR. MICHELSON: We must be missing a point somewhere. What you say would be true if I were to vent the top of the pressurizer somehow to the primary system and I assume I am not doing that. If we have a place that vents the top of the pressurizer over to the primary system, the pressures would dump; at least, down to a very low elevation; but we have no such vent and, therefore, the water colum is supported.

So it is a system pressure that does all this. Until such time as we put a vent in of some sort, it will continue to do it.

MR. EBERSOLE: In the present context, for pressurizer breaks, with proper operation of HPSI, the pressurizer level will rise to complete flooding. Thus, it wouldn't be maintained in the usual context and the operator should not be disturbed by that.

In short, there is no thrust here, I hope, at attempting to maintain pressure liquid inventory at the expense of not getting enough water in the core, which was the Three Mile Island case.

MR. SHERON: What you are saying is that the HPI would essentially bring the system water solid.

MR. EBERSOLE: Yes. Therefore, that's not maintaining pressure liquid inventory. That is completely flooding out here.

MR. SHERON: Yes.

MR. EBERSOLE: Your entire pressurizer level would be maintained.

MR. SHERON: The analysis would show that it would be

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maintained due to the higher pressure in the system.

MR. EBERSOLE: Can you discriminate between maintaining and actually flooding out solid? That's what you want to do, isn't it?

MR. SHERON: There would be a steam flow through the water and y[illegible] level would be essentially a two-phase mixture.

MR. EBERSOLE: That implies a degree of controllability of the injection. Why don't you do that?

MR. SHERON: This is one whole area of concern with this next item here.

MR. EBERSOLE: Will you trip the high pressure point injection to do that?

MR. SHERON: A bulletin was issued with specific criteria for when operators are allowed to throttle back on HPI with the 50 degree subcooling. This is a point which we are still looking at now.

Yes, eventually, when your HPI flow exceeds your break flow, you will have a potential to go water-solid.

MR. MICHELSON: There was one bit of information I learned which I wasn't aware of. Maybe everyone should be aware of it since it is not easily obtained from looking at the general configuration.

The surge line entrance to the pressurizer, as I understand it -- for TMI, at least -- takes the form of a tap with holes drilled around the perifory of it; apparently in the neighborhood of two-inch holes. That kind of configuration is fine for the purposes of distributing the surge flow that might come up the surge line into the pressurizer but it also creates a little different kind of drain situation because now the counter-current water and steam flow in the case of say an open relief valve must pass through the same two-inch holes in opposite directions, and I think it could tend to greatly retard the rate of drainage as opposed to a large diameter pipe.

Now I understand also that this isn't necessarily the same for every plant. It is plant-specific as to how they might have arranged that entrance to the pressurizer.

Maybe B&W wants to comment on it.

MR. KANE: We don't have anybody here that can answer that question.

MR. ROSZTCOZY: I would like to comment briefly on one of your responses. You said there would be such a situation eventually available between the pressurizer and reactor system. Where such a line is, of course, existing in the design and pressurizer spray line, that is, it is a controlled line, and the question is that, under the circumstances, will this pertain or not?

I think the point is very well taken. One ought to consider in the generation of the guidelines whether it would be any help to ask the operator to open that vent line under certain circumstances.

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MR. MICHELSON: I looked into that and found you contain a check valve which prevents it from being as effective as it could be. Of course, you do have to somehow vent it if you want to -- it didn't look too promising. You ought to go back and look at the specifics.

MR. ROSZTCOZY: For this specification mentioned here, we are talking about providing flow for the core leg to the depressurizer for drainage. It may be it would be an improvement if that line were to be --

MR. MICHELSON: We looked at the problem and tried to find some way of handling this. It didn't look too promising but the only simple means appeared to be the possibility of using the spray line as a vent. If you can vent it, you can certainly, at least, improve your reliability.

Keep in mind you will never drain the pressurizer completely this way; only partially. As soon as the water level from the pressurizer drops to the entrance elevation to the main loop, that's as far as it drains that way unless you develop some kind of pressure differential.

MR. SHERON: As I just mentioned, the I&E bulletin which was issued instructs the operators to check other system parameters and that HPSI shutoff criteria precludes pressurizer level as a primary indicator of system inventory.

This, again, is the criteria which says that one must see 50 degrees subcooling on the hot and cold legs and have

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been in that mode, I think, 20 minutes before they are allowed to shut off the HPSI pumps or throttle back on them.

We also indicated in the NUREG report on feedwater transients in B&W plants -- the Tedesco report -- that a longer term study is under way of more direct and more easily interpreted indicators of water inventory. The status was not going to be covered in this meeting.

MR. ZUDANS: These are new criteria now, post Three Mile Island.

MR. SHERON: These were issued in April, I believe.

MR. ZUDANS: After Three Mile Island.

I read someplace a document dated 1978 discussed all these problems and said that the pressurizer level was not an indicator of the system status in the case of feedwater drainage. The document was dated in 1978. It indicates if the operators had been instructed to read this document, there wouldn't be a Three Mile Island accident.

PROF. CATTON: We found out they never even heard of the Davis-Besse incident nor had they heard of Oconee.

MR. ZUDANS: It was discussed in quite about the same amount of detail you are discussing now.

MR. SHERON: B&W's response of January 23 to Mr. Martinson's letter acknowledged the fact that the pressurizer level would not be a good indicator for certain transients and said they did not expect operators to make judgments based solely on that but it was never carried any further.

MR. ZUDANS: That's like a missing link, I guess.

MR. SHERON: The next item is small break isolation and repressurization.

(Slide)

This comes about by asking if I have a small break -- certain lines in the primary system -- and if the operator is smart, he can determine where they are and isolate them by a downstream block valve or whatever.

What does the system do? I can get repressurization, I guess I mentioned previously, with HPSI. Okay. If the shut-off head is higher than the PORV setpoint, then this system will keep pumping water into the system until it goes water-solid and then I run the risk of lifting a PORV, discharging water, and then one sees our postulated failure. So there is a concern there.

The other one is with natural circulation. The system can depressurize due to natural circulation. One question might be: If I isolate a break, do I aggravate the situation of natural circulation during some period of transition? In other words, if I isolated a break and I repressurized the system and I failed the PORV, it would appear as a small break in the pressurizer steam space.

The applicants have not specifically analyzed this. The PORV failure has been addressed in SARs. However, it has been referenced from the standpoint that it has been bounded by other small break calculations. There was not a specific analysis. We kind of walked our way through this as to what would happen.

We do not expect any new or unusual behavior to occur based on isolating a break and perhaps repressurizing and opening the valve. However, we are planning to require that the isolation of small breaks with a PORV failure be analyzed. We do not have an analysis specifically at this time.

There is, as I said here, operator action required on the throttling back of the HPSI pumps again. In other words, if I isolate the break and my HPSI stays on, I will eventually refill the system and I eventually make it go water-solid and the operators would have to do something to prevent those valves from lifting, which would be throttling back of the HPSI pumps so the system won't go water-solid.

MR. EBERSOLE: A full scale failure of the PORV is a fairly large break, the kind of damage you are talking about here.

MR. SHERON: We are talking about the valve lifting here.

MR. EBERSOLE: Say it lifts and sticks wide open.

MR. SHERON: 1.05 square inches.

MR. EBERSOLE: Suppose you get that condition and you have both steam generators in full cooling mode. Therefore,

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you have the beneficial effect of bringing pressure down from the secondary transfer as well as this large aperture. Let's say that's a prolonged condition. The operator doesn't intervene. The pressure of the system will go down how far in that case? How far and how fast will it go down?

MR. SHERON: Are the HPSI pumps running?

MR. EBERSOLE: Yes.

MR. SHERON: No break?

MR. EBERSOLE: The valve is wide open.

MR. SHERON: You would draw a volume balance again between a flow that the HPSI pump --

MR. EBERSOLE: I want to hear you say the pressure will not fall to a point where I am in jeapordy of discharging the low pressure accumulators, because if I do that, I will break natural circulation and then I will be in trouble.

MR. SHERON: I don't believe the system pressure would fall to let the accumulators inject. They inject at about 600 pounds and the gas will enter the system, if that's what you are worried about, at about 150.

MR. EBERSOLE: You think you are well above this.

MR. SHERON: The HPSI pumps for the high pressure are 2400-2500. You will reach some balance fairly high up between the HPSI flow and the flow going out of the PORV.

MR. EBERSOLE: You have a safe pressure pad.

MR. SHERON: Yes.

MR. EBERSOLE: For the case of full opening of the pressure relief valves plus full cooling on the secondary side.

MR. ROSZTCOZY: As long as the cooling is to the steam generator, as you postulate it, then the pressure would hang up just slightly above the pressure of the secondary side.

On the secondary side, you are using relief valves for the steam relief and opening the secondary at something like 1000 psi. The primary would stay slightly over the 1000 psi and this low pressure safety injection would not come into the system.

Cooldown from this on down would be controlled and I believe it includes in it --

MR. SULLIVAN: In any case, in some transients the operator would try to depressurize the steam generator to enhance cooling.

MR. ROSZTCOZY: What do you have in mind?

MR. SULLIVAN: You said it wouldn't depressurize any further than the secondary side of the steam generator, which is held about 1000 pounds.

MR. ROSZTCOZY: Yes. The case that has been postulated would settle at that.

MR. SULLIVAN: Doesn't the operator have the ability -- and, in fact, I think he is instructed in a case or to -- to depressurize the secondary side of the steam generators to enhance cooling?

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MR. ROSZTCOZY: In a controlled manner. It has certain cooldown procedures. It would follow those.

MR. EBERSOLE: If he did cooldown the secondary site by mistake, he would invite -- unless he followed instructions and closed the nitrogen off -- discharge of nitrogen, wouldn't he?

MR. EBERSOLE: He would have to drive himself into it. I think this is clear. It would almost be willfull, I hope, instead of....

MR. MICHELSON: An operator error of more interest than that is the case wherein I have a small cold leg break, and during the process of the break I decide, for one reason or another, to maybe try to reduce pressure by opening the pressurizer relief valve. At that time, he will proceed for sure to fill the pressurizer full of water if the surge line is still covered. He will put quite a bit of inventory out of the system and create a further complication to the whole matter by seeing his pressurizer pulled -- I am perhaps again misinterpreting what do do at that point. Have you accounted for the kind of operator error wherein the operator may decide to vent the pressurizer during the course of a small break?

MR. ROSZTCOZY: Instructions to the operator are to open the relief valve only if there is a repressurization and if that repressurization reached 2300 psi.

MR. MICHELSON: Is there a prohibition telling the

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operator under no other circumstances to open the valve, or is it simply an instruction that in case of a certain situation, go ahead and open the valve? Is he prohibited in every other case?

MR. ROSZTCOZY: I would like to suggest that you ask this question of the people who will be here in the afternoon, who worked with the individual procedures. They can tell you how they get into the emergency procedures.

I know the thinking was not to open the valves unless depressurization proceeded up to 2300.

MR. MICHELSON: If it got you in serious trouble, you would want to put a big glag and say: "Don't open it." Then you have to go into the problem of a single failure: A weld coming open. What do I do.

I would be much more comfortable if the analysis included a small break in the cold leg plus an inadvertant pressurizer relief valve operation.

MR. EBERSOLE: You are touching on a generic problem. There are standard revisions in what I will call negative instructions. Absolutely do not do this, don't do that, do not do the other thing.

Emergency instructions tend to be positive.

These leave to his own imagination what he should not do, and that's not very good.

MR. SULLIVAN: As we discussed this today, we have

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now brought up a number of things that are questioned. Is the staff systematically looking at breaks, possible actions that the operator may take, and trying to figure out what he should not do and what he should do, and trying to write a set of procedures?

If I was operating a plant now, I'm not sure I would know what to do.

MR. ROSZTCOZY: You are taking a very pessimistic view. I'm not aware of any case, with the exception of this last one -- and I believe this last one has an answer to it, also, because the only thing that was postulated in this case is that, in addition to having a small hole in the core, like you opne up another small hole at the top of the pressurizer.

This case we postulate, I believe this Exxon case has not been analyzed, at least not in the last few months. However, there has been a spectrum of breaks looked at in the cold leg and a spectrum looked at in the top of the pressurizer. I probably need some additional thinking, but my guess is that the conclusion should be to -- you see, this is not a limiting break. There are other breaks more limiting than this one and the consequence of this will be better than what you have already analyzed.

For all these very small breaks, the conclusion was that you are not coming anywhere close to uncovering the core. You have water to the top of the core, enough so it even runs into the hot leg, and they have some water left in them. So you are not close to any limit.

The differences which come from one analysis relative to another won't make any significant difference in the conclusion. Should the question come up which postulates something quite different to happen, something that really hasn't been considered and could reduce this water level significantly, then I think right away we should go back and look at that case and see if it requires changes in the operating procedures.

PROF. CATTON: Can I ask a question?

DR. PLESSET: Wait a minute.

Are you finished?

MR. SULLIVAN: The thing that is bothersome to me is that, following up on the does and don'ts, you have told the operator what to do. I would like to provide as much margin as you can to limit the transients. What you have told the operator to do, he may do, but he may do something else, and it looks like it will take a fairly significant effort to look at all these transients and decide exactly what he should do, and if he gets this indication, he should not do something else because, evidently, that's what happened to TMI; he did things that he should do and then he didn't do some other things, and then he also did some things he really should not have done at all.

MR. ROSZTCOZY: Going back to the TMI case --

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DR. PLESSET: I have to postpone your speech and let Carl make a comment. You can answer both of these together later on.

MR. MICHELSON: I didn't have a comment.

DR. PLESSET: All right.

Did you have something?

We are running a bit behind, I think. We won't scold you; there are other reasons for it. Make it short.

Then Zoltan will make a short response.

PROF. CATTON: There are two approaches to looking at these problems. One, suggested by Dr. Okrant, is to view it as one of the bad things that could happen first and then ask yourself: Are there possible ways those things can occur which lead to a different kind of insight to the problem?

DR. PLESSET: That point was made many times.

Zoltan, a brief --

MR. ROSZTCOZY: Very briefly, to answer, really, Harold's question: Yes, it has been looked at very systematically, at what sort of event can happen and what do you expect from the operator? In connection with your reference to TMI-2, in that case, as [illegible] as I know, the operators had not violated their procedures in any sense. Procedures which were available to them simply didn't discuss some of the hangups.

What has been corrected is that now they are being provided with appropriate procedures to follow instead of just trying to figure out on their own what to do.

DR. PLESSET: Let's let him finish his presentation. We interrupted him occasionally.

MR. SHERON: Another item in the report was pressure boundary damage due to bubble collapse.

(Slide)

There are essentially two sources of what I would call a watterhammer effect one could envision. One is collapsing steam bubbles in subcooled liquid which produce pressure pulses which would impinge on the primary coolant boundary, like the core of a steam generator.

Second is the effect of injecting cold ECC water into a steam-filled pipe, which could produce pressure loadings on the structures.

MR. ZUDANS: Thermal loads, too.

MR. SHERON: Thermal loads, as well.

Injection of cold ECC into a steam-filled pipe, we have run some tests at LOFT and SEMISCALE. As a matter of fact, many tests. They were requested in a letter a while ago to specifically comment on what they had seen -- they being EG&G -- regarding the pressure oscillations, and they reported back for all the LOFT and SEMISCALE tests, they have not seen excessive pressure oscillations due to injection of ECC into the steam-filled pipes, and the maximum oscillations were about 10 psi.

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MR. MICHELSON: On that point, did their tests essentially involve a confined region of pipe filled with steam and, also, what do you think of the possible effects of the vent valves?

MR. SHERON: The confined region would be their cold leg pipe, which is where they inject.

MR. MICHELSON: Was it flooded at both ends when injected or opened at one end and only flooded at the other?

I don't know the geometry that well. It makes quite a difference in the answer as to whether you inject cold water into a trapped steam bubble as opposed to injecting it into a steam-filled pipe broken at one end.

MR. SHERON: They injected both an intact loop and a broken loop. In that sense, you have both cases; where there is an intact, and the other case where it is broken at one end.

MR. MICHELSON: Perhaps they have a good simulation, I don't know. That's why I asked.

And the question of the vent valves?

MR. SHERON: There was one SEMISCALE test run, if I recall, where they simulated the vent valves in the system, and the best I can say is that I do not recall in the report there being any mention of excessive pressure oscillations being seen when the valves opened. We can certainly check on that for that SEMISCALE test.

There were also tests by CE, Westinghouse and EPRI,

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which showed oscillations -- a water slog oscillating in the pipe -- when the injection flow was sufficient to produce a slug of water in the cold leg. By a slug, it would fill the pipe before it would run out and essentially broke off that pipe.

For HPSI flow for a small break, that flow was not high enough to produce the slugs of water in the cold leg pipe so one would not envision getting a slug of water being oscillated back and forth in this pipe.

MR. MICHELSON: What you envision is rapid concentration of the steam in the pipe, which literally sucks the water out to pump the cold leg in the case of a high steam generator, for instance -- pardon me; a low steam generator -- so the condensation of the steam as a result of injecting cold water will suck and fill the pipe with water momentarily.

It is those kinds of oscillations I would have in mind. That's when you have to look at the vent valve operation at the same time.

MR. SHERON: That would show up in the analysis. In other words, the evaluation models take into account the condensation of steam due to the injected ECC water.

MR. MICHELSON: I doubt that it takes account of the instantaneous condensation. If it does, it is very sophisticated.

PROF. CATTON: You sort of wash out these oscillations

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with your control of water packing.

MR. SHERON: This is typically when you start seeing deviations in the code, itself, is when you start getting perhaps these very short-term non-equilibrium effects. Yes, you could see water packing, which could affect us.

PROF. CATTON: You control the water packing so you would, in essence, remove these oscillations.

MR. SHERON: Maybe it does have the proper detail to predict these pressure oscillations one might see from very fast condensation.

PROF. CATTON: Are they important?

MR. SHERON: They can be if they are excessive. I think I am trying to address this from the standpoint of: Do they cause any structural damage to the system? From that standpoint, the evidence we have ssen from the test facility says no. The pressure oscillations would not be big. The loads, in fact, would be bounded by the loads from the large break LOCA.

MR. ROSZTCOZY: May I add a few words to this? In connection with the programs Bryan mentioned, we are part of the ECCS bypass program and the specific effect has been studied in some detail, and some models have been developed to predict how big a slug you could form and what would be the acceleration of this slug and so on.

These are more detailed than normally what would be

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in an evaluation model. There are means available to calculate these loads and see how large these loads would be.

Based on a very rough look at these, it appears to us the loads will be smaller than this load following a large break LOCA and this would not be the controlling event. Nevertheless, it is our position the applicant should have the responsibility to quantify these loads, to do some actual calculations on these loads and compare it to the one he used as his design basis and show these are not delimiting ones.

MR. MICHELSON: My real concern is an oscillatory effect that will be set up as you inject cold water into a steam-filled leg. It will condense the water and momentarily draw a new charge of water into the leg. The higher pressure on the hot leg site will proceed to open a vent valve and send a new charge of steam back into this region, which is now somewhat heated.

Then that new charge of steam will drive the water back out and then the cold water will recondense that charge of steam and it will set off a periodic condensation and cold slug refill, heat up, condense back again -- that sort of thing.

If it goes real well, one would have to ask about the mechanical effects on it. Also, the effects on ECCS response.

MR. EBERSOLE: You are extrapolating with a pressure system from GE?

MR. MICHELSON: It is expressing how these things

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will work very nicely.

MR. ZUDANS: I would like to get back to the question of these loads would not be contr-lling. Large LOCA loads would be controlling. But these could occur many times. The other is only a single event. These smaller oscillations, smaller waterhammers, are multiple loads. They can't be compared to the single event.

MR. ROSZTCOZY: The subsequent loads following LOCA go throught a number of oscillations. I recognize the difference between this and the other.

MR. ZUDANS: Okay.

Now we are talking here strictly about the mechanical surface loads that occur. I am wondering to what extent the associated metal temperature changes are being looked at. They would produce the fatigue more likely than these mechanical loads. You may develop cracks with repeated condensations, injecting cold water in hot areas and so forth.

MR. ROSZTCOZY. The oscillations we have seen in some of these tests are relatively high frequency types of oscillations so I don't think there is any significant temperature change with the possible exception of the metal surface, itself. There is no propogation of this temperature effect.

MR. ZUDANS: That's my concern. The surface temperature change produces local cracks. It's like a skin-type of stress. If you heat up very shallow, you will create high compression stresses. It may not be significant. Maybe there is not enough time to change to surface temperature quickly, I don' know. I am wondering whether it has been looked at.

DR. PLESSET: I think we will go on. What you are asking is not out of the question. Presumably, it will be looked at. This area is going to be looked at.

MR. ROSZTCOZY: Yes. This is one of the items we are asking be looked at and evaluated.

MR. MICHELSON: Are you looking at TMI data to see if there is anything there to give hint as to whether this sort of thing could have been happening? Is there enough instrumentation?

MR. SHERON: The only pressure traces we are aware of is the one system pressure trace. That did not show any high frequency oscillation.

MR. MICHELSON: It gets lost depending on where the sensor is.

MR. SHERON: The instrumentation is on a very low speed, I understand. It would wash out just being recorded.

Zoltan said we will require licensees and applicants to analyze these loads to confirm them. We have done an additional look-see and don't believe they will be excessive. We think they are bounded. We have reasonable assurance they are bounded.

However, we want additional confirmation on specific

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applications.

For the collapsing steam bubbles, again we looked at these. These are bubbles passing through a subcooled liquid which would condense the water rushing together and would form a pressure wave which would propogate out. We have looked at this. We would expect, if there was one bubble in the system, there would be many bubbles. Therefore, the system would be hydraulically soft, such that any pressure waves that occurred would, A, be non-directional, and, B, they would be attenuated before they got into any structures.

Again, for this case, as well, we are asking licensees and applicants to confirm this with additional calculations.

MR. MICHELSON: Is the particular place one would be interested in with this be say as steam was rising in water-filled steam generator tubes but you use a U-tube type steam generator input, is that the same conclusion drawn, that these localized effects would not affect the tubing, keeping in mind the possible degredation of the tubing which we know kind of occurs?

MR. SHERON: Yes, sir. That's primarily because the steam generator tubes would also be designed to withstand again the subcoolant loads that occur, which we beleive would be more severe and of greater magnitude.

I think that the degredation of the steam generator tubes, the requirements of the Commission are such that they are

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within acceptable limits. Otherwise, they have to shut down and plug those tubes.

(Slide)

The last item in this report was the fact that the break energy was not representative of the core exit energy, which essentially says that the break is not going to remove the decay heat load in the core unless what is coming out the break is actually what is coming out of the core.

The one concern here is that we have HPSI being injected. If the break is in that cold leg, it can't be by-passed.

Another one would be that HPSI does not condense with 100% efficiency. The analysis codes that are used to represent small breaks take into account this distribution of energy around the system; namely, that what comes out in the break is not what is coming out of the core.

I believe the B&W code also throws away a part of the HPSI flow into the broken loop so they take into account the fact that some of this HPSI flow does not even make it into the core but actually goes out the break.

The codes, because they are equilibrium codes, assume over a time step there would be 100% efficiency, and the steam and water would mix and come to equilibrium temperature and pressure.

We don't believe the non-equilibrium effects will be

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big. They would tend to raise the pressure slightly because we are not condes-ing at 100% in any short period of time.

That was all I wanted to say on that. Are there any questions?

DR. PLESSET: There were a lot of comments during the course of the morning that touched on this. I think that's enough.

MR. SHERON: The last item I was going to touch base on are non-condensable gasses; what effect they might have on a small break.

(Slide)

These are staff estimates. These are the various sources of non-condensable gasses that can enter a primary system during a small break. There is dissolved hydrogen in the primary coolant. This is usually kept anywhere from between 25 and 55 CCs I believe per kilogram of water. This is done to suppress radiolytic decomposition during normal operationn.

Dissolved air in the refueling water tank. The source of water for the HPSI. Hydrogen generated by any cladding that is reacted with the water. There are flood tanks. They have two sources. Dissolved nitrogen that could be in the water. There is the free nitrogen used to pressurize the tanks. There is an equilibrium concentration of hydrogen gas up in the pressurizer, which is periodically vented. There

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is radiolytic decomposition of the injected ECC water since this doesn't have the hydrogen in it to suppress the radiolytic decomposition. However, this will probably be negligible as a source as long as the hydrogen concentrations are above 5 CC per kilogram of water.

Then there are the gasses that are in the fuel bins. These are estimated to be about 1500 cubic feet at STP, accounting for both gap fission gas at the end of -- these are the relative volumes if this gas is expanded to these termperatures and conditions.

MR. EBERSOLE: Are you saying there are 700 feet of gas in the pressurizer?

MR. SHERON: Yes.

MR. EBERSOLE: That was in the --

MR. SHERON: Remember, it is partial pressure.

MR. EBERSOLE: What about the entrance mechanism of hydrogen into that space? Do you have a valve system that brings it in? Is this correct?

I am thinking about continuous leakage of hydrogen from the normal hydrogen source. Is there any possibility of that? Is it blocked by automatic safeties once you get into depressurized conditions? You have hydrogen in tanks at high pressure. These get to the water somehow or other. There is normally a flow. Do you guaranty any stoppoage of this when you get into one of these -- if so, how? I am looking at it

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in the same light as the low pressure tanks.

MR. SHERON: I haven't looked to see whether those were --

MR. EBERSOLE: How do you guarantee stoppage of hydrogen flow into the system once you get into the emergency mode?

MR. KANE: From where?

MR. EBERSOLE: You inject hydrogen into the water to handle the overpressure.

MR. KANE: At the make-up tank.

MR. EBERSOLE: Yes.

Do you stop that process when you get into a emergency mode?

MR. KANE: The make-up is isolated.

MR. EBERSOLE: That's isolated by appropriate means and continued injection.

MR. SHUMWAY: This water reaction --

MR. SHERON: This is the amount generated, by percent. If I have 1% I would get 4,344 cubic feet at STP generated.

MR. ZUDANS: Could you give details about this radiolytic decomposition? When does it exist? When does it stop? What is the way to control it?

DR. PLESSET: If you don't mind, we will let that go. There has been a lot of discussion of that. What they are concerned with is suppressing the elimination of oxygen by excess

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hydrogen in the system. They can tell you about this later. We are awfully far behind. Maybe we will let that go.

MR. SHERON: What I did was: I took volumes of gas that I would expect -- conservatively expect -- to be introduced into the system during a small break, again remembering I assumed that all the gasses remained in the system.

(Slide)

In other words, no gas without the break. I also assumed that all the gas in the liquid got stripped out by the boiling process; it was 100% efficient. I assumed that the boiling in the storage tank was 50 degrees Fahrenheit and flood tanks were 86. I have a higher solubility at those lower temperatures so I could put more gas into the tanks, BWST and flood tanks.

I assumed during the course of the accident somehow I injected the whole BWST into the system and switched to a different mode. I took the gas that I assumed would get into the system. At high pressures, I assumed I got all the hydrogen out. I assumed I had a tenth of a percent zirc water reaction and I assumed I had all the dissolved area in the storage tank in the system.

These are the relative distributions. These were the triangles, the totals. I assumed that the volume they occupied was not occupied by any steam in the system and what I did was expand it. You will see at 600 psi I assumed the accumulator is turned on. Again, there is a steady state calculation. I just assumed that as the pressure decreased, the gas in the accumultor space expanded isothermally and I let the dissolved gas in the water come in.

Remember, the free nitrogen would not come in until down around this 150. If I assumed that all this gas somehow found its way to the top of the hot leg U-bend, no gas accumulated in the upper head at all --

PROF. CATTON: What is your volume composed of? You have volume of the hot leg U-bend at 170 degrees.

MR. SHERON: These are two U-bends. If I drew a straight line across the bottom of the U, okay, and it's that volume above it. About 85 cubic feet above that.

PROF. CATTON: Okay.

MR. SHERON: So I took two of them, 170 cubic feet, assuming each went out equally in both of the hot legs, and again saying this was a conservative calculation because I am assuming it all somehow went to these hot legs and none stayed in the upper head, which is where we expected it to say.

I would have to expand down to around 400 psi before I would start to see the hot legs start to fill up with a non-condensable gas. Most of this occurs -- it starts primarily because I'm starting to get nitrogen into the system from the accumulator tanks.

I would point out, too, that these numbers are very

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similar for a CE System-80 plant, which I have also done estimating on. They are about the same for most plants.

MR. EBERSOLE: One thing is different: The CE and Westinghouse plants don't have candy canes. Therefore, the volumetric requirements to stop natural convection in those plants is a great deal less. Do you know what that number is in contrast to 170 cubic feet? Does staff know?

It is good practice to take B&W information and apply it to the other plants which have a different configuration quality.

MR. SHERON: 162 is for CE, I think.

MR. EBERSOLE: I'm not sure Westinghouse and CE would be in comfort with -- it would take a great deal less to stop natural convection. Do you know the number?

MR. SHERON: 162 cubic feet is what CE estimated it would take to stop --

MR. EBERSOLE: All the flow in the tubes?

MR. SHERON: That was the volume of the U-tube.

MR. ROSZTCOZY: The horizontal section of the U-tubes. Keep in mind in that case some of these tubes are coming up on one side of the pressurizer and have a relatively long horizontal section before they turn down. Depending on where they are located, some have a shorter or longer one.

The number Brian is quoting, I believe, is the number for the total of the 4,000 or 6,000 U-tubes, whatever they have

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for the horizontal section. I don't know if we have a number from Westinghouse at this time. The Westinghouse and the Combustion information is coming in new. Some is not in-house yet.

PROF. CATTON: In the U-tube, the horizontal sections are all elevations, so wouldn't you get a gradual degradation of the numbers?

MR. ROSZTCOZY: All of this is presently being discussed. Just because they are at a different elevation does not mean that you would have that. It does not mean that.

PROF. CATTON: It doesn't mean you would maintain it, either.

MR. ROSZTCOZY: No, but the way we are picturing it is there would be a level difference between the two sides of the U-tube that balances the other forces that try to initiate natural circulation. The level of the currents could exist in most of the tubes -- or all the tubes -- at the same time. It would require a gas bubble or steam bubble which is larger than the horizontal section because it has to account also for the level difference. This level difference could exist in tubes which have different elevations for the horizontal part. The density difference and the elevation difference would be controlling independent of what the elevation of the horizontal section was.

MR. EBERSOLE: I would like to say on the critique

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side of the B&W design the easy way to avoid -- you see, all you have to do is read it. There is no way to vent a U-tube design.

MR. SHERON: Very quickly, as long as the volume up there is down in this range, there is very little effect on the total natural circulation, primarily because most of your pressure drop is through the pumps, I should say. So you can have substantial blockage here and still have very little effect on the overall flow.

Heat transfer, the same way. The units are very much overdesigned. I haven't done any estimating calculation on the effect of the non-condensable gas under heat transfer. You get a buildup on the condensing surface and some degradation. Calculations that have been done by other vendors indicate it is negligible until you start dropping down, so the pressure between the primary and secondary system is about the same.

The effect of the non-condensable becomes amplified but you have poor heat transfer, anyway, because you have a driving Delta T.

MR. EVERSOLE: On balance now, since you are talking about condensables in considering cost-risk-benefit ratios, are you of the opinion now we are going to venting of the candy cane or not? Will we rely on these numbers?

MR. SHERON: These are preliminary numbers that the staff put together, the staff being me. We have asked B&W to

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supply numbers to analyze the effect. I don't believe at this time we have made any recommendation or decision on whether venting is necessary or not.

MR. EBERSOLE: Of course, there is a risk it might be inadvertently vented.

MR. SHERON: You have to weigh the detriments of any sort of system like that with the benefits it might give you.

MR. ROSZTCOZY: Venting is being considered as a possibility not as much for the cases we are discussing here, which are the normal small break incidents, but there is an increasing emphasis to go beyond this and look at what would happen if something goes beyond the normal predictive concept, like it happened in Three Mile Island. That is the case which will probably have a stronger effect on any venting type of requirement.

MR. EBERSOLE: You are going beyond the single factor criteria delta?

MR. ROSZTCOZY: In our thinking, yes.

MR. EBERSOLE: What will you do with the upper head injection on Westinghouse? You inadvertently discharge that gas and you're through?

MR. SHERON: You have to assume double failure.

MR. ROSZTCOZY: We are going to look at it.

DR. PLESSET: They are safety grade, I believe.

MR. SHERON: The preliminary conclusions we have on

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non-condensable gasses for the B&W plant was that for very small breaks in which the steam generator must remove decay heat, we don't see the accumulators turning on. The pressure doesn't drop until the low 600's. If the break is large enough that the pressure actually drops below 600, the break will take away the decay heat, anyway.

For breaks which do turn on the accumulators, you still have to drop the pressure much below 600 psi, down to maybe around 150, before you expand the gas out into the system in order to get any significant quantities of nitrogen.

In addition, the accumulation of the gasses will probably be in the upper head region -- or, at least, some of it will be there; not all of it will find its way into the top of the candy cane -- so the estimates prepared, assuming it all got up to the candy cane, were conservative from that standpoint.

Without any accumulator actuation or significant core oxidation, we don't believe that non-condensable gasses will hinder decay heat removal by the steam generators.

MR. ZUDANS: This is based on .1% zirconium-water reaction. What is the picture if it is 1%? If I shift the curve out, it goes way above.

(Slide)

MR. SHERON: It will go up, I agree. I think, for the small breaks that we have ssen for the B&W plant, they do

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not uncover the top of the core, which means you will have almost zero oxidation. I can't say that for CE or Westinghouse yet. We will look at their analyses and how much oxidation they do predict.

MR. ZUDANS: This is the only part of your composite figure that is very sensitive to the assumption. The others are pretty stable. This one, if I use a factor of ten, from 300 psi at 40 cubic feet it would be 400 cubic feet, and the rest of the curve would be way above your 170 feet.

MR. SHERON: I can always pose enough oxidation where I will get in trouble fairly quick.

MR. ZUDANS: Really not that much extra. I am wondering how you came up with this.

DR. PLESSET: He covers himself by saying that he takes the case where the core doesn't get uncovered. If the core gets uncovered, then that's another story.

MR. SHERON: These are estimates from B&W and B&W analyses do not show any substantial core uncovery. I don't think they showed any for the small breaks analyzed.

MR. MICHELSON: The kind of model you want to keep in mind is the case where you start out with a somewhat larger break and, for one reason or another, are able to isolate it. Certain types of breaks can be isolated. Then you would get involved in a core uncovery situation possibly and some additional hydrogen generation. By isolating the break, you

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are now forced back onto the same generator with the heat sink since your break is gone and you have to work back into a heat removal mode.

MR. SHERON: The only breaks I understand now that can be isolated are the PORV line and the letdown line.

MR. MICHELSON: Some people do have loop valves, you know.

MR. EBERSOLE: Do any B&W plants have them?

MR. MICHELSON: No.

MR. ROSZTCOZY: None of the B&W plants have them, I believe.

MR. MICHELSON: Some PWRs do have them.

MR. EBERSOLE: If we have to confine our conversation to just B&W, we can stop here.

MR. MICHELSON: That's the potential for a very large break being iscalted.

MR. EBERSOLE: It is a fact of life that operators are told to isolate from a large break to a small break configuration probably beause they wouldn't be entirely successful here.

MR. MICHELSON: The emergency instruction says to isolate the break; go back and look carefully at your process designs. Occasionally, there are valves between the primary containment isolation valve and the primary loop which might be left open, and these, if they are motor-operated valves, the

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break could be experienced in that line and the operator could recognize it and go ahead and close his manually operable valve. So the possibilities are very plant-specific and I think you would want to look at each plant to find out where all the breaks could be that could be isolated that might be of a fairly large size. You would be surprised.

MR. ROSZTCOZY: I'm not sure what connections we are talking of here but most of those are low pressure.

MR. MICHELSON: The shutdown cooling connection, for instance, off the loop is going out to the isolation valves. People may provide an additional valve in the line. It is not safety-related in terms of function but is in there for other purposes. The development would normally be left open but would have the capability of closure from the control room.

Such occasions as that will raise such issues. You would be surprised, looking at your designs, at the number of valves in there that are not automatically operated but which are capable of remote operation.

MR. ROSZTCOZY: That cooling system is typically 600 psi.

MR. MICHELSON: Not where it is attached inside the containment. Usually full pressure up to the inboard and out to the isolation --

MR. ROSZTCOZY: The valves left open are the valves protecting the low pressure part of the system.

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MR. MICHELSON: The break is in the high pressure section of the pipe between the isolation valve and the primary loop. If the particular designer decided to put another valve there for one reason or another -- I'm not saying shutdown of the cooling system is necessarily the example but you have to look carefully to see if such provisions have been made. They often are put in for other reasons.

MR. SHERON: Just to quickly summarize what we have discussed this morning, we saw no disagreement on the phenomena described by Mr. Michelson, the repressurization and so forth and what B&W has calculated as to how their plants operate.

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We also acknowledge the fact that Mr. Michelson's report has underscored the importance of natural circulation for decay heat removal during small breaks.

B&W has performed a number of detailed analyses in response to both the staff's request for information as well as Mr. Michelson's report, and these results show the phenomena occurring which Mr. Michelson pointed out.

However, decay heat removal has not been unacceptably impacted as far as we could determine from these analyses.

MR. EBERSOLE: Concerning the second statement, I wish you would refer to the set of 26 questions on the Pebble Springs project, wherein you state that you can get along with HPSI injection without the benefit of the secondary site.

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MR. SHERON: For certain breaks.

MR. EBERSOLE: I don't remember the boundary, the bracket, but I don't think it went down to very small breaks, but that statement is a little bit broader in scope than it might be.

You do claim that you can get along without natural circulation beginning at a point in size of a small break, which I think you --

MR. SHERON: Yes, but, however, prior to Mr. Michelson's report coming to our attention -- or I should say subsequent to it -- we have put a stronger emphasis on the necessity for natural circulation to remove decay heat for these small breaks. We have gone to the vendors asking them to verify their models.

MR. EBERSOLE: When one goes to a small break which is sufficiently small so you do have to have natural circulation on the secondary site of the transport, do your plants attempt in any way to provide mass flow injection at sufficient pressure to override the pressure-operated relief valves and get heat transport through them alone, like the original Shippingsport design does?

I am driving fluid into the core at a sufficient rate from the high pressure -- I'm establishing a flow-through, relieving the pressure-operated relief valves to get heat removal without the secondary site. I understood B&W had a

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sort of left-handed objective in doing that. Am I wrong?

MR. SHERON: I don't believe that is the preferred method.

MR. EBERSOLE: Not preferred; is it possible?

MR. JONES: Yes, it is possible, with the exception of Davis-Besse because of low HSPI pumps.

MR. EBERSOLE: Is that the one exception?

MR. JONES: Yes.

MR. EBERSOLE: Does it take one high pressure safety valve to do this or both?

MR. JONES: I will have to say both now. I think it is possible with one but I'm not sure.

MR. EBERSOLE: Will it unseat the pressure-operated relief valve and carry on with the cooling function?

MR. JONES: The PORV is not big enough. In fact, you will probably go up to the safety valve.

MR. EBERSOLE: Is that a design objective, to do that?

MR. JONES: No, but they are capable of performing that function.

MR. EBERSOLE: You have a periforal capability. Do you discuss that anywhere explicity? I got a half discussion of it on Pebble Springs.

MR. JONES: At present, I can't think of anyplace we discuss it.

MR. EBERSOLE: You kept saying -- well, you don't say

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anything about the ultimate capability of the plant without the secondary site.

MR. JONES: In the May 7 report, there are a bunch of small break analyses which demonstrate that for breaks greater than .01 square feet, you don't need the generator at all and you don't need to take any action. If you turned onto HPSI manually at 20 minutes, that would handle the accident. Smaller breaks would also be handled in the same manner.

MR. EBERSOLE: Thank you.

MR. MICHELSON: One thing you want to be careful of in your summary. That is that what I wrote dealt with these problems concerning a 205 plant, whose behavior, of course, is perhaps a little bit different. I haven't seen the evidence that you have yet examined the 205 so you could draw these conclusions concerning my report. I think the conclusions are only valid relative to the 177 plant. Is that correct?

MR. ROSZTCOZY: Both types of plants have been looked at because of the discussion. We are looking at both operating plants and that includes, I believe, six -- not counting Three Mile Island -- it includes six lowered loop plants and one high loop plant, so this evaluation is supposed to cover most of these. Most of the work was done on the lowered loop, and whenever there was a need, we went to the higher loop.

MR. MICHELSON: Perhaps I haven't made myself fully clear. Davis-Besse is not a 205 plant and has a different

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configuration than does the other. My question is simply this: .ave you done the 205 plants and are these conclusions valid for a 205 plant?

MR. ROSZTCOZY: We have not done the 205 plants. We strictly limited ourselves. The next round, the 205 will be looked at.

MR. MICHELSON: I have no doubt the same conclusions will pertain. I just want it clear these are not conclusions of my report but, rather, conclusions for a 177 plant based on the same kind of phenomena described in the 205.

DR. PLESSET: Okay, thank you, Brian. I think we should proceed.

MR. ROSZTCOZY: The next item will be Rene Audette. Because we didn't know at one time how much time might be needed, Rene compressed his part and could present it in two possible ways. One is his longer presentation and the other is the abbreviated one. The abbreviated is complete but in a somewhat faster manner. Since we have fallen behind schedule, my suggestion would be to try to abbreviated version if that's all right with the committee.

DR. PLESSET: Let's do that. I am sure it will be longer than planned, anyway. We do have a need for a ten minute break first, though.

(Recess.)

DR. PLESSET: All right, Rene, the floor is yours for

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a ten-minute presentation.

(Laughter)

MR. AUDETTE: Thank you.

(Slide)

I prepared this very short summary. Essentially, calculations run by B&W. This is just a quick summary.

The calculations run by B&W were really to confirm their initial thinking about the way these breaks would go.

(Slide)

This curve was prepared by B&W. It is one of those in their report. Essentially, from their hand-calculations and previous computer calculations. They were able to come up with expectations of what they could expect over the small break spectrum as they got to the lower end of the spectrum.

From calculations before they had seen from larger breaks above a tenth of a square foot down to maybe .05 square foot, the depression took them down to the core flooding tank initiation, HPI initiation. However, for the lower end of the spectrum, the staff had never required calculations at that end of the spectrum because calculations to that point had shown core uncovery.

The only failure was the loss of one HPI system. From their hand calculations and previous -- I don't know what it was based on; I'm sure engineering judgment -- they could visualize cases where they could drop to the steam generator

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secondary relief pressure. Cases would actually hang up at a higher level with an equilibrium between the break and HPI injection and cases actually resulting in repressurization where the heat removal through the break occurred and through the auxiliary feedwater due to loss of natural circulation would not be capable of removing the decay heat, so repressurization would occur.

The main purpose of their analysis was to confirm these particular characteristics. In going through the series of calculations, we started off with the .07 square foot break previously run in July 1978, which had shown a slight core uncovery.

For the case where the auxiliary feed would be on but only HPI would be injected using all Appendix K assumptions, in this case the auxiliary feedwater was turned off completely and two HPIs -- this, assumed to be the failure -- two HPIs came on when depressurization to 1600 for that particular calculation -- 1600 psi, that is.

Did you take these down to 1345?

MR. JONES: They were all down to 1365.

MR. AUDETTE: I'm sorry.

For conservatism, B&W analysis assumed more or less the lowest pressure at which HPI could be initiated. Their normal initiation level is 1600 psi. They conservatively took the lower bounds.

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In this analysis, two HPI came on when the 1365 pressure was reached and no core uncovery took place. Long-term cooling, which they defined as the time at which HPI injection is equal to core boiloff so there would not be any reduction in inner vessel level, would cease.

Now, .02 square foot break was about the smallest break they could get without repressurization, again running the analysis with the auxiliary feedwater off and only two HPI, again core uncovery was not computed and long-term cooling set up at 650 seconds. This particular calculation leveled off at just above the secondary site relief valve setting.

For the .01 square foot, the repressurization occurred in this case and two HPI came on -- I'm sorry, I'm jumping to another calculation.

For the .01, the depressurization was short of turning on the HPI. There should not be a ditto mark here. The depressurization stopped at 1385, about 20 psi above the lower trip point they had selected for the HPI system. Repressurization occurred.

To introduce any kind of cooling, a manual startup of the one auxiliary feedwater system was required for about 20 minutes and no core uncovery in this case. Mixture level in the inner vessel leveled off at about the hot legs.

Then the loss of feedwater accident, a transient something on the order of what happened at TMI with the PORV held open. However, the rest of the transient did not simulate the TMI incident. Two auxiliary feeds came on at the normal time, about 40 seconds after reactor scram, and single HPI. Essentially, an Appendix K type calcuation. In this case, long-term cooling about 1000 seconds.

Three other calculations where it was just assumed the PORV opened up. Mechanical failure of the PORV opening with the auxiliary feedwater being initiated normally after the scram, in this case a low pressure scram and a single HPI.

I also missed a point here. On all of these calculations, it was assumed the off-site power was lost so the main coolant pumps were tripped and the loss of feedwater accident, off-site power was assumed to still be intact so the primary pumps were still running.

The other two PORV failures, simple openings, it was calculated with the auxiliary feedwater off. However, in the first case, the NAS type 1.2 or Appendix K type calculation was assumed and in this case one HPI was inadequate with the EC pumps turned off so natural circulation was lost and the core would uncover in time. The calculation wasn't carried out to that time.

In a further check on that particular incident using ANS type 1, the same assumptions on all the equipment show that the core would remain covnered and that long-term cooling with a single HPI pump would be established at about

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4700 seconds. Most of the calculations were carried out to about 3000 seconds. These times for long-term cooling were from hand calculations. Actually, at 3000 seconds the transient is fairly stable and lends itself to straightforward hand calculations. Up to this point, the calculations essentially were all done with the Appendix K model. This is the model that was reviewed by the staff and accepted by the staff.

(Slide)

In this model, the only difference used for that series of calculations -- this particular volume is the volume that is used in the later calculations to really identify when natural circulation is lost -- was lumped in with this volume, No. 5 in this case and No. 15 here. Only two volumes on the primary side of the steam generator.

In the later calculations, to do a better job of calculating when the natural circulation was lost, this volume was added to each of the steam generators and that considers the bend in the U-tube down to the injection point of the auxiliary feedwater, so when auxiliary feedwater is injected, it is injected only into the steam volume below and not in- :ded in the volume that is present above the steam generator tubes or above the auxiliary feedwater injection point.

PROF. CATTON: In thi- case, the separation of the steam in that node, the flow is in the same direction. Would you flow down through that node normally and the steam flow

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would be up through it?

MR. AUDETTE: Right.

PROF. CATTON: What about the circumstance at the top where you have the flow horizontally and the steam separating vertically in the top of the candy cane? It seems to me you don't really have that done properly.

MR. AUDETTE: This, I think, was more to try to identify exactly when that steam would develop from the candy cane. I don't believe this model covers that. This is still part of our review, and one of the things we will certainly be considering when we go through this thing.

This was more or less to get a better identification of when steam collects in this upper portion, more or less in the upper regions of the steam generator above the auxiliary feedwater injection. It was not considered at all in the other model.

The auxiliary feedwater injection into that single volume did not allow for steam collection in the upper portion of the primary site of the steam generator. As soon as auxiliary feedwater was injected, there was condensation for the whole volume.

PROF. CATTON: Is that the node you use to decide when natural circulation is terminated?

MR. AUDETTE: In these calculations, that's the node that set it off. That would be the first node to indicate loss

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of natural circulation.

PROF. CATTON: I think your model could do with a little improvement if you wanted to set that point firmly.

MR. AUDETTE: I don't think we want to give away the staff's position yet.

DR. PLESSET: That's not his model.

PROF. CATTON: Whoever the model belongs to.

MR. AUDETTE: The model used for the calculations down to the point I already covered had a single node up here for the upper part of the steam generator.

For the calculations below the ones I have discussed already, this particular model was in effect.

(Slide)

Again going back to the .01 square foot break again in the cold leg, similar to the calculation run up here with the new model, in this case an Appendix K type calculation assuming two auxiliary feedwater coming in 40 seconds after scram and single HPI, no cure uncovery and long-term cooling at 4900 seconds.

Natural circulation, the main coolant pumps were off and natural circulation was lost in this calculation.

To consider the case where one of the steam generators might be out during a steam tube rupture, a case of .01 square foot break in the cold leg -- one of the steam generators being isolated shortly thereafter -- would show a single auxiliary feedwater running and single HPI showed no core uncovery.

There is a whole set in the larger package covering each of these instances. The long-term cooling for that case was 4975 seconds. To cover essentially a break as close to the make-up rate as they could get -- .005 square feet in the cold leg -- with the two auxiliary feeds running, again the Appendix K type assumptions, loss of off-site power, loss of natural circulation, long-term cooling at 5000 seconds.

Then a case that Brian covered in part this morning, .01 square feet break at Davis-Besse with the Appendix K type assumptions, again long-term cooling at about 6000 seconds. This was the summary of the calculations contained in the blue book, the May 7 report.

All of these cases, outside of the PORV stuck open, with no auxiliary feedwater and only one HPI core uncovery were computed for each case and no clad temperature damage or clad temperature rise.

MR. SULLIVAN: Rene, could I ask you a question about your slide? The ones that are on the upper portion of the slide were done with an older model, right?

MR. AUDETTE: Right, with the old Appendix K model, what I keep calling that, from about this point up.

MR. SULLIVAN: It had homogeneous hot legs, no bubble rise in the candy cane.

MR. AUDETTE: The hot let pipe in the steam generator

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primary had bubble rise in it in the old model.

MR. SULLIVAN: Would it compute natural convection?

MR. AUDETTE: Yes, you would get steam in the upper regions which did compute a lot of natural convection.

When you started to inject auxiliary feedwater in the model, it would put auxiliary feed in essentially right at the top of the steam generator primary, which is not physically the case. That's why they went to the second node, to get a more realistic injection point in that volume.

DR. PLESSET: Were they all Appendix K except the one you indicated; all these cases?

MR. AUDETTE: When I say Appendix K, something like this would not be Appendix K because it is assumed the auxiliary feedwater is on. A true Appendix K calculation here would have auxiliary feed and single HPI.

DR. PLESSET: 1.2 ANS, that's what I should have asked you.

MR. AUDETTE: Yes, these all had that. We could survive PORV stuck open with no auxiliary feed.

MR. SHUMWAY: What about PORV with the 1.2, was that calculation not run out long enough?

MR. AUDETTE: They computed there would be core uncovery. It wasn't run out to the core uncovery but it was obvious that's where it would go. We never ran that out that far.

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MR. SHUMWAY: And these times are the times when the HPI equals the boiloff?

MR. AUDETTE: Yes. All the calculations are only carried out to 3000 or 4000 seconds. These times here starting at 47 on out were hand calculations. By that time, the system was in pretty definite equilibrium and you could hand calculate the trend at about what time you would reach a match between boiloff -- looking at the decay power curve, matching that curve to the HPI input.

MR. EBERSOLE: For the 1.2 curve, did you say there was no final answer because there was no --

MR. AUDETTE: The level was moving down and it was obvious.

MR. EBERSOLE: The 20% difference makes that.

MR. AUDETTE: Yes. ANS times 1.2 becomes quite important.

MR. EBERSOLE: That's very noticeable.

DR. PLESSET: It sure is.

MR. AUDETTE: I will just go to the summary now.

(Slide)

From the series of calculations run and discussion of a couple of transients that B&W did not compute, like the safety valves opening -- for some reason getting open and being stuck -- that kind of prank would essentially fall within the scope of the analyses they had already done.

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Our conclusions concluded here that auxiliary feed-water at 20 minutes would provide core covering for both the lowered and raised loop plants for breaks smaller than .02. Any larger breaks would depressurize to the HPI injection or core flood or level off at the steam generator secondary relief valve and have sufficient cooling.

HPI, the one calculation where, for the lowered loop plants, there was no auxiliary feed at any time, the only cooling was through HPI injection and bringing in HPI at 20 minutes was sufficient to come to equilibrium and reach cooling without uncovering the core.

In the case of the 1 HPI train when the stuck PORV --

MR. EBERSOLE: Doesn't statement 3 contain statement 1 here? It has to have a range of failure sizes. The stuck PORV -- do you mean stuck wide open?

MR. AUDETTE: Yes, we always assumed that; about .007 square foot type break.

MR. EBERSOLE: A much bigger hole.

MR. AUDETTE: As I read this, this business here at the end doesn't -- I would rather think that one over. Number 3 I don't think is correct as I read it right now.

DR. PLESSET: Do the calculations include the heat input in that one case where the pumps were not running; the main pumps?

MR. AUDETTE: I'm not sure.

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Bob? The case where the pumps were running, do you have the heat input from the pumps in the system?

MR. JONES: No.

DR. PLESSET: Was it significant? Would it make a significant difference? They are pretty big pumps.

MR. EBERSOLE: It doesn't take long until the input from them is greater than the --

DR. PLESSET: Anyway, it is significant.

MR. JONES: My understanding is that the actual heat delivered into the fluid is fairly low -- about two megawatts from what I heard back at B&W. I don't know the real number. It could be significant, depending on the actual value of heat that is posited into the fluid.

DR. PLESSET: I heard three megawatts. I wouldn't guarantee it.

MR. ZUDANS: It is significant. Two megawatts is about right but the decay heat is the same order of magnitude.

MR. SULLIVAN: That's per pump. There are four.

MR. ZUDANS: I think total. Not eight.

DR. PLESSET: You could tell us about that, anyway, Rene. They didn't include it. Was it significant? Would it make any significant difference in the calculation? They could tell you later if they don't have it now. There is only one case, as I remember.

MR. AUDETTE: That's right. That's this case here,

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loss of feedwater accident.

DR. PLESSET: We would like to know. Is it a significant error introduced that way? Can you say it is negligible? You don't need to tell us now if you don't recall.

MR. JONES: If it is about four megawatts, it would be negligible. We are tabbing long-term cooling at about 1000 seconds with the one HPI pump. That's a fairly high decay heat at that time.

MR. ROSZTCOZY: I believe it is 2700 megawatt plant. One percent decay heat would be 27 megawatts, and at that time the decay heat would be over one percent. We are talking in the order of maybe 30 to 50 megawatts decay heat at the time as compared to the 2223 megawatts --

DR. PLESSET: That's per pump, isn't it? If you had all the pumps running, it would make a difference.

MR. ZUDANS: You are talking about long term heat removal being established. About an hour later. What about that?

MR. ROSZTCOZY: I didn't hear that.

MR. ZUDANS: One hour later, your decay heat would be one-tenth of a percent.

MR. ROSCTCOZY: No; maybe 1%.

MR. SHUMWAY: 6000 seconds, it is 1%.

MR. ZUDANS: For this burnup.

MR. AUDETTE: I was stumped on this item 3 because I

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was thinking of the stuck PORV without auxiliary feed. In both of these plants, if auxiliary feed is there and a single HPI, you will have covering. I was recalling the one case where we had no auxiliary feed at all, that we had a core uncovery. If we have an Appendix K type calculation for the stuck PORV with a single HPI train, there would be core covering. The statement is correct. Then the hot leg breaks, again, as was pointed out this morning, say .01 or .02, would be quite similar to the cold leg breaks because of the action of the vent valves as far as depressurization.

MR. EBERSOLE: Statement 3, does that presume that the stuck PORV is delivering flow from a fully --

MR. AUDETTE: The pressurizer fills from these calculations. Item 5 was shown by the one asymmetrical calculation. If one of the steam generators is isolated during the rupture, this is adequate here to provide core covering. These are all breaks at the very low end of the small break spectrum. The results of this analysis provided what we considered an adequate basis for coming up with operational guidelines that have been provided to the utilities.

MR. ZUDANS: You said that from 100 seconds, all the calculations were done by hand.

MR. AUDETTE: Beyond 3000 seconds.

MR. ZUDANS: Was it at this time already clear you had reached long-term cooling equilibrium?

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MR. AUDETTE: The depressurization was fairly level. Pressure was fairly constant or level.

Maybe I can show you one other transient of pressure decay for one of these calculations.

MR. ZUDANS: 3000; not 1000.

MR. AUDETTE: Right.

MR. ZUDANS: It is not clear to me what you can do by hand on this model.

PROF. CATTON: Extrapolate.

MR. ZUDANS: Just extrapolate the curve? Oh.

MR. AUDETTE: This is with the .01 square foot break.

(Slide)

This is assuming both steam genrators operating with normal auxiliary feed about 40 seconds after the reactor scram and single HPI initiated after the pressure had dropped to 1365. This is the pressure trace, the repressurization that occurred. Then the combination of the injection of HPI, the loss of fluid out the break, and condensation at this point. Natural circulation has been lost. The only heat removal in the steam generator is through condensation of the steam in the primary tubes.

Decay power also decaying slowly. It results in this depressurization peaking at this point and slow depressurization and then the hand calculation carried on from this point.

MR. ZUDANS: What about if you ran it for that many

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more secibds. What would indicate what you call long-term cooling points?

MR. AUDETTE: Just the --

MR. ZUDANS: The fact that this curve would be horizontal or what?

MR. AUDETTE: This would flatten out -- no, it should drop even more rapidly.

MR. ZUDANS: Looking at this picture, I am wondering how do you establish this 4900 seconds or 5000 seconds as the time this will occur?

MR. AUDETTE: What they had done -- I'm guessing -- looking at this pressure decay extending on out, looking at your HPI injection characteristic curves and decay power input and loss out the break as a function of this pressure, it is a combination of all those inputs coming to a point.

MR. ZUDANS: Where the amount of HPI blowing in would be equivalent to blow-out.

MR. AUDETTE: Bringing it up to saturation would match the heat removal required from the core. Is that the way you proceeded in your calculation? I am assuming that. I am putting words in your mouth, I know.

MR. JONES: I can't remember the details on how we calculated the long term cooling calculation and inventory duirng time. The basic procedure we used for these long-term transients was we held the system pressure constant at the last

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calculated value. As you can see, the system is depressurizing.

We then took the HPI characteristics at that flow and calculated how much core heat it would be capable of removing. That establishes the time that long-term cooling will be established.

The unbroken legs matches what is being boiled off in the core.

MR. ZUDANS: In other words, you looked at the core decay heat generation curves and said: Okay, after that many seconds, core will generate that much. This is exactly what you can remove.

MR. JONES: Right, and then calculate the level in the long-term, we held the system pressure at that point, used the lead flow indicated on the high pressure and calculated a boil-off from the system, subtracted that inventory from what was remaining in the system at the end of the calculation to establish how much water was left above the top of the core.

MR. ZUDANS: In other words, you are doing it because if the pressure goes down, you will have more coverage.

MR. JONES: That's right.

MR. ZUDANS: It is kind of conservative.

MR. JONES: Yes.

DR. PLESSET: Dr. Bates shows me the pumps are each 9000 horsepower so, roughly, I would say that at least five megawatts per pump -- if all four are running, that's 20

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megawatts. Quite a bit. I just wanted to mention that.

Thank you, Rene. You really were very succinct. We appreciate it.

Zoltan, how long do you think you need for the next presentation?

MR. LAUBEN: I suppose I can do it --

DR. PLESSET: Why don't you try it?

MR. ROSZTCOZY: Realistically thinking, that would take a half hour.

DR. PLESSET: I think that's good. Everybody will look forward to a 2:00 o'clock lunch.

MR. LAUBEN: I am Norm Laubin. I am also in the analysis branch of ESS.

(Slide)

We had some audit calculations performed on some B&W small breaks. The purpose of these audits was to audit the small break calculations which may repressurize and may exhibit some heat removal problems.

(Slide)

Two cases were chosen for EG&G Idaho to calculate using a preliminary version of RELAB 4 MOD 7. The primary reason for choosing that was a self-initialization feature in RELAB, Basically, the models that are available to do a calculation such as this do not differ significantly from the models you would find in RELAB 4 MOD 6. I say preliminary

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because RELAP 4 MOD 7 is not what research refers to as a re-leas d ode yet.

(Slide)

The two cases chosen were based on the results that B&W had calculated so we could verify the important phenomena.

Case 1 was .01 square feet break in which auxiliary feedwater was delayed 20 minutes. When HPI came on, there were two HPI pumps. For this break size without auxiliary feedwater, the system may not depressurize to the HPI actuation point and repressurization will cur.

Case 2 was a .01 squa oot break with normal auxiliary feed delay of 36 seconds that B&W used in their analysis -- 36 seconds after reactor trip. One HPI pump was a sumed. This was chosen because as voids form in the candy cane, loss of natural circulation can occur.

The differences in modeling between these two cases, I will discuss in a moment, because B&W also had differences in modeling for these cases.

I will also add Dr. Fabic of research is going to discuss other work done by Idaho in support of TMI and relate bulletins and orders tomorrow. In particular, the TMI transient calculation. It is his intention to discuss that tomorrow, I believe.

DR. PLESSET: Without giving away all the suspense,

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can you give us a two-line statement of what he will talk about tomorrow?

MR. LAUBEN: I really can't. Well, I guess I can. I can surmise what he may say, okay?

DR. PLESSET: We will take it on that basis.

MR. LAUBEN: I haven't seen what he is going to say but my guess would be, based on what we received from Idaho, that there are several important boundary conditions that are difficult to know in TMI; namely, the amount of HPI going on, the real condition of the steam generators, and the real condition of the letdown.

Without these boundary conditions -- or a knowledge of these heat removal capabilities -- it is very difficult to know exactly what happened. In fact, even some simple heat balances in critical period of time, like from two to ten minutes, will tell you something doesn't even look right even on a simple hand calculation basis.

Idaho is looking into this. They ran some trips to EPRI, I believe, who is looking into these boundary conditions in somewhat more detail. They are looking at improving pressurizer models and steam generator models to get a better handle. They ran into some of the same problems at B&W, undershooting pressure during early types and that sort of thing.

They were concentrating on the first twenty minutes of the accident, the idea being you can't move on to the rest

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of the accident until you are pretty sure you have a good idea what is going on in the early part.

DR. PLESSET: Thanks.

MR. LAUBEN: Okay.

(Slide)

Following are the initial conditions for both calculations. I guess I don't need to run down these. As I said, they were both .01 square feet breaks. Of interest, perhaps, is the last one. B&W provided us with HPI and auxi'iary feed curves, which are flows of the function of pressure. Also, flow splits as a function of time.

We matched the particular heat sink characteristics the same way they did. That is, at least the input to those heat sinks. One important difference is particularly important to the second case. That is that whereas B&W controlled the collapsed level in the steam generator secondary site to 17 feet -- that is, when auxiliary feed provided enough level in the steam generator to reach 17 feet -- then they would keep it at 17 feet and just provide enough to replace whatever water was boiled off, whereas in the INEL calculations done for us, that was not done. The level was allowed to increase continuously. That makes a significant difference, as we will see later on.

(Slide)

For the first calculation that was done, standard

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large break nodalization, which had been utilized in verification of RELAB 4 MOD 5 and appears in volume 3 of that document, and the things that are different that aren't shown are things like the accumulator injection points, which are not a factor in small breaks such as this, where you don't depressurize down to accumulator actuation and anything else that really doesn't enter into the calculation is not shown.

This calculation already had separate nodalization to this extent in the upper plenum of the steam generator. However, the RELAB model does not inject into an upper steam generator node so I don't think it would show the same kind of problem B&W showed; what they separated their nodes later on.

But we will show some different nodalization. However, this is what I would call standard nodalization. Where S is shown here, it means the junctions had vertical slip. B means volumes have the bubble rise model. They used the Wilson Bubble Rise Model in this case.

What we are really comparing in this case, I would say, are calculations with a standard B&W small break model and a standard RELAP large break model; at least, for this first case.

MR. EBERSOLE: What does line 16 represent on that model?

MR. LAUBEN: That's at the top of the candy cane.

MR. EBERSOLE: The solid line 16 above the vessel.

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DR. PLESSET: That's 18, what you are pointing out.

MR. LAUBEN: Oh, I see. Let me see, that is the vent valve -- no, it's not. Oh, that's probably the bypass.

MR. EBERSOLE: Why does it go to only one steam generator? Oh, it just bypassed the vessel; okay.

MR. LAUBEN: I don't mean the bypass --

MR. GARLID: It feeds to the plenum.

MR. LAUBEN: It feeds from the downcomer to the upper plenum.

MR. ZUDANS: Vent connection.

MR. LAUBEN: The vent valve is right there; 15.

MR. EBERSOLE: This accounts for bypass flow from high pressure injection, doesn't it, where appropriate?

MR. LAUBEN: That's right. Junctions 57 and 56 are the HPI injection --

MR. EBERSOLE: That's unheated water going to the reliefs, is that right? High pressure injection, some fraction of it, can be hypothesized to go to the breaks without going across the core.

MR. LAUBEN: That's right, it could.

MR. EBERSOLE: It dilutes the capacity of the relief valve.

MR. LAUBEN: The break is right here. That could happen for the particular case.

The first case was the delayed auxiliary feed. You

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would have a heat sink for a while while you are boiling off the steam generator and then you have no heat sink at all.

(Slide)

While you still have some heat transfer, secondary pressure drops. When you lose it, the pressure rises. Modeling in the secondary doesn't matter too much in a case like this. Also, in this case there were two HPI pumps that came on -- excuse me, let me say something about HPI first.

HPI is supposed to come on at 1365 plus a delay. This little dip here went below 1365. To be consistant with B&W, we decided not to have HPI come on at that point. Rather, what happens is the HPI does not come on. You have no auxiliary feed. The system pressures up to just about the point of the relief valve. It was timed so when the auxiliary feed came on, it would just miss the safety.

The RELAB indicates it exceeded the safety, but once again, one of the safeties did not pop, so one could see exactly when it would reach the peak, the 20 minute auxiliary feed delay.

When auxiliary feed comes on the system, you pressurize it and 1365, which is 18 or 1900 seconds, HPI comes on and you have depressurization.

So I think the thing about this is th t this appeared to us to be a pretty good comparison of the B&W calculation.

The next one is break flow.

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MR. EBERSOLE: Before you leave that, I want to have a look at it. That's a .01 break. It showed that the PORVs were in function. You have pressure above the setpoint; 2500, about, haven't you?

MR. ZUDANS: They were not allowed to function.

MR. LAUBEN: I don't remember if they were allowed to function.

MR. EBERSOLE: If we go to the relief setpoint PORVs and that's a two-phase discharge, which I presume it is, the inference can be that a small break, because of damage to the valves in handling two-phase discharge, will naturally propogate to an intermediate break.

MR. LAUBEN: Maybe so. In fact, it may have even lapped.

MR. EBERSOLE: The small break lights it off and, because of two-phase discharge, it proceeds into a larger break here, right?

MR. LAUBEN: I would certainly say that's something that should not be ignored.

MR. JONES: Remember, this case is assuming we have no auxiliary feedwater throughout the first 20 minutes of the transient. That's why it got up there.

Where you had the old auxiliary feedwater, the pressure was 1800 psi.

MR. EBERSOLE: When you didn't have it, maybe that's

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a good thing; I don't know.

PROF. CATTON: Only the RELAB reached 2500.

DR. PLESSET: It would be interesting to have it for 1.0 ANS-2 as well as 1.2. That would make a difference, I'm sure. It would be very interesting to have that, I should think.

PROF. CATTON: Did you allow the relief valve to open up?

MR. LAUBEN: No. It was inadvertent at first. In retrospect, we were glad it happened. How high would it go up before the 20 minute delay would catch it? About 100 psi more than what B&W's calculation showed. So we didn't ask them to repeat that.

(Slide)

DR. PLESSET: Pretty good agreement.

MR. LAUBEN: Yes, which is almost surprising when you look at break flows. Perhaps the idea is that these break flows average out in this region. It wouldn't make that much difference. I couldn't tell you exactly why B&W CRAFT break flows look like this.

MR. CUDLIN: I am Joe Cudlin.

We don't have any provision in CRAFT to smooth out any water packing problems. That oscillation break flow could be partially attributable to water packing and could also be an alternating movement of liquid in and out of the leak

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volume. Our leak volume may not have been the same size as the one used in the RELAB analysis, either, which would contribute to that.

DR. PLESSET: If they had water packing, that is enough in itself to cause a little distress. It is interesting that the RELAB was --

MR. LAUBEN: Should water packing make much difference out at those times? It would? Okay, I'll take your word for it.

MR. CUDLIN: It depends, to a certain extent, on what size break flow you use in the RELAB model compared to what size you use in a CRAFT model. It almost looks to me like the CRAFT break flow there is alternating between a subcooled model and a slightly saturated flow, which would jump by orders of magnitude like that.

MR. ZUDANS: My question is: If your break flow is so violently different, how can you possibly get the same type of conclusion?

MR. LAUBEN: I'm not sure. All I can suggest is in this period of time, they average out to be about the same. I am not sure if that's fortuitous or not.

MR. ZUDANS: The first seconds are distinctly different.

PROF. THEOFANOUS: The early part, where it is smooth, is very different. That should be possible to explain.

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MR. LAUBEN: Definite difference in the break flow models.

PROF. THEOFANOUS: They use different models?

MR. LAUBEN: Yes.

DR. PLESSET: What did RELAB use?

MR. LAUBEN: I think it was homogeneous equilibrium. Henry Fauske.

DR. PLESSET: Okay.

MR. JONES: Our subcooled discharge was the Bernulli Model.

MR. ZUDANS: The question still remains: How come the results --

MR. LAUBEN: I think perhaps the answer in part is that without the auxiliary feed, the break flow may still be small enough that you are just not taking up enough emergy to make that much difference. Factors of two or three difference are in the flow here. I think that may be the primary reason. Without the heat sink, you just aren't taking enough energy out of your break.

DR. PLESSET: The pressure is kind of a smoothing thing to look at, anyway.

MR. LAUBEN: Yes.

(Slide)

Okay, this is the mixture height in the vessel. I guess it doesn't say where it is. This is the mixture height

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in the vessel comparison between CRAFT and RELAP. As we saw, the break flows were different and RELAP's was smaller. I might explain why there is more mixture in RELAP. In any event, both of them showed no core uncovery.

MR. MICHELSON: What is the zero point on that slide?

MR. LAUBEN: The bottom of the core.

MR. MICHELSON: Bottom of the vessel or core?

MR. LAUBEN: The bottom of the core.

(Slide)

Temperatures: I will just briefly show the hot leg and cold leg temperatures. They show the same behavior, which is not surprising. It shows both can do a reasonable heat balance, I guess, for a case like this. It is probably not that taxing.

(Slide)

Now we get to this case. This is the one without auxiliary feedwater delay and I want to explain this curve. First of all, this curve is based on results not of the model -- well, let me say this: In this case, we are looking at the same RELAP model we looked at before for the other break, but in this case CRAFT modified their model, as was explained by Rene, to include the additional volume up on top and they already had the bubble rise in the candy cane and they already had the multiple horizontal junctions that were explained before.

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RELAP did not have those things or things like this at this point. We kind of decided we would do this in a pristine way, start with the model we had before and see what kind of answers it gives without prejudging what should or should not be done to the model. Start with the same model.

Obviously, RELAP predicts somewhat different behavior; namely, the pressure continues to decrease, no loss of natural circulation, no increase in pressure the way CRAFT had shown it. The only reason there is a slight increase in pressure here is that the HPI injection flow is kind of high and starts to fill up the system down there.

We said all right, apparently to explore this phenomenon of the potential for interruption of natural circulation, more sophisticated models need to be added to the calculation.

(Slide)

Therefore, let me say this: The hot leg piping was broken up. Where this, before, was one node, it was now broken up into three nodes. Vertical slip was put into the two new junctions. In addition, bubble rise was added to the hot legs, which wasn't in before but it was in the B&W calculations. I haven't shown it here.

Let me say in addition, one of the cold legs -- I believe it was this cold leg -- had additional nodes in it before and they were combined. There didn't appear to be any

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need for cold legs. There is kind of an evolution of a shall break model from a large break model. You realize certain things are needed and certain things aren't.

So a combination of nodes was accomplished here. Additional nodes were incorporated in the hot leg. A bubble rise and vertical slip were incorporated in the hot legs. In addition, let me also say that two calculations were done with this nodalization; one in which the horizontal slip model was developed specifically for small breaks for RELAP 4 MOD 5, which is still resident in MOD 6 and 7. They were used in one case. In another case, they were not.

In particular, in this junction and in the junction entering the upper plenum. This didn't appear to make much difference. I will be talking subsequently primarily about the one that did not have horizontal slip on those junctions because I have more up to date plots for that particular case.

(Slide)

Let me put back the original picture and see if, by the magic of xerography, we can overlay some plots here.

(Slide)

They don't overlay exactly. The old RELAP calculation depressurized like this. The new one exhibited repressurization and then depressurization, which wandered down to where it was before.

As I mentioned to you earlier, there was no control

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on steam generator level in the RELAP calculations, which made them a slightly different calculation. I believe the B&W operating procedures say something like if you find out you have a small break, raise the level of the steam generators. You don't keep it down at the 17 foot level, as I recall,

If you want to make a correction to that....

MR. JONES: Yes. If the RC pumps are off --

MR. LAUBEN: That's what we have in these cases.

MR. JONES: -- the ICS will automatically control the --

MR. LAUBEN: Okay, so you actually were doing a calculation of what I guess would be a more severe condition where the steam generator level was lower.

In the case of RELAP, the steam generator up to this point had not even filled up and, indeed, it appeared that you were simply adding auxiliary feed to the secondary side, and by sensing the heat alone, it was enough to take the heat out. We can see that in the next figure, I think.

(Slide)

Here we are comparing pressures to the B&W calculation and in the RELAP calculation. Both of them show a rise, though I'm not quite sure why. I think there are differences because, truly, steam generator models are somewhat different. There are differences in early time, as well.

In the B&W case, you hit the steam generator relief

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valve pressure and it stays there, whereas in RELAP they are adding so much auxiliary feed that the pressure is actually decreasing so there is plenty of heat just from the auxiliary feed alone during this time, and eventually you get to the point where it is completely depressurized.

That's our preliminary indication. I wouldn't want to state that with a great deal of assurance. We are still looking at that. That appears to be the preliminary indications as to why it behaves in that way at the end part of the transient.

I guess I should say a cautionary word about all these interpretations. Maybe that pre-empts one of my conclusions but these things are still being looked at.

(Slide)

Okay, probably I will end up -- well, I already went past my half hour. This calculation shows mixture level in the candy cane and vessel site. As you can see in the RELAP calculation on the vessel site the hot leg stays full until this point. I think I have a plot later on that shows the reason why suddenly this drops. The reason is that you uncover the hot leg nozzle and that allows water to go back into the vessel and steam to rush up into the hot leg.

The level drops in the candy cane at that point and that's where you -- I hate to call it lose natural circulation because the RELAP calculation -- I'm sorry I don't have a plot

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of core flows. You don't really lose natural circulation in the sense that B&W was showing. I'm really not quite prepared to go into a sufficient explanation of why.

We have been discussing this with the analyst at Idaho and I think it requires some further consideration. But, at any rate, that's the reason why you drop it. If I did have a core flow -- here, I'll tell you what I do have; a broken leg flow.

(Slide)

First, let me say that this period of time here is from about 200 seconds to 700 seconds. B&W shows a flow that is total flow -- a set of hot leg flows, slightly above it, maybe 30 or 40% greater than this. When they lose natural circulation at 650 seconds, their hot leg flows rock out to the bottom here.

RELAP doesn't show this. It shows an oscillilatory behavior in the hot leg flows.

MR. ZUDANS: Zero.

MR. LAUBEN: It's above zero. That's kind of insignificant compared to this. I apologize again for not having a core flow. The core flow oscillatior is even higher. It shows a substantial amount of core flor. Maybe half of that is circulating through the vent valves. imagine B&W would show about the same thing.

MR. ZUDANS: Could you overlay the previous picture?

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MR. LAUBEN: Yes.

(Slide)

MR. ZUDANS: Interesting.

MR. LAUBEN: That's right, they certainly do coincide. It does interrupt flow to a degree.

MR. ZUDANS: When it comes unstable in the calculation, at that point --

MR. LAUBEN: I'm not sure it is unstable yet, either, but it is not the long-term interruption of natural circulation that is shown in the B&W calculation.

If you look at the pressure, I was trying to look at the pressure and decide whether or not, when I see this upsurge of steam as you are going over to the steam generator and condensing and causing the pressure to be reduced, I'm not sure the timing is such that I believe that completely yet. I'm a little bit hesitant to go much further.

MR. ZUDANS: The real question is: Can you believe the calculation from that point on?

MR. LAUBEN: That's not a numerical. That's a 70 second cycle, something like that. I don't know physically why I would t believe the calculation yet. You may be right. Until we analyze it further, I wouldn't want to say whether it is believable or unbelievable.

PROF. THEOFANOUS: Is this like a level phenomenon taking place? It automatically gives you a surge and nothing

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else but --

MR. LAUBEN: It may be just that. If you look at the core, the vessel level goes up. Let's see, do I have that here or -- yes, I think there is an upper plenum level picture in here. That's core mass.

(Slide)

Obviously, there is some kind of voiding of the core occurring during this period.

Here is the upper plenum mixture level.

(Slide)

You can see this is the level of the hot legs right here. You can see this phenomena starts, exactly when your hot leg mixture level gets down to the level of the nozzles. It provides a vent path and you have a level swell. It fills it up again. I don't know, that's not exactly the kind of thing B&W was talking about.

What they are talking about is losing the heat transfer altogether. If I had the core flow picture, you would see it doesn't get lost. I think there may be some key in all this to bubble rise models, too. I'm not sure.

What do you use at CRAFT?

MR. CUDLIN: Wilson.

MR. LAUBEN: You use Wilson?

MR. CUDLIN: That's right.

MR. LAUBEN: Well, we will have to look at it more

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carefully.

PROF. THEOFANOUS: Could you relate to what you use for condensation? If you do the condensation slowly, you allow the bubbles to separate easier and have less of this dynamic swelling, I think.

MR. LAUBEN: CRAFT keeps a heat transfer coefficient near the top of the steam generator. I don't know what the number is but I think it's constant.

Maybe Bob knows. We were discussing on the phone the heat transfer model in the steam generator. I think it is a constant heat transfer coefficient you use on the secondary site, is that right?

MR. JONES: It is.

MR. LAUBEN: That's because, especially in a plant like this where you have auxiliary feed on top, you bring the auxiliary feed onto the tubes and you do get good heat transfer up there.

Zoltan pointed out the heat transfer area is so tremendous that even a small amount -- even a modest coefficient -- will transfer plenty of heat during this period of time.

Now RELAP, on the other hand, I was discussing this with the Idaho people, has a distinct water level on the secondary site. You can notice that the heat removal above the mixture level on the secondary site is very low by

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comparison. Most of their heat gets transferred in the first heat slab below the mixture level, so there may be some difference there we will have to look at.

These are all things that require further exploration.

MR. MICHELSON: Before you remove that, where is the zero reference point?

MR. LAUBEN: It is probably the top of the core. This is the hot leg nozzle elevation right there.

DR. PLESSET: I will suggest you finish up.

MR. MICHELSON: One more question. This is kind of generic in nature. These calculations keep dribbling on down to lower levels. Does it really, at that point, turn around and start going back up? How do you know?

MR. LAUBEN: We don't yet.

MR. MICHELSON: You haven't run it further; okay.

DR. PLESSET: Why don't you finish up?

MR. LAUBEN: I will. I have two conclusion slides. The first one says in the first case the comparison looked pretty good and no core uncovery was shown. I will put that up next.

(Slide)

And there is the second slide, having to do with the case with no auxiliary feed delay.

(Slide)

I'm sorry, I left out a very key word. It may have

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been a Freudian slip here. It should say RELAP and CRAFT differ in key variables when analyzing this case. The differences may be due to auxiliary feed control.

I think I might add it may be due to steam generator heat transfer models, In either case, no core uncovery was indicated. I would say that RELAP seems to show more core cooling in this period of time after 700 seconds and that the type of interruption in natural circulation was somewhat different in the RELAP calculation.

Also, that we should study this case further. That is the key conclusion at the end there.

MR. MICHELSON: If I understand your answer correctly you can't yet conclude there is no core uncovery. You haven't run the calculation far enough.

MR. LAUBEN: Fair enough. As far as we went.

DR. PLESSET: I am going to declare a recess --

MR. KANE: We would like to make a clarification on something we said earlier.

DR. PLESSET: All right. Brief, I take it.

MR. CUDLIN: I have had a chance to look at the noding diagrams and look at the break flows again. I would like to correct my observations.

I think what is going on here is, in the CRAFT model, the break opening is located at the bottom of the control volume and it is being alternately covered by liquid or

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steam so that is reflected by a jumping back and forth between the mass flow rates at the break.

I think the RELAP model -- you said you used AGM, Norm?

MR. LAUBEN: I think so. Fauske in the subcool and the --

MR. CUDLIN: You used the inertial junction type? My guess is that RELAP bases its leak rates on volume average conditions so you would not see alternate covering of the opening by liquid. We found that for MOD 6. I don't know if it is in MOD 7, as well.

DR. PLESSET: Okay, thank you. That helps.

Let's recess until 3:15.

(Whereupon, the luncheon recess was taken at 2:15 PM.)

end AM

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AFTERNOON SESSION (3:15 PM)

DR. PLESSET: Let's reconvene.

MR. ROSZTCOZY: We have with us Bruce Wilson from our operating branch. Bruce has participated in the preparation of the guidelines and the emergency procedures and also reviewing examinations given to the operators. Bruce will follow with his first presentation, which is a review of the B&W guidelines.

MR. WILSON: My purpose here is going to be twofold. First will be to talk about the guidelines developed by B&W in order to prepare emergency procedures for the small break accident. These procedures were reviewed and approved by the NRC staff subsequently.

Secondly, it will be to talk about the methods for review and approval of the procedures that the individual facilities developed.

Followin- my two presentations, another member of the operator licensing branch, Bruce Bogar, will speak on audits we conducted at four of the operating facilities, Crystal River being the only exception since they are being done this week.

I notice our scheduled called for us to begin at 1:30 and conclude at 4:30. With luck, we can conclude on time. I don't think the three presentations will take that long.

(Slide)

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In a parallel effort with the small break analysis B&W developed the guidelines for the small break accident for the individual facilities to write the emergency procedures for the operators to cope with the small break accident. The guidelines were divided into two parts. Part 1 was background information for a spectrum of loss of coolant accidents. Part 2 were the actual guidelines for the small breaks.

Part 1 was basically background information, basically a description of the plant behavior during a small loss of coolant accident in which availability of feedwater and reactor coolant pumps are considered. Part 2 contains the actual guidelines, themselves. They were delivered to the NRC for review May 6, 1979.

We reviewed the guidelines and transmitted our comments to B&W by May 9. The subsequent revisions were then sent to the appropriate facilities. The guidelines are divided into the following sections:

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These are symptoms and indications, immediate actions by operator, precautions, follow-up actions. This generally follows the format of most emergency procedure guidelines.

Usually, however, we will try to combine the precautions with the follow-up actions so the operator knows when it is necessary to take these appropriate precautions. Now, immediate actions, we require the operator to know these from

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memory. They should be directed at achieving a stable plant configuration in as short a period of time as possible for the operator. Once he has achieved this condition, he is able to consult the procedure, itself, and take it out and follow the subsequent actions or follow-up actions as they are written for him.

One major function of the guidelines was to provide acceptable criteria to the operator for terminating high pressure injection. The two criteria B&W specified are as follows:

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If the HPI system has been actuated because of a low pressure condition, it must remain in operation until one of the following criteria is satisfied: The HPI is in operation and flowing at a rate in excess of 1000 GPM in each line and the situation has been stable for 20 minutes or all hot and cold leg temperatures are at least 50 degrees below the saturation temperature for the existing RCS pressure.

If he cannot maintain this degree of subcooling, the HPI shall be reactivated. Initially, B&W recommended HPI -- continuation of the HPI had three criteria:

One, keep the high pressure injection system running at least 20 minutes. We found, in certain circumstances, this was not acceptable. The main steam line rupture would be one where we feared continued operation of the system wasn't

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necessary and would repressurize the system and pressurize the safety valves.

The guidelines address four small break accident situations.

(Slide)

These were not necessarily as they occurred at Three Mile Island. However, in the order in which they occurred at Three Mile Island, but since they did at one time or another come up there, B&W decided to put them in the guidelines. We consider the shall break accident with feedwater and reactor coolant pumps; with reactor coolant pumps and no feedwater; no pumps and with feedwater; and without either of the above.

The first case, naturally, is the easiest one to control. One reactor coolant pumper loop is stopped and the cool-down rate is established using the bypass valves, if available, or atmospheric conditions. For low temperatures and pressures, the operator can switch to decay heat removal systems.

In the second case, without the steam generators as a heat sink, the basic classes of break response that are possible are the following: All decay heat is removed via the break; the decay heat is removed with both HPI and the break; HPI is not automatically initiated and the RCS system re-pressurizes.

I don't know if Part 1 or Part 2 of the guidelines has been distributed to the committee but these cases are

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covered in Part 1 under "Descriptions." I don't see any purpose in getting into each individual case right now but we did address these in the procedures and give the operator appropriate guidance to follow.

PROF. CATTON: Anywhere in your guidelines, in setting these things up, is there an attempt made to try to figure out what dumb thing the operator is likely to do in order that you can maybe modify the procedures? I see a lot of the kind of thing you are doing going on but nowhere do I see anybody who is dealing with the operator. Either there is a whole bunch of different simulators around the country or -- people must know what dumb things operators do. What guidelines can you specify so that the operator won't do those dumb things; particularly the ones you know about?

MR. ZUDANS: Or what not to do.

PROF. CATTON: I would hope this is where that would lead.

MR. WILSON: With all due respect, we would prefer not to call the operators dumb. They make human mistakes. They are compiled. We are making every effort --

PROF. CATTON: You have simulators around. You have an excellent opportunity to assess how good these procedures really are. B&W ran 180 through their simulator. They run all the operators through from all the plants. Should there not be some feedback from that? Aren't they exercising these various

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procedures at the simulator?

MR. WILSON: These, no, because most of the operators completed the simulator training on the TMI-2 accident before the procedures were developed and approved. The last group of the Rancho Seco people are going through the simulator training tomorrow or the next day.

They were not able to use these particular procedures on the simulator. There is also one section of the accident situation that the simulator was not able to simulate. That's what you get -- I guess it was termed a reflux boiler mode of condensing.

PROF. CATTON: That wasn't the point. I asked: Are you doing anything to try to figure out what mistakes the operator can make so you can feed them back into how you write your procedures? I gather the answer is no. That's fine.

MR. WILSON: The mistake we recognize made at Three Mile Island was to terminate high pressure injection. It was actuated on a low pressure condition and terminated before that low pressure condition was satisfied.

We are making an attempt here to drill into the operators that particular mistake. According to the small break analyses, if anything else is done, as long as maximum high pressure injection is maintained on a small break, the core will be covered. That is one step we are making towards that.

DR. PLESSET: I am surprised at your great confidence

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in these simulators.

PROF. CATTON: It is not that I have confidence in them.

MR. ZUDANS: That's not the point. The way I read it, I would agree with that. It is a very good point. You run the simulator, you collect all kinds of information. You can see what reactions operators have. You collect statistics on that. You could classify all the mistakes with the frequency and probability of occurrence. That would give you some indications as to what to be stressed in instructions like these as a negative part.

PROF. CATTON: The [illegible]tiveness of the procedures.

MR. WILSON: That's true, it could be done. In terms of getting proper statistics on this, I don't think the industry is able to do something like that right now. It would take a great deal of time and money to commit these licensed operators to operate in a simulator for that period of time in order to gain this necessary data.

PROF. CATTON: There were just a hundred-some-odd run through. I was surprised nothing like this was done when they ran so many through in such a short period of time.

MR. ROSZTCOZY: One must realize in order to do the type of thing on the simulator like you are recommending, one would have to program on the simulator a good number of different small breaks. There would be -- I don't know -- five or

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six different small breaks, and then the operator would be confronted with one or another of these and you could check his response, how he is handling it. This has not been done.

In the past, if anything, there was one small break program and that showed the pressurizer level dropping down as soon as you pushed the button and so on.

This is a big step and would require a lot of work to prepare the simulator. Then, if you take all the people who are qualified operators and put them through on this program, it takes a while. The B&W case, I believe, is only the operating plants so that includes only four utilities.

MR. WILSON: Five.

MR. ROSZTCOZY: Five utilities.

To put through the five utilities on a training program -- I think it was a one-day training program; a six hour training program. Each operator went through the program. The purpose of that was to look at what happened at TMI-2 and go through the scenario of that. That took from April, when it started, maybe until June just to complete this for five utilities.

We are talking about a much larger number.

DR. PLESSET: I think you put overreliance into building up the right neural patterns in the skulls of operators with the aid of a rather limited machine. It might be more worthwhile to spend more effort in getting better skulls to

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start with.

PROF. CATTON: I would agree with that.

On the other hand, when you have the system there, to pay very little attention to it seems surprising.

MR. ZUDANS: If they even run for four hours, I guarantee, before that operator passed, he made some wrong moves. Why not keep a record of the wrong moves and analyze them?

PROF. CATTON: At least, it is an opportunity to check the man's reaction under a bit of pressure. Inadequate as it may be, I would feel it would be better there than when running a plant.

MR. WILSON: Let me make one more attempt at this. First, I agree, I don't think any thought was given to this particular idea beforehand. Perhaps it should have been.

Secondly, the idea of the simulator training for each of the individuals was to train them on the TMI break and similar accidents or transients that could cause depressurization and initiation of the high pressure injection.

Thirdly, when they did this training, the operators, themselves, were instructed beforehand what they were going to see and what the best course of action was to get themselves out of it. This wouldn't have been classified as a virgin type attempt by the operator, himself, to see a new situation.

PROF. CATTON: But he is up there with a bunch of

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people watching him. He will be nervous.

DR. PLESSET: You are saying put more etfort into the simulator and simulator training. I think, more importa than that, would be to have an arrangement whereby 1400 lights and alarms didn't go off at once. Nobody can respond to that effectively. It seems to me you are limited as to what you can do. This may be a better area to concentrate on than in putting a lot of faith and further time on a simulator which is deficient.

PROF. CATTON: You keep assuming I am saying spend all the time on the simulator. I am n t.

It's just that it is there. Why is the information being thrown away? That's all I'm asking.

DR. PLESSET: Okay, I don't want to protract the discussion.

MR. EBERSOLE: This kind of information was on those simulators prior to TMI.

PROF. CATTON: They were not paying attention to it then. I wonder why they are not now.

DR. PLESSET: Any other comments?

MR. LIPINSKI: This question of feedback and the writing of procedures, after Three Mile Island -- I won't specify the reactor because I don't have the details -- an operator was performing a procedure. He got down to the bottom line which said to push this button. I believe the procedure

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called for him to hold it. So he turned the page and went to the top of the page and it says to push these two buttons. The previous one said hold this one; the next said push these two. Except they are ten feet away and he didn't have ten-foot arms.

He exercised his ingenuity, got a piece of tape, taped the first button and walked over to push the other two buttons.

It turns out that he turned two pages in the procedure.

Somewhere, if there is an incident of an operator going through a procedure making a mistake, the procedure ought to be specific and say this procedure can be completed by a single man such that when an operator flips two pages, it becomes obvious to him he doesn't need ten-foot arms.

MR. WILSON: I heard of that incident. I didn't know all the particulars. I just heard that it was either a reactor trip or safety injection was caused by the operator skipping a page. I was not aware he taped over a switch.

MR. LIPINSKI: He taped the first button to walk ten feet over to press the next two.

MR. WILSON: Then I guess you would classify him as a dumb operator.

MR. LIPINSKI: Is there something to be learned from the lesson in terms of a procedure so the procedure specifies a single man can do it or that it takes two men? I don't know

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if all these procedures can be done by one man.

MR. ZUDANS: The procedure should not skip the page.

MR. WILSON: It had to be an individual performing the procedure who was unaware of the steps. It was possibly the first time he completed it. We may look at something like instituting a requirement that you cannot do a procedure unless you are completely aware of it. Many of the procedures I am aware of will have that statement in the beginning: "Read through the entire procedure first." Particularly surveillance procedures on reactor protective systems and engineered safe-guard systems that require the operator to read the procedure first and be familiar with what he is doing.

MR. LIPINSKI: He may have done the same error twice if the pages were stuck together. He may have read it twice the same way until he went to execute it and realized he had to walk ten feet.

The point is that if these people are working on the simulator, you can see what mistakes they make. Can you learn from these to try to improve the procedures? That's the main point.

DR. PLESSET: Those pages would be nice and clean and wouldn't stick together in the simulator. It's around a dirty, old control room that they get gummy and stick together. No matter how much time you spend at the simulator, you won't run into this.

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You have to concentrate your energy, it seemed to me. There are all different ways of improving everything -- better simulators; more training on them -- but there are lots of other things that might be more important as far as helping the operators. That's what I think we should try to think about in general, it seems to me.

Now other people may not agree. I think that the simulator is a little bit like going to school. You don't learn everything that way, in spite of all the distinguished professors around here.

(Laughter)

Does anybody want to contradict that?

MR. LIPINSKI: These operators see very few unusual events in an operating plant. That plant, when it runs, is started up and runs according to plan and shut down according to plan. The abnormalities are few and far between. It is only the simulators where they get to see the abnormalities with planned frequency. The simulator has an application in that respect for abnormalities. Normal operation is different.

DR. PLESSET: I am not saying to get rid of the simulators. Just don't put too much input on one area of the improvement of operator behavior.

MR. SULLIVAN: We have looked at what you have recommended for changing those procedures. What are you doing in the long-term? How do you see we will get out of this

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problem of having a set procedure or do you plan on changing anything?

MR. WILSON: In terms of training requirements, licensing programs or what?

MR. SULLIVAN: The whole thing.

MR. WILSON: Yes, we are looking at it. We have half our licensing group now engaged in an individual task force and the other half is preparing commission papers and looking at the overall program. We only have some preliminary feedback from what the other people are looking at now. It is much too early to tell.

MR. SULLIVAN: So you will be looking at the whole way you train operators, the way your procedures are written and how they respond.

MR. WILSON: Yes.

MR. ROSZTCOZY: This was a requirement for the B&W plants to complete this, including the training of the operators prior to the start of the plants. In a case like Oconee, which had already restarted, the whole sequence of events has been accomplished and completed. Some of the other ones are presently on their way.

MR. SULLIVAN: I look at the procedures and say that would take care of a TMI problem but I don't think we are smart enough to sit here and figure out all the different problems that an operator can get himself into. What is being done to look at those types?

MR. ROSZTCOZY: Bruce brought this up earlier and stated, as far as the small break LOCA is concerned -- and that is what their procedure is for -- the only thing that is really important is not to turn that safety injection water off. If it wasn't initiated, initiate it.

Another one is to keep the auxiliary feedwater going.

There are basically two things the operator has to remember and has to keep going. As long as he keeps those two, then the other things will not have too big an influence.

MR. GARLID: Is the operator given some sense of priorities like that, like Zoltan referred to? The most important things are this and this. In training, do the operators get a sense of the priorities, an indication of what is crucial?

MR. WILSON: In the control room, it would only be relying on instrumentation and training. In the procedures, we have tried to specify or lay it out that way in terms of what is required under the immediate actions that he must do. This would involve maintaining high pressure injection flow and subsequent action, which would be to restore auxiliary feedwater.

MR. GARLID: This gets into the realm of human engineering. Does your staff have connections with other industries -- like the aircraft industry, where pilots train on

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simulators?

MR. WILSON: We are looking into it now. We have looked into it in the past. As far as I know, we have no legal justifications or regulations to require human factors engineering in the control room. I have been looking at this and several other members of operator licensing have been for the last few years. We have been talking with Dr. Alan Swain from Sandia, who is large in the field of human factors engineering.

We recognize the problem. We understand that many of the control rooms today are designed with a gross lack of human engineering and, hopefully, it will be looked at in the future, also.

Whether or not this played a part in the accident, it certainly plays a part in any future actions.

MR. MICHELSON: I wanted to discuss with you the Oconee small break procedures. Is this a good time to do it? I was afraid you were about to get off that question.

MR. WILSON: What I was going to do was complete the guidelines, the courses of actions recommended by B&W for the operators to take, and then get into our review of the procedures.

MR. MICHELSON: Okay, that would be a better time.

Let me ask you a more generalized question which you can answer now or later. It is not real clear to me what the operator does if he is in the process of a startup or shutdown and experiences a small break which seems like a credible situation, or maybe he is even on shutdown cooling and his system somewhere experienced a small break. What procedure do I go to; the small break procedure or is there something else, some other procedure to go to? How does he know which one?

MR. WILSON: In terms of being on shutdown cooling, right there, by definition, that will take care of the small break accident. He would be concerned with it.

MR. MICHELSON: I don't think I can agree with you that takes care of a small break accident. When experiencing a small break, I have to do something about inventory. What am I supposed to do? Am I supposed to start the HPI pumps? I'm not sure under that circumstance. Something else?

The same questions on startup and shutdown. When do I decide to drop off the small break procedure and go to some other? What should I do?

MR. WILSON: Going from the small break procedure to other procedures, we tried to identify this but this doesn't answer your question for what happens if he is, say, in the heat-up phase. We haven't addressed that.

Perhaps it is something we missed. There is a likelihood of it. I know it occurred at Zion, for example. No, we have not looked at that.

MR. MICHELSON: I think quick looking is needed when these plants are running and going through startup and shutdown

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and shutdown cooling.

MR. EBERSOLE: I think it is within the scope of your fairly narrow topic here because you mentioned it. You said that you were going to ask operators to commit certain things to memory here, presumably so he can respond fairly efficiently and fast.

There are two schools of thought here. I want to get into the aircraft field a minute. The probable name for a backup is the pilot/co-pilot relationship. It is fine to memorize things. Operators take pride in memorizing things. In doing that, they introduce a deadly hazard that they will forget one or two steps along the way. Invariably, whatever they do should be followed by a check-off to determine that they have, in fact, done what they intended; preferably by a second party.

MR. WILSON: This is what we normally expect the operators to do in an emergency situation. We have evidence they did it at TMI. The first indication we had was they believed there was a turbine trip followed by, nine seconds later, a reactor trip. They were following their reactor or turbine trip procedures. From the testimony I read of the operators and which we believed to be the case, this is the method of our examination when we go to the plant.

The second operator, when he becomes available -- I believe there were two operators taking care of this problem

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and the third one said the first thing was to take out the emergency procedures. We do not believe it is necessary to sign-off on each step with ar emergency procedure, but they usually take them out to verify that they have performed the required actions and go into the subsequent actions. This is the method, we hope.

MR. EBERSOLE: Did they do this at Three Mile Island? Even so, did the running operation escape this process?

MR. WILSON: The preliminary evidence I have just from the interviews they had with the operators was that it appeared they were following a reactor trip procedure. I don't know at what point they became aware of the low pressure condition where they should have been following a loss of coolant procedure.

MR. EBERSOLE: Do you agree there should be a follow-on from the -- a follow-up, a check-off?

MR. ZUDANS: Check list.

MR. EBERSOLE: I don't mean sign-off. I am talking about a check-off.

MR. WILSON: That's how we do it now. The second operator is supposed to be there with the procedure, reading it to him to make sure he verified all this.

MR. EBERSOLE: That happened in Three Mile Island but, even so --

MR. WILSON: I think it happened at Three Mile Island.

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That's what I am saying.

Let me complete the guidelines and we can move on to the individual procedures. We have identified the courses of action to take for a small break accident considering feedwater and reactor coolant pumps. With reactor coolant pumps and feedwater available, it is a relatively easy transient to take care of. Steam generators can be used until the low pressure injection system can be iniated. If feedwater is lost, they can switch to the pump. If it is lost, the number one priority would be to maintain maximum HPI flow.

Stop one pumper loop, which is a source of heat into the system to take out. As pressure increases, if the break is small enough and the pressure increases, operate the PORV. The next priority would be to restore feedwater as soon as possible.

MR. MICHELSON: Stop for just a moment. There is a question which I asked this morning about what happens if you already have a small break LOCA going, and I guess under certain of your small break LOCAs pressure can increase according to your calculations.

Now we have a specific indication that he is supposed to open the relief valve besides? That should be analyzed to make sure how that behaves.

MR. ROSZTCOZY: There is a case we discussed earlier and I believe in this set -- Rene showed this on his slide --

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we did not have a special case which would have covered this. The way the spectrums are done is most probably bounded. I agree, since this is a case -- some sample analysis should be available here.

MR. WILSON: The next case in which there is a small break without reactor coolant pumps but with a heat sink and steam generators: The operator will cool the plant down, maintain high pressure injection but will cool down the plant with natural circulation. If unable to restore that or unable to verify that, restore with the reactor coolant pumps if they are available. If not, cycle pressure between 2300 pounds and 100 pounds above pressure with the POB. If the POB is not available, you allow the system to go to the 2500 setpoint of the safety and make every attempt possible to restore feedwater.

MR. ZUDANS: What is the last line?

MR. WILSON: What we are looking at is a situation where the break size is small enough so the RCS will --

MR. ZUDANS: The first line is natural circulation. If unable, start pumps. Next line, unable, start pumps. That line is no natural circulation, no pumps. How do you --

MR. WILSON: B&W said there is a small break size spectrum of size in which the break size isn't able to relieve the break. I assume that pressure reached saturation and is repressurizing at the primary system. We are trying to stay off the code of safety with the pressurizer because we will open

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up at 2300 pounds and allow it to come down to about 100 pounds above steam generator pressure.

MR. ZUDANS: This last sentence refers to a case where you have neither the steam generator nor coolant pumps can be started.

MR. WILSON: The steam generator is there but no natural circulation.

MR. ZUDANS: Could you cool down by injection and by the relief valve? All right.

MR. EBERSOLE: All this is built against the modified version of the B&W plan. These are not safety-graded in the operating mode now.

MR. WILSON: A lot of plants operate with a PORV isolated. We looked at every such case. Here we maintain maximum HPI flow and allow the pressure to go over here. You would do that here if the PORV is not available. That's where he has to get some type of feedwater back into the steam generator.

MR. EBERSOLE: It isn't stated but it is certainly inferred. Suppose I just modify the sequence and say associated with a small break or virtually no break at all, I lift the safety on the secondary site of one of the boilers? Is there an operator instruction for that? He is blowing down the secondary now and also cooling the primary load to some greater or lesser degree.

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MR. WILSON: You are assuming it is stuck open.

MR. EBERSOLE: One of them; single.

MR. WILSON: We are about four into it now.

MR. EBERSOLE: I am not being that tough. Has he a procedure to cope with that? I am trying to invoke the maximum rate of cooldown because that can be troublesome in several aspects.

MR. WILSON: They will probably lift the steam safety valves on most traps.

MR. EBERSOLE: Let's say we are talking about a kind of discussion here that is not scoped to include other type accidents, and let it go at that. I think you are elaborating on a particular kind of acciden, telling the operator what to do.

In the second topic, we will find there are lots of differences that are not amplified here. There are literally dozens or hundreds of them which are simply void at this point in time. I abhore the idea of dealing with this without looking at the generics of it.

MR. WILSON: We are looking at that in the long-term aspects, too. I am working on a band-aid while others are looking at surgical procedures.

MR. MICHELSON: I am not sure any failures have occurred yet for case No. 3. That's simply loss of site power, isn't it?

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MR. WILSON: Case No. 3, if you have a loss of off-site power, you would lose feedwater, too.

MR. MICHELSON: I hope not. You have auxiliary feedwater, don't you? This is loss of off-site power. You would normally address that with a single failure, I thought.

MR. EBERSOLE: Case No. 3 is off-site power failure.

MR. MICHELSON: You have to yet account for single phase, which could be a PORV, for instance.

MR. EBERSOLE: Is this implied by looking at details of this particular circumstance, that you also will examine the quite large number of other evolutions that can take place for detail of operating instructions, including the prohibitions --

MR. WILSON: What we are saying is in all other accident situations in which the high pressure injection system has been manually or automatically initiated for a low pressure condition, they must fullfill these criteria.

MR. ZUDANS: Is there intent ever to put these procedures on a computer so it could be instantly retrieved on a screen rather than shuffling through heavy books and finding something?

MR. WILSON: There was an attempt at Oconee to do that. I don't remember whether it was impractical or manpower considerations or what.

MR. ZUDANS: I think of handbooks or standards of codes. To get a volume this size, finding something specific

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gets to be difficult. You only have ten seconds left to find something. Maybe in one half-hour, it's difficult. Why not consider putting this in on the screen and scan through it in an instant?

MR. EBERSOLE: Call out a section and punch a button and have the whole show.

MR. ZUDANS: Call out the symptoms you see and let the computer respond with the procedure.

MR. MICHELSON: Now you need two computers and two screens and everything because you need to have the procedure. The alternate would be a hard copy back up data.

MR. ZUDANS: No reason to change that concept. In an emergency, it's a time-saver.

MR. WILSON: You still rely on the operator to diagnose the symptoms.

MR. ZUDANS: When he goes to the book or the screen, that requirement of identifying the symptoms is still there. He can't help it. He has to be able to identify symptoms. If he doesn't, he has Three Mile Island.

MR. WILSON: That's true.

MR. MICHELSON: Can I comment once more on No. 3? I'm bothered a bit by the area of site reconfirmation between 2300 and 100 pounds with the steam generator.

I think we generally concede you have to pass water for periods of time under that kind of operating circumstance, before we got HPI and so forth. Do you think this is what you want to do?

MR. ROSZTCOZY: I'm not sure I understand the thrust of the question. What are my choices between doing this and what else can I do?

MR. MICHELSON: One thing you might do is -- I don't know, you get uncomfortable sitting there cycling that PORV open and closed all the time. You might have to do it quite a few cycles in this operation.

MR. ROSZTCOZY: He leaves it open.

MR. MICHELSON: He leaves it open until the pressure is down and closes it when the pressure is restored and opens it again and so forth; that's how I read No. 3.

MR. WILSON: This is more or less a last ditch attempt here. He does not have his reactor coolant pumps.

MR. MICHELSON: Loss of off-site power ought not force him into a last ditch attempt. There should be a neat way of handling that. It is very easy to believe the leak came first, tripped the turbin and --

MR. WILSON: The last ditch is to sit there and let the system relieve at 2500 pounds.

MR. MICHELSON: That might be the better way as opposed to cycling PORV. Have you looked at that? Is that the preferred way of operating?

DR. PLESSET: There is a better way to do it.

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MR. MICHELSON: Apparently we are writing operating instructions on the basis of these kinds of little statements. I am wondering, have they really been worked through?

MR. WILSON: We will look at this in more detail. Mr. Denham said at the Commission meeting for the lifting of the order on Oconee that this was a consideration. We were not to look into the reliability of the safety -- we still have the option of closing the block valve. If the safety valves don't function, that's our last option. It's kind of a reliability study.

MR. MICHELSON: The best option is to open up the relief valve and leave it open. It's not clear to me why even the 100 pound limit relative to the steam generator pressure -- I'm not sure why they are cycling. Why don't they bring it down?

MR. EBERSOLE: Even with cycling, you have two options: Close the relief valve or close the block valve in line with it.

MR. KANE: I would like to state our logic behind what we put here because we discussed this particular issue in a reasonable amount of detail. We chose to open the PORV, as Bruce indicated, to keep the system off the safeties if the system was going there because the PORV does have a block valve on it and the safeties do not.

With that condition, we decided to just blowdown the

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system to near the secondary site pressure as a continuous blowdown. This keeps from cycling the valve a number of times which would occur if say you went up to the where it actually blowed down 100 pounds or whatever the setpoints are, back up again and activate the safeties on a cyclic basis.

We made the decision to just open the PORV, load the system down a long way on a continuous blowdown instead of many actuations on a short basis, and since the PORV could be isolated, we had thought this was the best manner in which to preserve the reactor coolant system or the pressurizer as an intact system.

MR. EBERSOLE: You are really protecting the safety valves, but there could be several ways.

MR. MICHELSON: Why don't you bring the system on down in the steam generator?

MR. WILSON: That is not available for heat removal. You have lost natural circulation.

MR. MICHELSON: You are saying at this stage of the game they are not functioning as condensors yet. How long does that go on? I don't recall it being very long on your curves.

MR. KANE: That's correct. We would hope it only would take one time and they will be back down.

MR. MICHELSON: As soon as you got in the condensing mode, you would no longer cycle pressure, but now bring it down with the steam generators.

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MR. KANE: Correct.

MR. MICHELSON: Is that understood in the operating procedure?

MR. KANE: The operating procedure, as has been pointed out a number of times, should take care of any events that may occur. While we do not believe it will repressurize again, I guess there is always the possibility for it, and the instructions are written to take care of the possibility of repressurization again.

MR. ZUDANS: This would be 1100 psi cycles.

MR. KANE: That's correct.

DR. PLESSET: You have one more item to discuss, I believe, haven't you?

MR. WILSON: Okay.

No. 4, I touched on briefly before. It is essentially the same as No. 3. No. 3, you really don't have the heat sink until you either establish natural circulation or the condensor type mode.

No. 4 would be essentially the same. You are looking for the break in the PORV to relieve the decay heat until you restore -- this should be feedwater. Essentially, we are looking at the worst type of case No. 3.

MR. ZUDANS: It is interesting that you don't mention cycling here in this case.

MR. WILSON: No. We don't want to cycle because you

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don't have any steam generator pressure. You lose levels at about one minute. You probably lose steam generator pressure in ten to 20 minutes. If there is no feedwater, no steam in them, they will go back down.

MR. ZUDANS: Why would you want to cycle in case No. 3?

MR. WILSON: The cycle in here is to keep off -- you leave it open here to maintain the heat removal path. We are assuming the break size will not be sufficient, or, in this case, steam pressure will come down. It will either go off or, once you open up the PORV and establish a larger hole, the pressure will come down. It will be one of the two. It is not necessary to cycle.

MR. ZUDANS: But there is no difference. You open and blowdown in either case.

MR. WILSON: It was my understanding if there is some consideration in this particular case that by cycling this, it may improve the possibility for the boiler mode to start re-condensing. In this case, it is not.

MR. ZUDANS: Okay.

MR. EBERSOLE: In this last case, I would like to get towards the single failure criteria. You degraded the feed-water system so you don't have any now. That required fuel failures. You worked yourself into a situation where you had to say you open the PORV by doing that. You only have one

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PORV, right? It is not particularly reliable on opening.

MR. KANE: It seemed to work reasonably well on opening.

PROF. WU: It wouldn't close afterwards.

(Laughter)

MR. EBERSOLE: I'm talking about programming. It is not even a safety grade function.

MR. KANE: That is correct.

MR. EBERSOLE: You are saying here that this is your last ditch but you won't get there in the first place because you invalidated single failure criteria on feedwater, anyway.

MR. WILSON: The last ditch would be to open the PORV. If not available, allow relief through the heat safety valves. We will probably be relieving a single phase or subcooled mixture possibly -- if you go long enough, you will get saturated conditions, probably a two-phase mixture through the safety valves.

MR. EBERSOLE: Can high pressure injector components cope with that?

MR. WILSON: It looks like 300 GPM at 2500 pounds, between 50 and 300 GPM at that system pressure.

MR. EBERSOLE: That's enough, right?

MR. WILSON: Per pump. We have two pumps.

MR. EBERSOLE: Oh, all right.

MR. WILSON: That completes the guidelines.

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DR. PLESSET: Thank you, Mr. Wilson.

I think we have another topic.

MR. WILSON: The second part of this is the NRC methods for review of LOCA procedures. I really had difficulty coming up with a discussion of this because, basically, our objective was to review the procedures and revise them to conform with the guidelines. Once they did, we approved the procedures.

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What we did with our review objectives, there was, one, conformance to the guidelines and, two, workability for the operators. Each of these procedures was reviewed by the review team in the NRC headquarters and by review team members on the site.

These procedures that the facilities developed often had to go through two further revisions after the facility rewrote them to conform with the guidelines. We generally found three problem areas in reviewing the procedures.

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First was that in some cases the facilities did not have complete depth of knowledge of the small break phenomena. In the second case, they took exceptions to some of the guidelines, as you have been doing here. Three, they tended to adopt these guidelines to the existing procedures. I will take these one at a time.

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The first problem was primarily one of timing. This was due -- what we ideally should have had was for the people responsible for writing the procedures to receive the instructions from B&W on the small break phenomena, as we did, when we went down to Lynchburg during the initial phases of the review. We didn't encounter this. As a result, we went through more iterations to come up with the proper procedures. We didn't find, as the review progressed, that the facilities became more knowledgeable of this phenomena.

For the second problem, some facilities did not think some of the actions recommended by the guidelines were appropriate; specifically, some of those actions we have been talking about using PORV. The other exception they took was to bumping reactor coolant pumps.

In each case, we took the position if they could support alternative courses of action with engineering studies, we would modify the guidelines appropriately and accept their procedures. They, however, ultimately chose to follow the guidelines.

The third problem was in attempting to adapt the small break guidelines to the existing procedures. Once we went down the fault tree, dropping off reactor coolant pumps or feedwater with the small break phenomena, the operator would follow four different emergency procedures at one time in the control room. We didn't think this was possible to do so we

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insisted they change procedures.

We took the position generally this loss of feedwater had to be written into the LOCA procedure for the small break, but loss of reactor coolant pumps could reference another procedure. We found that it is not too difficult for the operators to follow subsequent actions of two different emergency procedures at the same time. Once they had achieved a relatively stable figure of plant configuration, some type of cooling flow -- forced or natural -- and heat sink, and most referred to a normal cooldown procedure, if the break size was sufficient to depressurize this, we did not reference another procedure for that.

For each of the licensees, a member of the operator licensing branch walked through the procedure in the control room. We usually did this with a licensed operator on duty at athat time. He was asked to identify and locate the implementation procedure and found no significant discrepancy in the course of doing that.

However, we did find that some of the manning requirements of the facilities were not adequate to conduct these procedures. We found this to be the case at Arkansas, Davis-Besse and Oconee. Take Oconee and Davis-Besse first. All tech spec limits for power reactors specify that during steady state conditions the minimum number of licensed people in the control room at any time can be one. The administrative requirements,

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however, at Oconee, Arkansas and Davis-Besse do not allow them to have less than two people in or somewhere near the control room. Rancho Seco didn't have this particular requirement so we made them put it in that the second operator should be in the vicinity of the control room to the maximum extent practicable. We relied on the Region 5 inspectors to interpret those words.

As a final step in the review of the LOCA procedures, we audited the level of understanding of the small break phenomena and the related procedures with the licensed operators and we found a level of understanding of the phenomena to be quite good, with a few exceptions. The discrepancies were discussed with plant management and additional training was conducted by the plant training organization and outside contractors. The actual audits, themselves, will be discussed by Bruce Bogar so I don't want to get into that further. If you want to get into the specifics of the LOCA procedures in more detail --

MR. ZUDANS: I have a question. Just to get an idea, what is the physical size volume of these procedures? One book or several books?

MR. WILSON: Here is Oconee's procedure.

MR. ZUDANS: That's the way it is sitting there?

MR. WILSON: No. It is generally in a binder in the control room.

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MR. ZUDANS: This type of print?

MR. WILSON: Yes.

MR. ZUDANS: No indexing?

MR. WILSON: They will be indexed.

MR. ZUDANS: It would take me more than ten minutes to find it.

MR. WILSON: I don't think so.

MR. MICHELSON: They are reasonably complex but perhaps not unmanageable.

I have one little problem with the Oconee one. First, of course, I tried to look at it from the viewpoint of: Something happened. I don't know if it is a big break or small break. It might not even be a break. A lot of things can happen which have somewhat similar symptoms. What do I do first? Which one do I start pulling out?

Then I looked at, say, the LOCA. There are two basic cases there. One is a small break and one is something bigger. The something bigger definition is a rupture in excess of capability of available high pressure injection pumps. A small break is that, too, for a while, depending on how long. That's what sets the minimum level the thing finally goes through.

There is an overlap, in words, at least, already. I don't know if it was in meaning or not. How do I decide it was a small break or not, first of all?

MR. WILSON: Guidelines in the typical B&W reactor

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would start off with a spectrum. You have excessive language. Almost every reactor will have leakage. The degree: The first indication will be rate of decrease. The pressure level will hold constant because of the control valve.

MR. MICHELSON: It may or may not, depending on how big the leak is. It may not be sufficiently small so you can hold constant levels in the pressurizer.

MR. WILSON: The pump, through its normal path, will go through the level control valve and pass between 150 to 220 gallons per minute. Its normal flow rate would be approximately 45 GPM. The Oconee procedure, in particular, will say the difference between a small leak and a small break -- and we cover this with each of the operators -- is greater than 140 GPM make-up flow. You will see its make-up level coming down. He has a gage showing make-up flow. It is usually calibrated to 160 GPM. Above 140, he assumes he has a small break and takes Case 2.

MR. MICHELSON: It is certainly bigger than a small leak. It may be a small break or bigger than that, couldn't it?

MR. WILSON: Yes.

MR. MICHELSON: Okay. I'm trying to track it.

MR. WILSON: If it is a larger break, both the pressurizer level and make-up tank level will be coming down. I'm trying to cover the spectrum of break sizes. For an even

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larger break, if it is efficient to decrease system pressure, when the pressurizer level comes down, the pressure should then follow it. When pressure comes down also -- this is getting into the larger breaks where it is sufficient to cause a reactor trip at about 1800 pounds and safety injection at 1600 pounds, the larger breaks are going to be completely dependent on the rate of decrease in the pressurizer level and the pressure.

We shift from one system to the make-up tank and make-up flow rate to the rate of decrease of the pressurizer level and the pressure to determine the break size. If he has high pressure injection initiated at 1600 pounds, he performs his immediate action, which is essentially verification to make sure he has fu`` HPI flow. The system pressure continues to come down. He , c e has a big break and will wait.

MR. MICHELSON: I'm not sure he knows that because what you described there is also characteristic of a large or small break which still comes within the small break response. It has potential for repressurization and that sort of thing, which the big break doesn't have. I wonder how you track this thing.

MR. WILSON: The operators will be following it by watching it. At this time, if it is somewhere between the large-small break and the small-big break, if you will, he has no choice; he relies on HPI. If the pressure is being restored

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he has the smaller break. If not, LPI and core flood tanks are not initiated by the operator. LPI is already running. Core pumps are discharged at 600. No more he can do, anyhow.

MR. MICHELSON: Let me ask a simpler question. I read through all this and got rather confused with so many choices, so many cases. Is it really necessary to have so many different cases to address this situation? Is it necessary he check all these things running and not running and so forth? Isn't there a simple standard response that works all the time or does he have to go through this analytical process of deciding which response to start trying to track?

Even then, it may not -- there may be a response here we haven't thought about, like a relief valve may be popping open a couple of times and hanging up or whatever, or hanging half-way open and popping all the way open again or something, I don't know.

But isn't there some simpler way of approaching this thing than all the complexity of trying to guess which one of these seven different small break cases it might fall into?

MR. WILSON: First, one of the people on our staff, who, I guess, shall remain nameless, suggested that the best way to do it would be to have a meter. If he gets a small break he dials small break so he can follow his action.

(Laughter)

This isn't quite possible. We have to rely on the

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operator to be able to diagnose and respond to this situation. The way Oconee wrote this particular procedure was their prerogative. We didn't want to impact into the format of it. We wanted to impact into conformance with the guidelines and workability.

You question the workability. I agree. There are t[illegible]r choice[illegible] to make. But we tried to get the most obvious ones where they will do the most good. If he has a small break in which he does have reactor coolant pumps and feedwater, the most likely situation, he has that right there. When he gets into degrading conditions, he can go deeper in the procedure and try to find them.

The other facilities did not -- I think Davis-Besse chose to follow this course of action, but most of the other facilities didn't. The point was to try and get the most important information to the operator where it would do the most good. We felt we did this at Oconee.

Ultimately, they may revise their procedure and take Case 1, 2 and 3 and combine them re excessive leakage right out to the small break with reactor trip.

MR. MICHELSON: Your remark on degraded procedures is also interesting. Where is the procedure I should start following if one of the reactor coolant pumps quits, or two of them quit or whatever? Does that make any difference? Do I still follow the procedure like all are running? When do I

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decide to go to some other procedure?

MR. WILSON: The pumps will quit when you lose power or the operator takes them off.

MR. MICHELSON: I'm not sure they will quit altogether. What happens if one pump quits? Do I ignore that and keep following the same procedure? Does it make a difference?

MR. WILSON: He will see, in certain cases, if he does have three remaining reactor coolant pumps, the procedure says stablish one pumper loop.

MR. MICHELSON: Is that in the Oconee procedure? I probably missed it.

MR. WILSON: It may be. I haven't looked at this in about a month.

MR. MICHELSON: I didn't pick this up but there was again an awful lot here and it gave me a headache before I got done reading it, even. Any procedure that has to be 30 pages long must be difficult for the operator to even thing about, even though I will admit you only go into pieces of it, but deciding which pieces to go into is a decision-making process in itself. It is not entirely straightforward, particularly if it runs into an odd situation where one pump isn't running and the other is and so forth.

MR. WILSON: I agree but there are so many faults in the conditions we would follow. We decided with B&W to look at the availability of both feedwater and reactor coolant pumps

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and we considered them in their entirety rather than pieces of them. You could say maybe, instead, you either have it or you don't. He knows which way to go for each case. If he has a partial on either case, he knows the alternatives.

MR. ZUDANS: I would like to modify my proposal about the computer. I would like to see a diagnostic center. Since they are continuously displaying a situation or state of the reactor without any actual function other than information transfer -- it reads the instruments that exist, the same way the operator would read it, and these are the options: The assistant could be this and this now. It is up to you to decide.

In the medical profession, they have set up diagnostic centers for their own activities. The doctor makes the decision whether he will prescribe this or that, but the computer information tells him you could be in these situations with the symptoms that exist and would not make that --

It only projects information; it doesn't control.

MR. SULLIVAN: You know, NASA went the full route. They even shut their main engines down on their rocket with a computer system if they detect something is going wrong. An abort on one of those would be very expensive.

This is all the way from that to much less than he suggested, I guess, as having any on-line computer to analyze the system continuously.

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MR. ZUDANS: Without any function to operate the system.

MR. SULLIVAN: It even could go as far as telling the operator these are the things you should do and also to make sure that things happen like the procedures say. I assume you are looking at things like this.

DR. PLESSET: They abort on a computer.

PROF. CATTON: It happens so fast.

MR. ZUDANS: That's different. They don't have people.

MR. SULLIVAN: They have two on top.

MR. EBERSOLE: Before he gets away, there is one continuing theme through here. We are talking about two systems; the pressurizer heaters and reactor coolant pumps, which are not legitimate ECCS mitigating pieces of equipment; they are in Appendix K and calculations. The instability of the situation caused you to lose off-site power and the pumps are too big to run on the diesels. The heaters in many cases aren't connected.

Another reason is hostile environment of the containment is such that to the best of my knowledge, none of the pumps are designed to sustain under those conditions. They may have arcing wires or whatever. I think that's also true of the pressurized heaters. Case No. 3 here is the standard model. You don't have the reactor coolant pumps.

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MR. WILSON: Which case now?

MR. EBERSOLE: No. 3. You don't have the pumps. What you are suggesting is something I think you have to look at. You are forcing the running of these pumps under hostile conditions in the containment. I don't know the circumstances when they fail. There might be some fires. They are not designed for this hostile environment. These big 8000 horsepower pumps are not designed for spray, humidity, water, whatever. These are the large diesel power apparatus inside.

I am now inviting some troubles because I am asking this from equipment which is not specifically for that purpose. You really intend to ask these pumps to operate under challenging conditions, is that correct?

MR. WILSON: Let me see if I can get this right. This was a situation where I lost natural circulation and --

MR. EBERSOLE: You have the containment full of water and spray, humidity, all these things, temperature. Now you are going to invite the reactor coolant pumps to run under conditions not within their design bounds.

MR. WILSON: Maybe you can help me on that. It is my understanding that B&W says, first of all, in terms of a mixture they are pumping, that they were able to pump a two-phase flow.

MR. EBERSOLE: I'm talking about electric motors. You are asking them to sustain this. Do you follow me?

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MR. KANE: I missed the first part of the conversation here.

MR. EBERSOLE: I am saying you are asking two heavy power motors inside the containment to continue to run when they are not designed for that purpose. The reactor coolant pumps are not designed for the hostile environment called for in a LOCA. The electrical characteristics are not compatible. You are inviting a challenge of the circuit breaker systems which protect against penetration. Do you follow me now?

MR. KANE: Yes, partly.

MR. EBERSOLE: You are asking these big pumps to run under conditions for which they are not designed. In the electrical sense only; not hydraulically.

MR. KANE: I don't think I can answer that question.

MR. EBERSOLE: You are asking the pressurized heaters to do the same. You are not doing that without a challenge, which you would rather not have, which means you will have electrical problems maybe of substantial magnitude operating outside the design considerations of those circuits.

MR. KANE: I can't answer that question.

MR. EBERSOLE: These things are tripped and cleared. Now you are using them. The heaters and big coolant pumps.

MR. KANE: The heaters are not assumed during the accident to start with.

MR. EBERSOLE: There is no discussion here of the

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heaters, is there?

MR. KANE: No.

MR. EBERSOLE: The operator isn't told what to do about them. What does he do?

MR. WILSON: Nothing in the guidelines directs him to the heaters.

MR. EBERSOLE: Does he turn them on or off?

MR. WILSON: They were turned off automatically.

MR. EBERSOLE: Is there anything to keep him from turning them on when he should not? They would turn off, anyway --

MR. MICHELSON: He may not get low levels in the pressurizer.

MR. WILSON: He is to maintain pressure control in the reactor coolant system.

MR. MICHELSON: Is it all right to leave them run or not?

MR. WILSON: You would have to rely on breakers that protect the system if there were shorts.

MR. LIPINSKI: TMI shorted out. They are all gone right now.

MR. EBERSOLE: I didn't know that. The main coolant pump could have gone violently. When they go, some of the older designs -- you are asking for a challenge to the containment, which is the penetration capability to intercept faults.

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Some of the older penetrations might not take it.

MR. WILSON: Some of the older designs aren't B&W. These are specifically B&W designs.

MR. EBERSOLE: You are asking every power equipment piece to run on undesigned conditions. This type of thing, I haven't heard of before.

MR. ZUDANS: It is not really asking, is it? You are saying if they are not there, do this. If they are there, you don't have that condition.

MR. EBERSOLE: It says attempt to restore core circulation. That's asking the pumps to run.

MR. ZUDANS: Under conditions of small break. So you may not have the adverse environment yet.

MR. EBERSOLE: At least, some of the small breaks can produce that adverse environment.

MR. ZUDANS: You are right, they are not qualified for that environment. That's legitimate.

MR. EBERSOLE: You are asking them to perform in the face of containment spray, perhaps.

MR. ZUDANS: That would, for sure, come in.

MR. WILSON: We are asking a non-safety piece of equipment to work -- you are saying we are asking it to work and the consequences may be worse than the benefits.

MR. EBERSOLE: I don't know.

MR. ZUDANS: The motors are not qualified for this

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environment.

MR. EBERSOLE: No, they are not.

MR. ZUDANS: You need more homework.

DR. PLESSET: Any other comments?

MR. ZUDANS: It is an interesting presentation. It gives us a lot of insight.

DR. PLESSET: Mr. Bogar, I think the floor is yours.

MR BOGAR: Thank you.

I am Bruce Bogar. I am also from the operator licensing branch.

(Slide)

What I would like to talk about are two things, really. The TMI-related operator training performed after the accident and then, secondly, the NRC audit, which is one phase of this operator training. I will go into that in more detail when I am finished.

A few days after the accident -- within a few days after the accident -- Bulletin 7905 was issued to all the operating B&W plants and I&E inspectors went through this bulletin with the people at the facility to emphasize the nature of the event, sequence of event and seriousness of the event.

Let me just say these may occur in different order at different facilities. They didn't all go down in this order, with the exception of the review of the accident.

B&W came up with a simulator training course which

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was about four to six hours, which consisted of, at first, maybe about an hour's worth of classroom training where they talked about the sequence of eve.. at TMI and talked about subcooling, saturation, what-have-you. Then they went to the simulator, itself.

First of all, they demonstrated the TMI event as it happened so the operators would see how the instruments responded. Then they repeated the TMI sequence with operators interacting, operators provi..ing little "hands-on" so they could control the incident

Then, back at the site, classroom training was provided to the operators in procedures, facility changes, small break phenomena, thermal dyramics, if you will, on subcooling and saturation.

To evaluate the effectiveness of the training program, the facilities administered written examinations. It was determined that, on these examinations, a minimum passing grade of 90 was required. If a fellow did not get 90, he was required to go back and receive some additional training and then take another examination until he got 90.

The NRC audit followed, really to evaluate effectiveness of the rest of the training program. I will get into the details of that after the slide.

We recognized that the operators had been given a whole lot of information in a very short period of time. There

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was a lot of emphasis to change the procedures, change the plant and get the plant operating again, so we recognized a lot of operators were given procedures they didn't have a chance to memorize as to immediate actions.

We requested -- or required -- that each of the facilities conduct follow-up training on procedures and design changes prior to startup. The kicker at the end would be the requalification training that is going to evolve as a result of the Three Mile Island incident.

DR. PLESSET: On this examination, if they didn't get 90, was it the identical examination they took a second time?

MR. BOGAR: No, sir. It was a different examination. Same scope.

DR. PLESSET: What if they didn't pass that one?

MR. BOGAR: Then they were not allowed to operate as a licensed operator. They were removed from duty until they could pass that examination.

DR. PLESSET: Do you think 90% was good enough?

MR. ZUDANS: That's the question I was going to ask.

MR. BOGAR: Just the philosophy of giving an examination -- you can write an examination that everybody will get 100 or or write an examination that people will get 50 on. It is hard to say that 90% would be a good number all the time.

MR. ZUDANS: The examination couldn't be anything less than the entire course, line per line. Unless he was 100%, he couldn't quality. It is not a textbook course. It is a very specific procedure which he either has 100% knowledge of that -- I think Milt's question is very good.

MR. LIPINSKI: Specifically, immediate actions required of him, given the symptoms, can he miss knowing what the immediate actions are?

MR. BOGAR: At this point in the -- when we did our audit, we didn't require them to have their immediate actions memorized because these were procedures that had been changed within the last couple of days. We didn't feel they had enough time to unlearn what they learned before, so we didn't require it at that time.

MR. LIPINSKI: It is my understanding at any time they are still not asked to have 100% accuracy in immediate actions.

MR. BOGAR: That's probably true.

DR. PLESSET: I questioned, as I think the other gentlemen, whether that's good enough. Maybe right after they were given it, but by this time, if they were given an examination, they should get every question correctly.

MR. BOGAR: Right now, yes, sir.

DR. PLESSET: Do you think they could?

MR. BOGAR: Yes, I think they could. We had pretty good luck with the procedures. You are asking me to know what 180 operators are thinking. I don't think I can.

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DR. PLESSET: I think they should be re-examined.

MR. BOGAR: That's part of their requalification training.

DR. PLESSET: That will happen?

MR. BOGAR: Yes, sir. They will factor in all this training and then every year they get a requalification examination. I would expect TMI-type questions to show up on that examination.

PROF. CATTON: Who gives the examination?

MR. BOGAR: The site. We review it.

PROF. CATTON: Do you review it before given or not?

MR. BOGAR: Not always.

PROF. CATTON: Do you have any say as to its content?

MR. BOGAR: Prior to administering?

PROF. CATTON: Yes.

MR. BOGAR: After the program gets the operating license, they administer their first requal exam. We go back our next trip and look at the examination and say what we thought of it with regard to the scope of the examination, the toughness of the examination, the grading of the examination and let them know whether or not that exam was satisfactory.

PROF. CATTON: Assume you don't think the examination was tough enough. What do you do?

MR. BOGAR: Ask them to rewrite another examination and submit it to us.

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PROF. CATTON: When do they have to do this?

MR. BOGAR: Prior to the next administering of the examination.

PROF. CATTON: Now two years have gone by if you don't think it is good enough.

MR. BOGAR: It didn't get administered the second time. They had to get our approval before it was given the second time.

PROF. CATTON: If you don't like the first one, you see, after it was administered, you will say: "You can't administer another until we approve it."

MR. BOGAR: That could happen.

PROF. CATTON: Does that have teeth in it? Can you do that?

MR. BOGAR: It can happen.

MR. EBERSOLE: Is that an open book or closed book examination?

MR. BOGAR: This is closed book.

MR. EBERSOLE: That's a test of memory. There are two aspects of him making a mistake there. He won't remember something. That could be compensated for by opening the book. The worst one is he says he will do something he should not do. Do you discriminate?

MR. BOGAR: The examination is graded off.

MR. EBERSOLE: The second type of mistake is vastly

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more significant than the first.

MR. BOGAR: True. I agree. I could also throw in the concept that perhaps the question wasn't worded properly so it led him down a different path. There is a lot to these examinations.

MR. EBERSOLE: Just the grade, itself, is not as significant as where the error was made.

MR. BOGAR: On the questions that are of importance, they have a higher point value than the ones that are just memorization of a number, for instance.

MR. EBERSOLE: Where he makes an error which is significantly troublesome -- I'm talking about where he makes a mistake which gives him trouble, forgetting about what --

MR. BOGAR: If he didn't give the right answer, he can't get credit for that problem.

MR. ZUDANS: Do you have any questions where a negative answer would cancel all the other positive answers automatically?

MR. BOGAR: No.

MR. ZUDANS: I think you should. There are instant reaction items that he should know completely, where there should not be an error accepted. It is not possible.

It is the same distinction as you would make between reading and reciting a poem and knowing the alphabet. I would say the first is knowing the alphabet, A-B-C-D. These are the

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instant reaction questions. Those should be on every desk. They should be positive in every case.

MR. WILSON: I think the question is basically: Should operators know all about the access to all emergency procedures?

MR. ZUDANS: Yes.

MR. WILSON: We, of course, are not able to do this after they get their license, except through the requalification program and by inspections by I&E inspectors. During the course of our examinations, however, we have had situations in the past where somebody says: "You have a reactor trip. What are your immediate reactions?" He has a list of ten in his procedures. He misses one. Should we fail him? This is a very subjective judgment on the part of the examiner. His tenth immediate action may have been to verify transfer to auxiliary transformer and he missed this step. You get to the procedure afterwards and say: "How come you missed this step?" Depending on the case, I might not fault the man.

However, with a reactor trip on certain facilities, one reaction is to close the isolation valve down and start the pump, if necessary. It is the only required reaction for the reactor trip. If he fails this, I will automatically give an unsatisfactory grade, It is vital to maintain the pressurizer level; yet, he misses only one step. It is prioritizing the required action.

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DR. PLESSET: Why don't you consider the possibility of giving both a closed book examination and an open book examination? If he operates a reactor, he is not going to necessarily just keep himself away from his procedures book. That's a more realistic kind of thing. Although, the first is useful, too. There are a lot of things he doesn't want to have to look up.

MR. BOGAR: During the course of the oral examination we tell them they have the availability of any information in the control room that they would use normally to help them; their books or procedures. We do allow them open book to some extent on the oral exam.

DR. PLESSET: I think you should be more formal and have a more lengthy examination than just an oral examination. In other words, it should be really a part of being accepted. As far as I can tell, it is only this written examination and a grade of 90%.

MR. BOGAR: I am talking a bit about our normal practice as opposed to this specific case.

DR. PLESSET: Oh, all right.

MR. BOGAR: In this case, yes, the 90 was okay. Whatever audits his people performed, that was the guidance in this particular case.

MR. ZUDANS: The way I understand that answer is that 90 is really pre-conditioned with another condition which

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says any of the vital reactions or vital answers are designed so you would get a non-satisfactory rating, regardless.

MR. WILSON: Perhaps you better cover what was done in the 90% examination, what this is about. There is confusion on this.

This is a completely separate examination administered by the facilities only on the TMI accident situation and its impact at that plant.

MR. ZUDANS: You are talking about something else.

MR. WILSON: I am talking about the normal licensing examination. We didn't cover all the emergency procedures.

MR. EBERSOLE: Do you look at the two demains where you examine him on what he should do and give him a grade on that, and take the other world and say now what is it that you should positively not do and have him trot out all those things involved there?

MR. BOGAR: I never asked anybody to do that. I asked what happens if, and what happens if, but never what aren't you going to do. I have never done that.

MR. EBERSOLE: You don't ask him to list the exclusions he must be careful of?

MR. BOGAR: Only if they came as a precaution to the procedure; that kind of question is asked.

MR. EBERSOLE: Don't do this and don't do that. You ask him to verify that he knows --

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MR. BOGAR: On some occasions, yes, sir.

MR. EBERSOLE: In the case of Three Mile, it was the most important thing he did. He did something he should not have done.

MR. BOGAR: I agree.

MR. EBERSOLE: That set of procedures is equally important to the ones you tell him to do. Tell him what not to do.

MR. BOGAR: That's lessons learned, I agree with you there.

MR. EBERSOLE: In principle, it's an old thing. A set of negative instructions, so to speak.

PROF. WU: In these examinations, are they diagnostic type questions so he understands why it should be done or why it should never be done?

MR. BOGAR: Our examination?

PROF. WU: Examination questions.

MR. BOGAR: This one or a normal?

PROF. WU: This one.

MR. BOGAR: This one, some of the examinations I saw had some diagrostic symptoms. This, this and this would happen here, pressurizer levels go up; what could be happening? What incidents have similar initial symptoms to a loss of coolant accident? Those type questions have been asked.

Let me get now to the audit that we performed. This

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was performed by members of the operator licensing branch, and in some cases the inspection and enforcement people that had received some training in the area. Let me give you a brief overview of what the audit was comprised of.

(Slide)

We talked about the TMI-2 accident; small break LOCA response. We reviewed facility changes. We reviewed procedure changes and we reviewed the operation of the auxiliary emergency feedwater system, whatever the local name.

MR. MICHELSON: How long ago was this done?

MR. BOGAR: I went out on one last week, Davis-Besse, and one maybe a week and a half before that.

MR. MICHELSON: The small break response you are talking about here is the very current information we have concerning small breaks; not that existing two months ago.

MR. BOGAR: Based on the B&W guidelines.

MR. MICHELSON: On the operating guidelines.

MR. BOGAR: Yes, sir.

MR. MICHELSON: I am not sure that reflects the very latest information. The guidelines are okay but if you are talking about small break response, maybe I don't understand how far you go in talking about response. You are just talking about the procedural response only.

MR. BOGAR: No, sir; we are talking about differences between a leak in the pressurizer steam space versus a leak in

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the water space.

MR. MICHELSON: I was surprised that it was not really developed -- maybe it was.

MR. BOGAR: I will get into each one of these in a little more depth.

(Slide)

With respect to the TMI-2 incident, we went over the sequence of events with the operators and asked them to more or less tell us what happened to the best of their knowledge and then to identify operator actions and the consequences of those actions throughout the event, to see if they had an understanding where the major areas of concern were.

MR. MICHELSON: Whose sequence of events did you use there?

MR. BOGAR: The one that came out of the bulletin.

MR. MICHELSON: That is, of course, quite a bit out of date now.

MR. BOGAR: The actions we were requiring of them had been identified.

MR. MICHELSON: This is an abbreviated sequence of events, the principal milestones.

MR. BOGAR: Yes; auxiliary feedwater not starting, termination of HPI, that stuff.

MR. SHUMWAY: What was there about the procedures or what thinking is behind the operators at TMI-2 not putting

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in more feedwater and getting the level up higher after they got the auxiliary feedwater pumps going?

MR. BOGAR: I am not sure they didn't do that.

MR. SHUMWAY: It was two hours before they got to that level in the secondary. Why didn't they do that right away?

MR. BOGAR: They had the initial 12 minute period where they didn't have any auxiliary feedwater at all. Then they fed the steam generators. The reason why they didn't maintain a specific level -- I'm not sure. I'm fairly certain at some time, when they realized they didn't have natural circulation, they attempted to raise the steam generator levels in an effort to increase natural circulation, or start it.

DR. BATES: Someplace along the line, we hear the normal procedure was going into natural circulation following the trip.

MR. SHUMWAY: Why didn't they raise it at a half-hour after the accident, very early in time? It looks like they were trying to follow some procedure that said as long as you have any reading at all, a few inches, then you're okay. Why not ten or 12 feet of water?

MR. BOGAR: That's part of the training. I think they were trained a minimum level in the steam generator is enough to remove decay heat at hot shutdown.

MR. MICHELSON: They were supposed to maintain 30

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inches minimum and they never had that until 20 or 30 minutes into the event. I don't know why. I haven't gotten a satisfactory answer as to what happened. They did not get level. They were evaporating as fast as they were feeding.

MR. BOGAR: I can't answer the question.

(Slide)

I will talk a bit about what we were looking at on the small break LOCA response. We were asking them to realize the difference between a loss of coolant accident say in a steam space as opposed to a water space, to see that they realized that, contrary to probably the training a lot of us had, that pressurized level could go up on a LOCA. We discussed with them the facility curves they had to make sure they recognized when they were in a saturated condition or subcooling state.

We talked about natural circulation, what had to occur for that to be instituted, what indications he had that he was, in fact, having natural circulation. We talked about the new requirements for termination of the high pressure injection in the B&W guidelines. We also talked about the available heat sinks to remove heat from the core and make sure the operator was aware of the various ways of removing heat.

MR. ZUDANS: What do the operators have to make a judgment on natural circulation?

MR. BOGAR: They look at Delta T, T hot versus T cold,

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make sure that's a reasonable value, 20 or 30 degrees. Certainly no more than 50. They can look at the conditions on their secondary side, whether they are turbin bypass valves or relieving steam. They can adjust the setpoint on the same valves to make sure that TC goes down followed by TH going down.

MR. ZUDANS: They only have one pressure and one average temperature, right? As far as temperature instruments are concerned, in how many places do they have the temperature taken from?

MR. BOGAR: At least one hot leg and one cold leg. I'm not sure of the number. There was an instrument in each hot leg, a temperature instrument, and each cold leg.

MR. ZUDANS: An interesting question, I think: Each of the pressure gages does not carry in some other color a scale of corresponding saturation temperatures, and each of the temperature gages doesn't carry another scale for the saturation of pressure. Wouldn't that be good to hav

MR. BOGAR: They have that at Arkansas.

MR. ZUDANS: They have? Boy, I'm glad! So they do have actually the Delta C between hot and cold leg; they have one pressure coming through the system --

MR. BOGAR: They have several of those, too.

MR. ZUDANS: And they have some saturation temperatures posted.

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MR. BOGAR: They have a curve that plots saturation versus temperature.

MR. ZUDANS: Easily accessible?

MR. BOGAR: Yes, sir, on the bulletin board.

MR. WILSON: They have a similar system at Crystal River. They have a subcooling alarm if they exceed 50 degrees at zero power versus 20 degrees at full power. They get an alarm from the control board.

MR. SHUMWAY: You mentioned the operators were told to look at Delta T to see if they had natural circulation, implying that the bigger the Delta T, the more certain they were that they had the natural circulation.

It can be just the opposite, as it was in TMI.

MR. BOGAR: That's the type of reasoning we used. We asked what type of Delta T they have. They said 20 or 30. The next question is: What if you have 100? No, that's something wrong. We addressed something like that.

MR. ZUDANS: Even if you had 20 Delta T, what is the absolute temperature?

MR. BOGAR: We are looking for indications there is some flow in the primary system.

(Slide)

Each facility was required to make changes. Of course, this was facility-specific. In some cases, the systems were already upgraded and the facilities made things happen in

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a different way. Each facility was required to instit.te a reactor trip upon a turbin trip and a reactor trip upon a loss of feedwater. These were not in the B&W systems prior to this and these, depending on the plant, had manual or automatic by-passes.

Another aspect of the facility change was the re-setting of the PORV setpoint with respect to the high pressure reactor trip. The setpoint was raised and the reactor trip setpoint was lowered on high pressure to reduce the challenges on PORV.

In addition, changes were made to the auxiliary emergency feedwater system. In all cases, the facilities were provided a flow indicator for auxiliary feedwater flow. I realize that was one of the things they didn't have at TMI. That would have been beneficial to verify auxiliary feedwater flow.

MR. ZUDANS: The pressurized relief valve was set at 2400 psi.

MR. BOGAR: It is now.

MR. ZUDANS: The reactor at 23?

MR. BOGAR: 2355.

(Slide)

As a result of the operator guidelines and the new philosophy, there were a lot of procedures changed. A lot of emergency procedures were changed. The main ones were the

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loss of coolant procedure, loss of feedwater, and loss of all reactor coolant pumps procedures.

We also looked at operating procedures to make sure they understood some of the changes to those which could incorporate your making sure a bypass was removed above 20% power and stayed below 20% power. We also requested the operators on their administrative procedures -- this would have to do with manning of the control room.

In the case of senior operators, when you are supposed to call the NRC or any other changes they may have instituted.

MR. ZUDANS: What was this about the bypass?

MR. BOGAR: On the reactor trip on turbin trip, since the turbin is shut down, normally, when the reactor is operating, they needed to have some allowance there, so they gave them 10% or 20% to let the reactor be at 20% power before causing the turbin trip to cause the reactor trip.

MR. ZUDANS: At that power, it wouldn't --

MR. LIPINSKI: Where do test procedures fit into this thing?

MR. BOGAR: I was going to get to that on the next slide. Specifically, the test procedures on auxiliary feedwater systems, we covered those. In some cases, the auxiliary feedwater system has to be put in an off normal mode in order to perform its normal surveillance test.

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We tested the operator's awareness as to what he would have to do to put the system back to normal.

MR. LIPINSKI: It is my understanding at TMI-2 the auxiliary procedure did not require all redundant systems to be put in the defeated condition. They rewrote those procedures at some point in time and caused both of the auxiliary feed systems to be blocked in order to conduct that test.

In discussing it with them, evidently B&W did not get involved with those procedure changes, nor did the NRC, to the best of our knowledge.

When you review these operators, do you get involved in looking at the procedures they may have changed somewhere along the line?

MR. BOGAR: No, sir. What we look at is the current operating procedure.

MR. LIPINSKI: The new procedures are still accepting the blocking of the redundant auxiliary feedwater system.

MR. BOGAR: That's not true.

MR. LIPINSKI: It was necessary to block --

MR. BOGAR: Well, if you have two trains of feedwater it may require you to do something to one train that will prevent it from performing its normal function, but the other train is still operable. The procedures don't do that now on these plants.

MR. LIPINSKI: You have verified that. Redundant

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systems are not simultaneously defeated.

MR. BOGAR: That is correct.

MR. LIPINSKI: On TMI-1, on March 27 they had to write an incentive report on their steam-driven auxiliary feedwater system. They performed a maintenance operation, closed the steam valve on the turbine drive, walked away from it, failed to restore the system to service. Somewhere later in time, it was uncovered that the system would not function. The electric-driven pumps are not automatic-start on that system.

Now, this, I guess, is the design so it is going to fall outside your procedure area, but I guess it comes under these administrative procedures to determine whether they are effectively completing restoration of these systems to service, test or on maintenance. Is anything being done to try to prevent these errors from reoccurring?

MR. BOGAR: That's not our normal function, to make sure that procedures are followed during the normal course of business. Inspection & Enforcement does that, to make sure the procedures are being followed. Procedures exist to prevent somebody from doing that. Whether or not he will follow them, that's part of management controls.

MR. WILSON: We have an I&E member on each of our teams who is doing that particular thing, looking at the administrative procedures and the surveillance and test procedures to insure they are being tightened to preclude this situation.

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They all look at double verifications of valve lines following maintenance and test procedures on that. Right now, we are discussing the operator end of the restart order.

(Slide)

MR. BOGAR: As a final item, we did cover the auxiliary emergency feedwater system with the operators to make sure they were familiar with the controls that were available to them in the control room so that they would know when the auxiliary feedwater system should automatically start, how it should control when it receives an automatic start, how to control the auxiliary feedwater system if it did not start automatically -- if they wanted to initiate it manually -- and how to control it after you started it.

We talked about the available suction supplies for the auxiliary feedwater system, the backups, and we talked about the surveillance testing which I got into just a moment ago, making sure the operator was aware of what conditions auxiliary feedwater systems were put into when it was being tested and what to do to get it out of that condition should he have need for auxiliary feedwater.

PROF. CATTON: Checking to see that the auxiliary feedwater valves were properly aligned in the past was not done every shift. I understand now that it will be on the checklist for each shift in the future.

Is there any attempt being made to find out maybe what

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other things ought to be on that list that are not?

MR. BOGAR: Maybe not through my branch but there is a lessons-learned group, if you will, made up of a lot of people in NRC that is looking into things like a shift review.

PROF. CATTON: I don't know if there is a procedure or not.

MR. BOGAR: It would be a normal procedure for a facility, if they had it.

PROF. CATTON: They don't have to have that?

MR. BOGAR: No, sir. A lot of their procedures may have looked at certain locked valves to make sure they are locked. They may have procedures that check these, but most of them don't have a specific valve check.

PROF. CATTON: If there is a procedure, does it come under your jurisdiction?

MR. BOGAR: Not normally.

PROF. CATTON: What procedures do? Just the abnormal amount --

MR. BOGAR: We are using their procedures and are giving them examinations to make sure they understand the procedures that their facility has provided them. If we find that we have a problem with procedures, we notify the Inspection & Enforcement group and then they follow from there.

PROF. CATTON: In this particular case of these valves, if it would not have been for TMI would it have ever come to light?

MR. BOGAR: Possibly not.

What may have happened is they may have discovered them and issued a licensee event report, and then that may have started a cycle. There have been other cases where valves have been found shut.

PROF. CATTON: I'm sure there are.

MR. SULLIVAN: More than likely, it wouldn't have.

MR. BOGAR: Would not have come to light; I agree.

PROF. CATTON: I'm not sure it would have been a licensee event report, either. It is not a safety item.

MR. ZUDANS: But they opened the plant illegally.

MR. BOGAR: It rendered both trains operable. That is against tech specs.

MR. SULLIVAN: I suppose somebody is reviewing all of these reports to see what should be changed in the procedures. If you found that you had --

DR. PLESSET: We can get you involved in that. This is under way.

MR. SULLIVAN: Thanks.

(Laughter)

PROF. CATTON: We are having a meeting next week.

MR. EBERSOLE: Let me ask a summary question. In the course of following this particular accident, I think you found inadequacies between the coupling of the emergency and

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abnormal procedures writers and the engineering segment, the designers. Do you intend to take this as sort of an example to look at that area more generally? That is, the degree of the coupling between the designer and the writer of emergency operating procedures? See, what I am saying is that I think you will find it is more or less a generic problem.

The designer is, in fact, not too well-coupled with the writer of emergency instructions. They tend to operate to a higher degree of independence than they really should. Is that your opinion?

MR. BOGAR: There are different ways of looking at that. A lot of times, when the operator is given a procedure that is written from some guy in the main office, it doesn't suit him the way one that the shift supervisor wrote. I agree there is probably a necessity for coupling but I think it requires some of the operator input for his judgment and what he can see.

MR. EBERSOLE: It is a two-way street.

MR. BOGAR: Yes, sir.

MR. EBERSOLE: I know of a particular instance where the operating segment believes they can deduce how to operate a plant from simply examining the schematics. They need no narrative help, they feel. Of course, I don't believe that but I think you might find that's not altogether an isolated case. The operator takes great pride in his operation. He believes

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he can operate anything, no matter whether it is a booby-trap or not, and, in fact, he will take pride in coping with the difficult operational problems rather than go back and try to fix it. It is part of his ego.

PROF. CATTON: Even if it is to an engineer.

MR. EBERSOLE: Particularly if it is to an engineer. In my own view, that's an area to be examined closely.

DR. PLESSET: What I was going to propose -- and I hope this will meet with your approval -- is that we take a five minute recess and come back for a five minute session for a few very brief summary remarks. Is that agreeable? Let's do it, then.

(Recess)

DR. PLESSET: What I thought I would like by way of summary -- I think today deserves it -- is to express a few ideas, to which I hope you will make additions regarding what went on today. The first item on the agenda was the staff review of the Michelson concerns. I thought they made a sincere and reasonably competent effort to do that. I presume that the committee and consultants would agree with that.

MR. ZUDANS: Except not the same configuration.

DR. PLESSET: I think Carl was fairly well satisfied. It's reasonable to say that.

MR. MICHELSON: I was only making sure they understood they haven't, of course, really given us the data for the 205

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plants.

MR. ZUDANS: That's what I mean.

DR. PLESSET: That was a point I think they noted.

PROF. CATTON: The basic processes are proper.

DR. PLESSET: The other thing that I wanted to make a very brief comment about was the analysis. They, in a skeleton form, presented the B&W analysis, which is a legitimate thing to do. This is a thick report. If any of you don't have it, you can get it.

I felt that, beyond that, I would like to see more staff independent calculations such as they indicated to us. They made calculations and I would like to encourage them to do more of this. I would like to get some opinions on that.

MR. EBERSOLE: I am in agreement with you. I would like to see them extend the scope of the small break program beyond just coping with this particular aspect.

DR. PLESSET: I think this is a thing that can get lost sight of in the enthusiasm to develop new codes and what-have-you. This is a pretty advanced code, anyway, isn't it? I would like to see them put effort in on this kind of thing with some useful end in sight rather than be concentrating, as they are, in the research program or the new code and finding out how wonderful it is, which is not of great interest to me. Anyway, I think this is an important and useful calculation.

PROF. CATTON: I think they did a pretty good job in

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predicting what was observed in codes that exist now.

DR. PLESSET: All the more reason to encourage them to consider more of this.

PROF. CATTON: To exercise the variations.

MR. ZUDANS: I would like to comment. This wasn't really a calculation because they did not put the same boundary calculations in B&W and, therefore, there were significant discrepancies in the results. I understand they are going to redo it.

DR. PLESSET: I think they should be encouraged to do this.

MR. ZUDANS: What is the purpose of that? You get some calculations in B&W that are reasonable because it is very sophisticated in one dimension.

DR. PLESSET: Do you want to make a comment?

PROF. THEOFANOUS: If you insist, I will.

DR. PLESSET: If we don't agree, we will say so.

PROF. THEOFANOUS: I feel that the small break analysis is receiving more emphasis and attention, but I am concerned and afraid that all this emphasis is motivated from TMI-2 and the problem is not looked at in a more generic fashion.

What happened is that, because we missed something along the way, suddenly we are not going to miss the same thing again because we know it. What I am concerned about is: Is

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there a possibility for something else falling in between the cracks as you go on responding to TMI-2?

Therefore, I feel that what is needed here is a more concerted effort, a more total effort, something that is more programatic and something that is more complete from the beginning of the start of the effort, going through the different stages; something that is well-designed, aimed at completeness instead of just taking kind of shots in the dark on different things.

I don't see that happening.

DR. PLESSET: I agree with you completely. Let me say that is perhaps something for research to do, and I don't think they are doing it. Maybe they should.

PROF. THEOFANOUS: That's right.

DR. PLESSET: They don't need to wait for a complete -- whenever that will happen, which is a long time away -- confirmation of TRAC or what-have-you. I think that we can get enough confidence in RELAP-4 so that it could be done, what you are speaking of.

But that's a research job. I think that is something we ask them for tomorrow. We will be talking with a different group.

PROF. THEOFANOUS: Who are we addressing now?

DR. PLESSET: Zoltan and the operating reaction division. We should encourage them to continue to do more of

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what they told us about today, which was limited to kind of verifying B&W's small break analysis, which they have to do in connection with their task of licensing and permitting reactors to operate.

I think one should go beyond that but that's a researcher's job.

PROF. THEOFANOUS: I don't quarrel with what you say. The reason I bring this up is that I don't see the effort as disjointed. I think we are at a point where the resources are rather limited. I don't think we can afford one group going on one way and another group another way. I kind of feel that the reason staff will respond more to the licensing staff is if Zoltan's people and we feel here there is much more emphasis. I think that will bring pressure to bear to the staff to start doing some cf these things.

DR. PLESSET: I agree completely with what you are trying to get at. We can in'icate to the reactor regulation people and the operating reactor people that we are interested and want research to d- this. I would say that's a good thing. I would be 100% in favor of it. I think it is a ver' good point you made.

PROF. CATTON: That fits within the requirement for user need.

DR. PLESSET: Yes. There is some talk about the ACRS being made a user. We can specify needs and ask for them as a

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user. I don't know what the status of that is.

PROF. CATTON: That might help.

DR. PLESSET: Anyway, we can do what we are speaking of in the interim by just using moral suasion or whatever.

MR. ZUDANS: Wouldn't this essentially mean like taking all the possible events and combining with a mixture of possible human error events, creating a completely new system where TMI is one of the combinations but, like Theo said, there could be a hundred others we don't know about?

DR. PLESSET: This is a very useful activity for research to do. Kind of saying: Well, use this one. Don't wait until you have the dream code. That's what I am trying to get at. There is something to do beginning now; not only at TMI-2 and verifying what B&W has done with that particular event. Go beyond it. I think this is terribly important.

What do you think?

MR. EBERSOLE: I think it is, too. It was running through my mind here that most of the research that has been done in Idaho has been on local matters. There was an interesting incentive to that. You are always working on improvement in the system to show that you would obtain lower temperatures under certain circumstances and you would buy an operating margin that was profitable. That is, the vendors had an incentive to do that research since it appeared as a financial advantage to them in terms of the operating level of the

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reactor.

I think we are entering an area here where there is no such incentive in a progressive sense. We are either going to show it is safe or isn't safe.

DR. PLESSET: It has to be done by NRC.

MR. EBERSOLE: That motivation is no longer with us.

DR. PLESSET: Very good point.

MR. EBERSOLE: Now it is a safety issue, pure and simple. Not economic.

PROF. THEOFANOUS: The other point that has to be made about getting more calculations, I thi there is the question of the validity of the projections. I think it is fair to say that the small break calculations are the least-verified calculations of any kind we know of in this kind of transient.

Some of the behaviors that are predicted for the system are not necessarily going to be correctly projected. To have a correct interpretation of how the system responds is very cruci l because that is how the operator must be trained.

Basically, there are two programs. One is to know the phenomena. Secondly, to carry out this phenomena over to the operator to know how to respond.

In order to make the second step right, we have to make the first step right, which means we have to have calculational procedures that can basically predict the phenomena, the

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whole sequence of the accident together with all the interference and interfaces between the operator and the accident and the equipment and the accident.

To my knowledge, I guess it is my guess -- or it is my feeling -- that, at this stage of the game, we cannot be very confident that whatever results come out of those calculations are going to be the correct projections. Now, this does not mean that I will say we should not do these calculations. Even if the calculation is incorrect, if you spend the appropriate amount of time with it, if people apply the right kind of thinking, they still learn something.

That's what I have been advocating for some time now. Even with the advances, I feel they are in acceptable shape. I think they are preferable from the point of view of small breaks because they can be non-equilibrium and have fair separation. They could be used even two years back to carry out all kinds of calculations.

It doesn't mean you should see those results and say here is the input, this is a black box, there is the output. Look at the accident scenario in between. I call it accident analysis studies. Even if the calculation, itself, has faults in it, and even if one cannot trust it altogether, enough triggers the imagination of the people, if somebody was going to give thought to it, that I think it would cover us for many respects where we are not covered now.

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That has to be remembered also; not just to look at the results and say this is what will happen.

DR. PLESSET: I am glad to hear you say one thing, anyway: That codes are available now to give us something very useful and of value. This is the point I wanted to make. They should be encouraged to make these accident analyses of the kind we are concerned with and not ma'e this just a far-out research project with a code that was verified and completely established and so on, which may never happen.

PROF. THEOFANOUS: That's right.

DR. PLESSET: Maybe, from a microscopic point, it is what they are aiming at -- a very microscopically correct description -- but we are interested in more global behavior. What happens to the whole system; not some little piece of it.

Harold?

MR. SULLIVAN: I have been doing some of the calculations now and I am surprised at how sensitive they are to the boundary conditions. You really need to understand how the operator is going to interact with the system to change the boundary conditions.

DR. PLESSET: I was going to come to that later. I think you have a very valid point. There is no question about it, that there is a crucial aspect of the problem here. That is one of the advantages of making extensive-enough studies, so that you appreciate this.

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If we stop at this stage and devote our research code activities to 2D/3D or whatnot, I wonder whether that will help us. This is laying the groundwork for you to think about tomorrow's discussion, in a way.

MR. EBERSOLE: I would like to call out something. I hope some of you are more familiar than I am with a standard sometimes called N662, which sets forth the limits of expectations of an operator and what they need to know to do what they are supposed to do. It is the game of rules that decides whether or not an operator can function. Do you know where that stands now? I don't know whether the staff is using this as a model for operator functions.

MR. MICHELSON: I think it's 660.

MR. EBERSOLE: Make it 660 to 662, I don't remember, but I know it was getting pretty well put together.

MR. MICHELSON: It got put together and out on the street for trial use and comment. Then they formed a new task force by throwing all the old members off and getting a whole new crew in, and they are in the process of reworking it again because of various resistances and concerns about practicality and that sort of thing.

MR. EBERSOLE: It used to be you can invest in an operator this degree of responsibility, but that's changing.

MR. MICHELSON: It turned out that perhaps in some areas it is a little idealistic, as evidenced by some of the

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observations at TMI, but it is still a good idea.

MR. EBERSOLE: A set of ground rules that set what an operator can and cannot do.

DR. PLESSET: What I wanted to do is incorporate this remark into the last topic of this afternoon. I am not very well satisfied with the situation with operator training and approval. I would throw that out. I think it is unsatisfactory, really not acceptable. I gather you have some of the same feelings.

MR. EBERSOLE: I think they should be trained on a more professional basis rather than a technician basis.

DR. PLESSET: This is very important for us to say. I throw it open to the consultants. You heard Jesse and me. Please feel free to comment.

PROF. CATTON: Several of us here have been involved with both the LER and TMI and that's a conclusion that comes through very strongly. There seems to be something lacking in how an operator is prepared for the job he must do, particularly for the education part of it as contrasted with the training part.

There is another loophole, too, that somehow needs to be incorporated into this. How does the information get from a particular incident at another plant back to that operator? We found out that it doesn't. It didn't with TMI. I don't know if it does now. It didn't in the past. This is

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another area that needs to be cleaned up. It all fits into this arena of professionalism for operators.

DR. PLESSET: I don't want staff to think we are painting them with a dark black brush. I think what we want to do is encourage them to do more, and better. I think they have already made significant steps toward improvement.

I would just like to indicate our opinion that we would like to see the pressure in this direction be maintained and more done.

MR. ZUDANS: In this context, last week the news described an incredibly broad program TVA is involved in. Independent of NRC requirements, they are setting up all these things we are talking about. They require a college equivalent background in the operator. They set up instrumentation with CRTs that will show the systems. They are quoted as saying they are a major utility owned by the federal government and they are going to show an example of what should be done.

DR. PLESSET: That's very good, but we have to be impressed more with deeds and results than words.

MR. ZUDANS: That's deeds.

MR. EBERSOLE: It's a great paper program. The realization of it is yet to come.

MR. ZUDANS: Another thing, a thought is in my mind. We are talking about small break accidents and the analysis of the same. Isn't it thinkable to devise full-scale experiments

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in many fringe areas of small breaks?

MR. EBERSOLE: Why say full-scale? This is particularly suitable for small-scale, isn't it?

MR. ZUDANS: I don't think so.

MR. EBERSOLE: What is involved here is not such to demand large-scale.

MR. ZUDANS: Actuall full-size power plant.

PROF. CATTON: Don't we have several full-sized experiments?

(Laughter)

MR. ZUDANS: That's the reason. What we have to do is recommend an instrumentation. Should anything like this happen, we would create a full-scale experiment which would then verify, including the boundaries as well as analysis. Without damaging a power plant, you can really design this.

MR. EBERSOLE: A full-scale experiment where you can turn it off in case the experiment goes sour?

MR. ZUDANS: There have been many of them, and all you have to do is provide the appropriate data-taking device and wait for one to happen.

DR. PLESSET: I am a little reserved about imposing too much of this kind of thing on utilities.

PROF. CATTON: But that's coming to pass, anyway, as part of the ACRS requirements on post-accident instrumentation.

DR. PLESSET: That was talked about for years.

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PROF. CATTON: If it comes to pass, we will have the experimental data. If it doesn't, we won't.

DR. PLESSET: Fine. I'm sure ACRS will be very happy to see instrumentation in place.

MR. ZUDANS: Mike Bender started talking about that 10 years ago.

MR. SULLIVAN: I would like to agree with you. I think the operators need a better education, probably not just in the academic sense but in the plant sense. I have read several of the operator interviews. They didn't know exactly how the system was drummed up at the time TMI happened.

DR. PLESSET: I can sympathize with a man going through that. Even a smart rat can get lost.

(Laughter)

MR. SULLIVAN: I would recommend a computer system there to help the operator through a myriad of information that probably nobody could digest. I would recommend that a computer system be there to recommend things he should do and also to tell him what is not working and to warn him. Also, it would be fast enough that it can record the data being transmitted to it. The one at TMI, I understand, was so slow that a lot of the information was lost.

MR. ZUDANS: The printer was slow.

PROF. CATTON: The availability of it was lost.

MR. ZALOUDEK: Let me add my name to the list, also.

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I am frankly skeptical of the ability of an operator to act when his microworld is falling down around him. I have been personally involved in a couple of large industrial accidents, not nuclear accidents, and I have been thrust in this spot, myself. I find that the only thing that really counts at that time is training because you can't think, not when the "fight or flight" instinct is taking over, when the adrenalin is flowing. You cannot think. You fall back on your rote training to perform the right action at the right time, if you can.

DR. PLESSET: Fine.

PROF. CATTON: That comment was made at TMI. We should be lucky that they didn't take off and run.

(Laughter)

MR. SHUMWAY: This goes back to earlier comments concerning the B&W analysis. The conclusion is that this CRAFT code can calculate the small break transients.

DR. PLESSET: I don't think we accepted that.

MR. SHUMWAY: I just wanted to voice that I cannot accept that.

DR. PLESSET: I don't think that was the reaction. We were kind of pleased there seemed to be some areas of agreement.

MR. SHUMWAY: Earlier in time, it looked pretty good. If you got off in some direction, you can be a long period away. Until the calculation on TMI was completed out, there was -- they used it to calculate these small breaks.

DR. PLESSET: It would be interesting to get a symmetry of what they are pretty sure exists in the core damage. It would be nice to make a prediction of what that symmetry is like.

PROF. THEOFANOUS: They cannot do it.

DR. PLESSET: Sure, they can, but let's ask them, anyway.

Well, I appreciate your helping in this summary. I think we can terminate the meeting. Thank you for your patience.

We will adjourn until 8:30 tomorrow.

(Whereupon, the meeting was adjourned at 5:45 PM.)

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TMI-2 RELATED

OPERATOR TRAINING

1. REVIEW OF TMI-2 ACCIDENT WITH I&E
2. TMI-2 SIMULATOR TRAINING
3. FORMAL CLASSROOM TRAINING
4. FACILITY WRITTEN EXAMS
5. NRC AUDIT
6. FOLLOWUP TRAINING
7. REQUALIFICATION TRAINING

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NRC AUDIT

1. TMI-2 ACCIDENT

2. SMALL BREAK LOCA RESPONSE

3. FACILITY CHANGES

4. PROCEDURE CHANGES

5. AUXILIARY/EMERGENCY FEEDWATER SYSTEM

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TMI-2 ACCIDENT

1. SEQUENCE OF EVENTS

2. OPERATOR ACTIONS/CONSEQUENCES

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SMALL BREAK LOCA RESPONSE

1. PRESSURIZER LEAKS

2. SATURATION/SUBCOOLING

3. NATURAL CIRCULATION

4. TERMINATION OF HPI

5. HEAT SINKS

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FACILITY CHANGES

1. REACTOR TRIPS

   A. TURBINE TRIP

   B. LOSS OF FEEDWATER

   C. BYPASSES

2. PORV SET POINT

3. AUXILIARY/EMERGENCY FEEDWATER SYSTEM

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PROCEDURE CHANGES

1. LOSS OF COOLANT

2. LOSS OF FEEDWATER

3. LOSS OF ALL RCP'S

4. OPERATING PROCEDURES

5. ADMINISTRATIVE PROCEDURES

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AUXILIARY/EMERGENCY

FEEDWATER SYSTEM

1. AUTOMATIC STARTS/CONTROL

2. MANUAL STARTS/CONTROL

3. SUCTION SUPPLIES

4. SURVEILLANCE TESTING

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REVIEW OBJECTIVES

1. CONFORMANCE WITH GUIDELINES

2. WORKABILITY FOR OPERATORS

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PROBLEMS ENCOUNTERED

1. KNOWLEDGE OF SMALL BREAK PHENOMENON
2. EXCEPTIONS TO GUIDELINES
3. ADAPTING TO EXISTING PROCEDURES

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OPERATING PROCEDURE GUIDELINES FOR SMALL BREAKS

PART I - BACKGROUND INFORMATION FOR A SPECTRUM OF LOSS-OF-COOLANT ACCIDENT

PART II - OPERATING GUIDELINES FOR SMALL BREAKS

GUIDELINES

SYMPTOMS AND INDICATIONS

IMMEDIATE ACTIONS

PRECAUTIONS

FOLLOWUP ACTIONS

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IF THE HPI SYSTEM HAS BEEN ACTUATED BECAUSE OF A LOW PRESSURE CONDITION, IT MUST REMAIN IN OPERATION UNTIL ONE OF THE FOLLOWING CRITERIA IS SATISFIED:

1. THE LPI SYSTEM IS IN OPERATION AND FLOWING AT A RATE IN EXCESS OF 1000 GPM IN EACH LINE AND THE SITUATION HAS BEEN STABLE FOR 20 MINUTES.

OR

2. ALL HOT AND COLD LEG TEMPERATURES ARE AT LEAST 50^{0} BELOW THE SATURATION TEMPERATURE FOR THE EXISTING RCS PRESSURE. IF THE 50^{0} SUBCOOLING CANNOT BE MAINTAINED, THE HPI SHALL BE REACTIVATED.

SMALL BREAK ACCIDENTS

RCP's	FW	RECOMMENDED ACTION
1. YES	YES	STOP ONE RCP PER LOOP. USE OTSG's TO COOLDOWN AT 100°/HOUR.
2. YES	NO	MAINTAIN MAX. HPI FLOW. STOP ONE RCP/LOOP. OPEN PORV IF RCS PRESSURE INCREASES. RESTORE FW ASAP.
3. NO	YES	COOLDOWN WITH NATURAL CIRCULATION. IF UNABLE, ATTEMPT TO RESTORE FORCED CIRCULATION WITH RCP's. IF UNABLE, CYCLE PRESSURE BETWEEN 2300 PSIG AND 100 PSI ABOVE OTSG PRESSURE.
4. NO	NO	OPEN PORV. MAINTAIN HEAT REMOVAL PATH FROM HPI THRU BREAK AND PRESSURIZER. RESTORE FW AND ECP's.

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B&W SMALL BREAK GENERIC STUDY

BREAK	AFW	HPI	EC PUMPS	LONG-TERM COOLING
.07 FT^2	OFF	2	OFF	390 SEC.
.02	OFF	"	"	650
.01	1 @ 20 MIN.	"	"	1730
.01	OFF	2 @ 20 MIN.	"	2774
LOFW	2	1 HPI	ON	1000
PORV	"	"	OFF	1000
PORV (ANS*1.2)	OFF	"	"	--
PORV (ANS*1.0)	OFF	"	"	4700
.01	2	"	"	4900
.01 (ASYM)	1	"	"	4975
.005	2	"	"	5000
.01 (DB-1)	2	"	"	6000

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TVA (C. MICHELSON) CONCERNS ON B&W 205-FA PLANTS

- CONCERNS ON B&W 205-FA PLANTS DURING VERY SMALL BREAK LOCAs DOCUMENTED IN REPORT BY C. MICHELSON (TVA)

- CONCERNS TRANSMITTED TO B&W BY LETTER ON APRIL 26, 1978

- B&W EVALUATED AND RESPONDED IN LETTER TO TVA ON JANUARY 23, 1979.

- B&W SUBMITTED MORE COMPREHENSIVE REPORT ON MAY 7, 1979 WITH ADDITIONAL INFORMATION ON B&W PLANT RESPONSE TO SMALL BREAKS

CONCERNS

1. ACCEPTABILITY OF INTERMITTANT NATURAL CIRCULATION
2. TIME DELAY IN TRANSITIONING FROM NATURAL CIRCULATION TO POOL BOILING
3. PRESSURIZER LEVEL WAS NOT CORRECT INDICATION OF WATER LEVEL IN CORE
4. CONSEQUENCES OF SMALL BREAK ISOLATION/REPRESSURIZATION
5. PRESSURE BOUNDARY DAMAGE DUE TO BUBBLE COLLAPSE
6. BREAK ENERGY NOT REPRESENTATIVE OF CORE EXIT ENERGY
7. EFFECT OF NON-CONDENSIBLE GASES (FROM CE SYSTEM 80 REPORT)

INTERMITTANT NATURAL CIRCULATION

- STEAM BUBBLES FORMED IN CORE OR HOT LEG ACCUMULATE AT TOP OF HOT LEG U-BEND
- WHEN STEAM VOLUME EXCEEDS VOLUME OF U-BEND, FLOW PATH IS BROKEN AND NATURAL CIRCULATION STOPS
- LOSS OF HEAT SINK CAUSES SYSTEM TO REPRESSURIZE
- REPRESSURIZATION CONDENSES STEAM IN U-BEND AND NATURAL CIRCULATION RESTORED
- STEAM BUBBLES REFORM, COLLECT IN HOT LEG U-BEND, AND PROCESS STARTS OVER

279 291

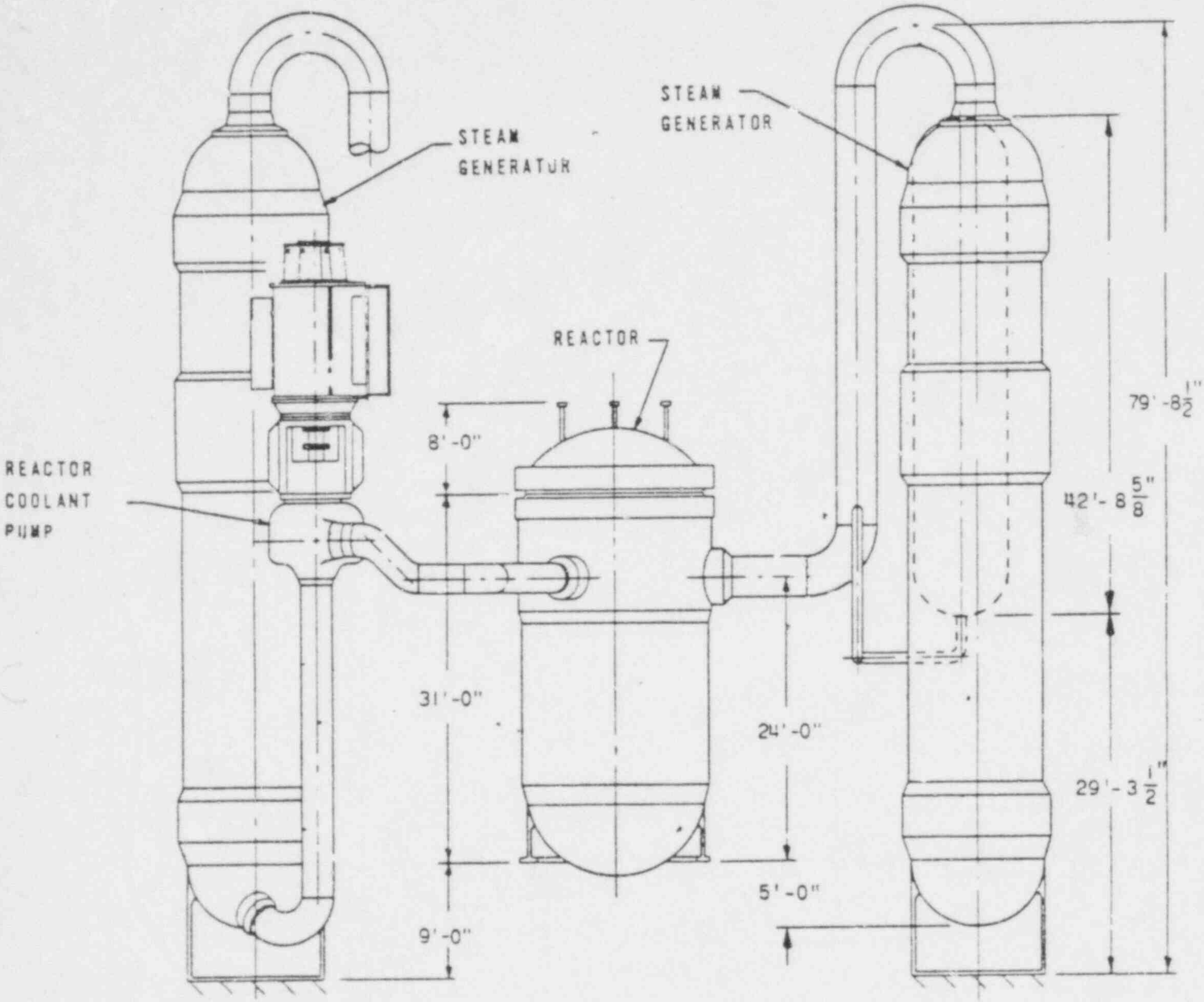


Figure 4. Reactor Coolant System Arrangement - Elevation, from Three Mile Island, Unit 2, FSAR.

279 292

18

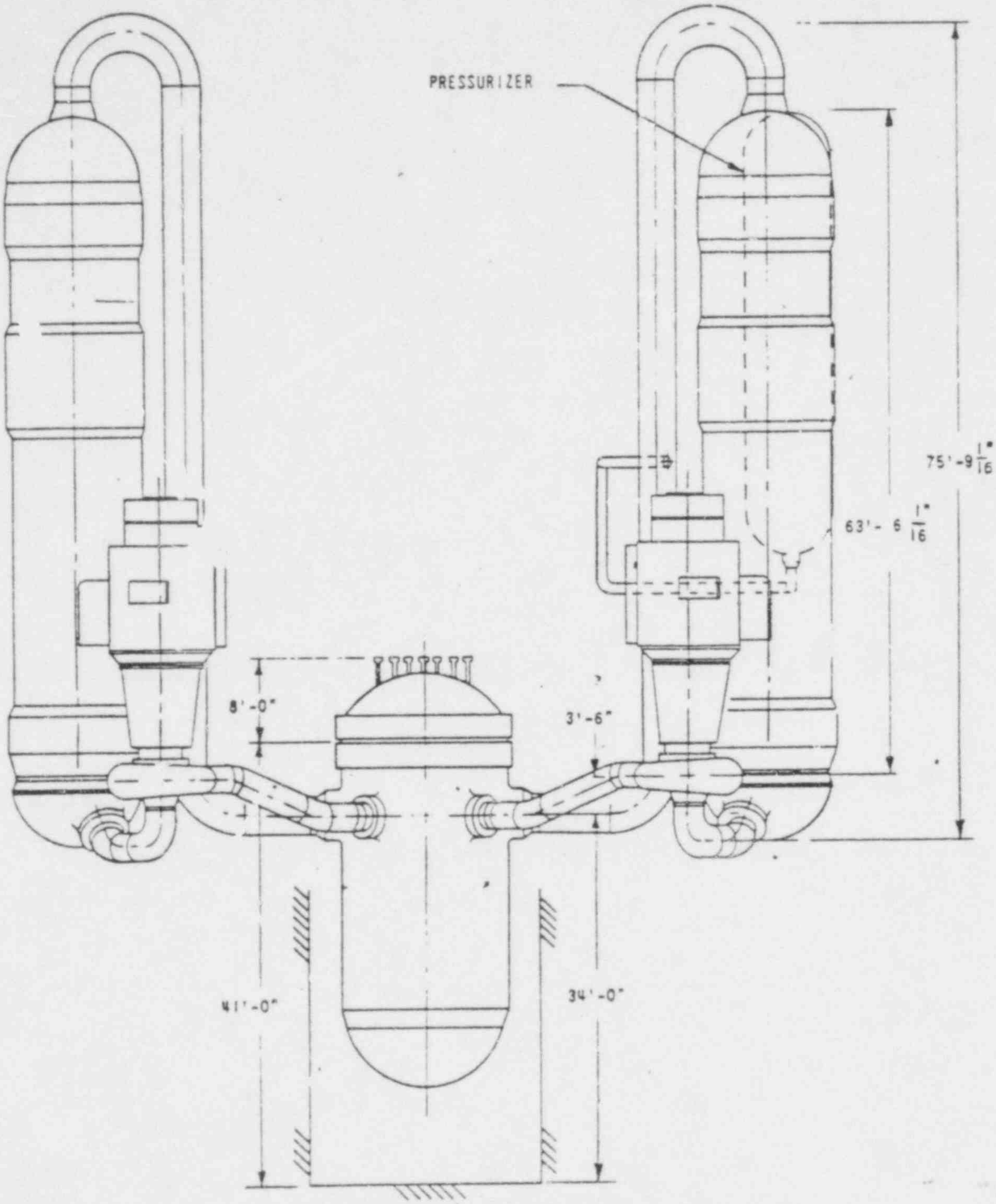


Figure 6. Reactor Coolant System Arrangement - Elevation, from Davis-Besse, Unit 1, FSAR.

279 293

- B&W PERFORMED ANALYSES FOR 0.01 FT^2 AND 0.005 FT^2 BREAKS FOR 177-FA LOWERED LOOP PLANTS & 0.02 FT^2 BREAK FOR 177-FA RAISED LOOP PLANT

- USED CRAFT CODE/SIMULATIONS TO 3000 SECONDS

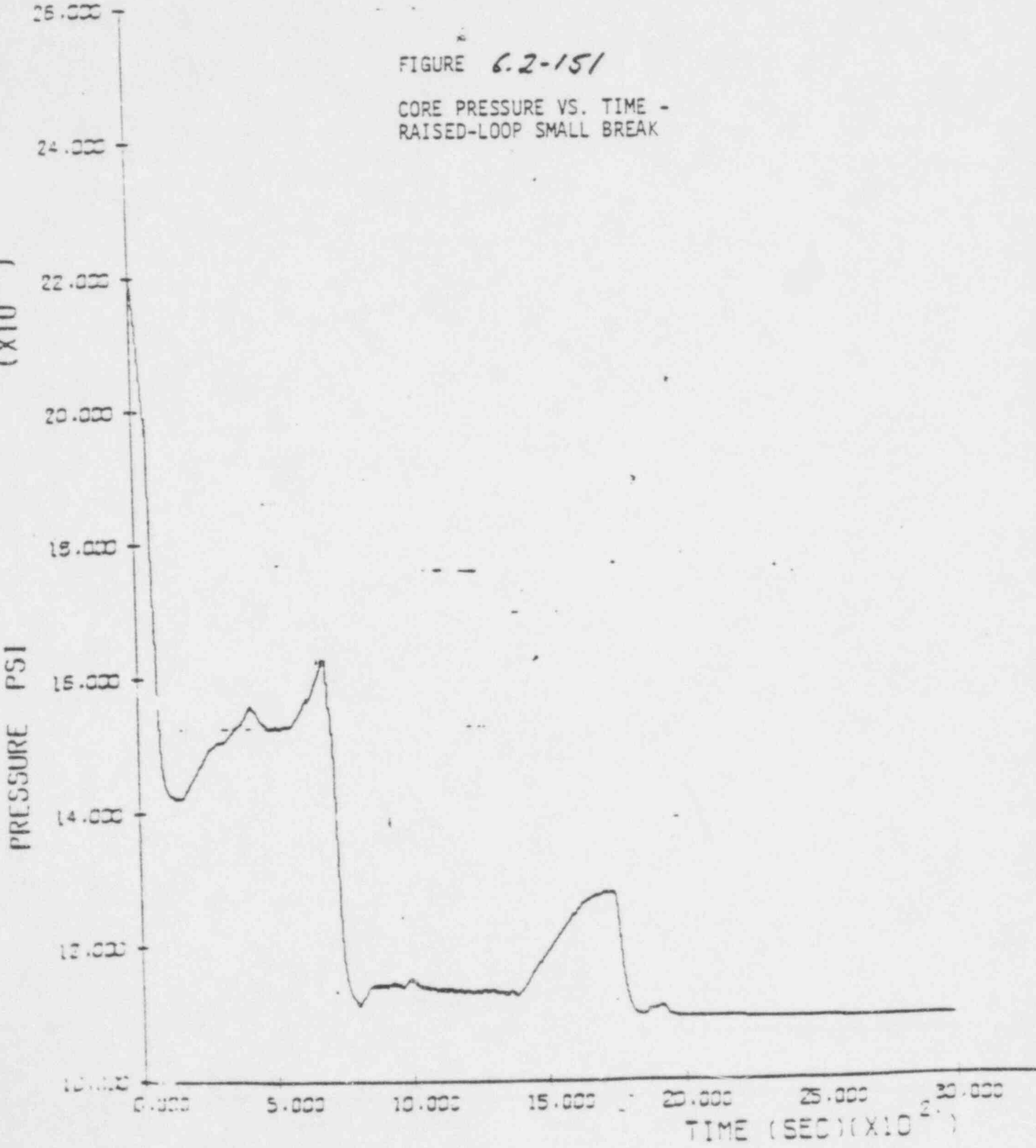
- FOR LOWERED LOOP PLANTS, NO CYCLIC REPRESSURIZATION OBSERVED - ONCE NATURAL CIRCULATION INITIALLY LOST, HOT LEG U-BEND DID NOT REFILL

- FOR RAISED LOOP PLANTS, CYCLIC REPRESSURIZATION WAS CALCULATED TO OCCUR

- ANALYSIS PREDICTED TRANSITION TO REFLUX BOILING AND CORE UNCOVERY WAS NOT CALCULATED TO OCCUR

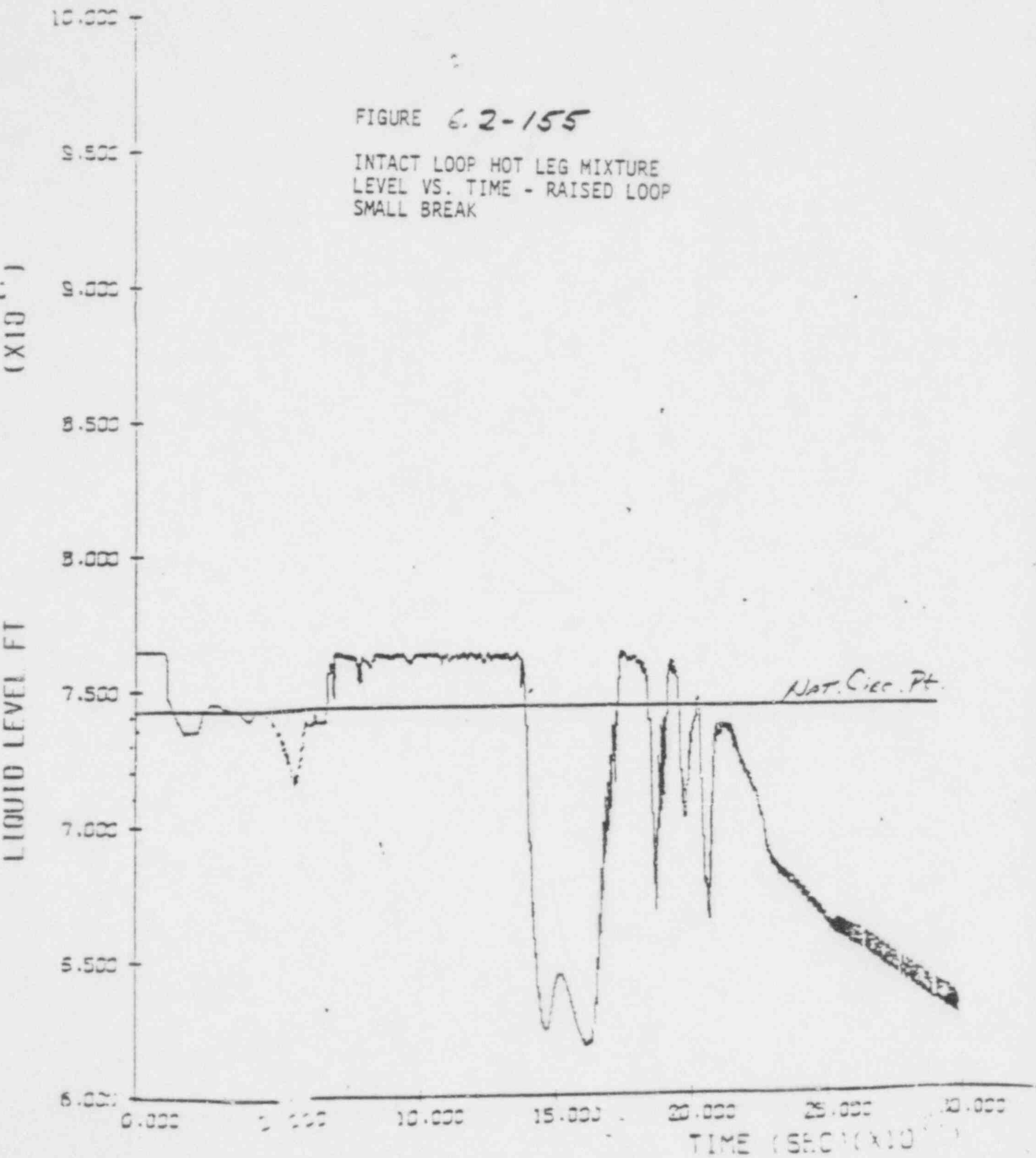
FIGURE 6.2-151

CORE PRESSURE VS. TIME - RAISED-LOOP SMALL BREAK



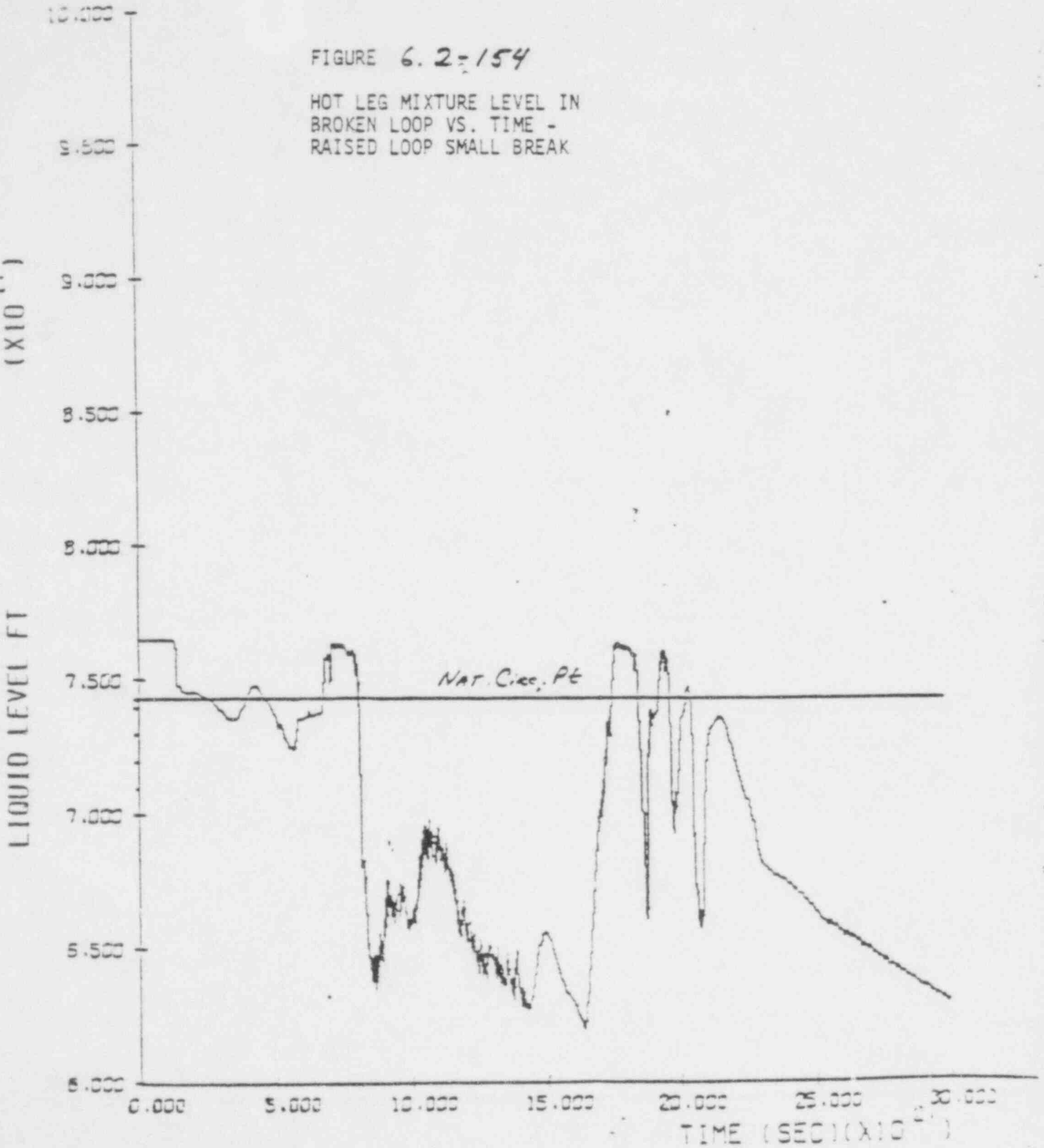
OIFT2 PD NEW EM

279 NODE 2



.01FT2 NEW EM

279 296 NODE 16



J0030 .01FT2 PD NEW EM

NODE 3

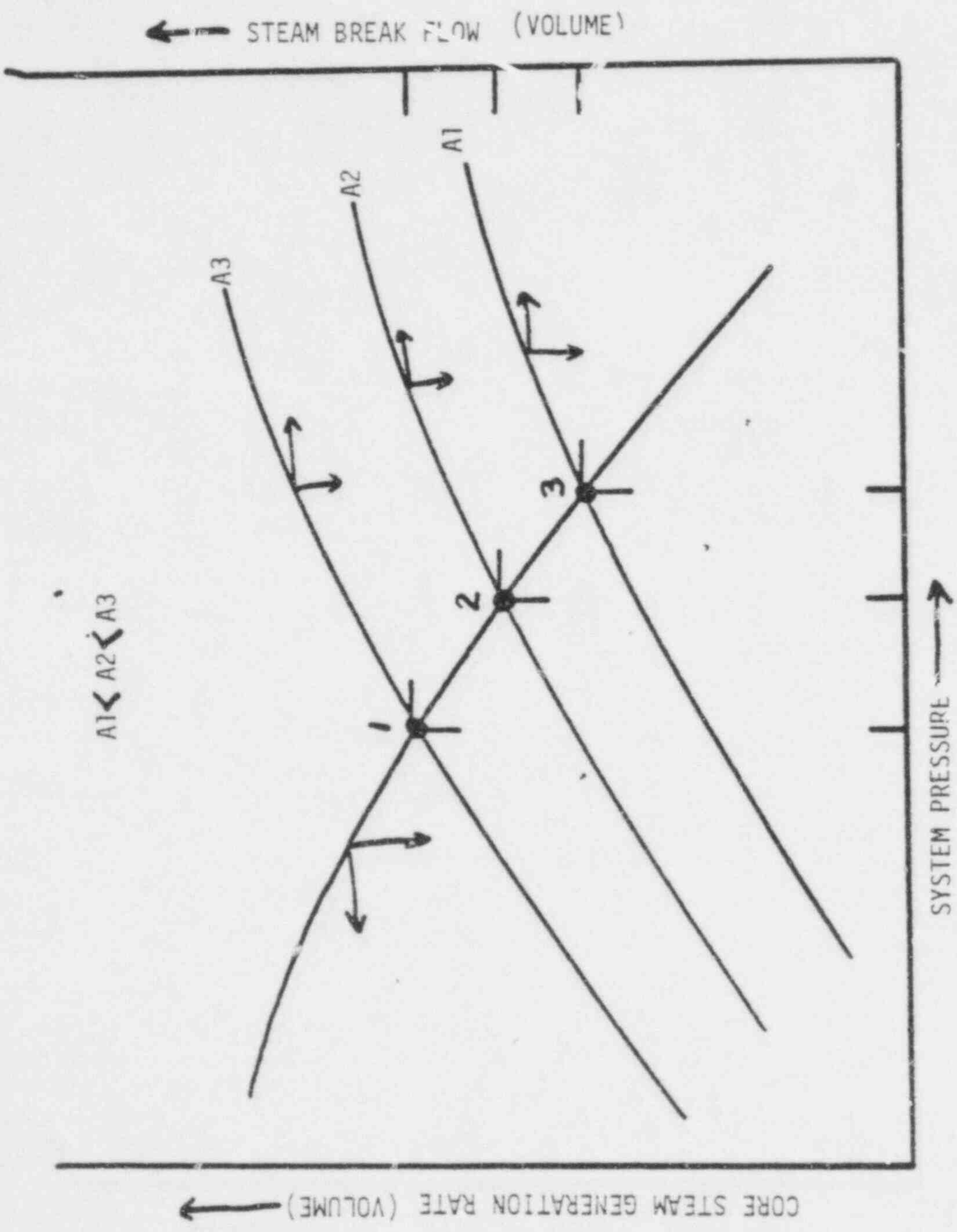
279 297

TIME DELAY IN TRANSITIONING FROM NATURAL CIRCULATION TO POOL BOILING

- ONCE NATURAL CIRCULATION LOST, SG LEVEL MUST DROP BELOW SECONDARY LEVEL IN ORDER TO COMMENCE WITH REFLUX BOILING.
- WOULD REPRESSURIZATION INCREASE BREAK FLOW AND LEAD TO CORE UNCOVERY?

- REPRESSURIZATION DETERMINED BY BALANCE BETWEEN STEAM GENERATED IN CORE AND STEAM RELIEVED BY BREAK.
- FOR DECREASING BREAK SIZE, MASS FLOW OUT BREAK DECREASES, MAXIMUM REPRESSURIZATION INCREASES. STEAM VOLUME GENERATION DECREASES.
- FOR RAISED LOOP PLANTS, CONDENSING SURFACE MUST BE ESTABLISHED BEFORE CORE UNCOVERY.
- FOR LOWERED-LOOP PLANTS, AUXILIARY FEEDWATER ENTERS FROM THE TOP OF THE SG. AUXILIARY FEEDWATER STARTED WHEN SECONDARY SIDE LEVEL DROPS BELOW 1/2 NORMAL OPERATING LEVEL WITH PUMPS NOT RUNNING. (BELOW 3 FEET WITH PUMPS RUNNING).

279 298


STEAM BREAK FLOW (VOLUME)
CORE STEAM GENERATION RATE (VOLUME)
SYSTEM PRESSURE
A1
A2
A3
A1 < A2 < A3
1
2
3

219 299

PRESSURIZER LEVEL AS A CORRECT INDICATION OF WATER LEVEL IN CORE

. FOR PRESSURIZER BREAKS, FLOW INTO PRESSURIZER WOULD PREVENT DRAINING AND MAINTAIN PRESSURIZER LIQUID INVENTORY

. REVISED PROCEDURES INSTRUCT OPERATORS TO CHECK OTHER SYSTEM PARAMETERS/HPSI SHUTOFF CRITERIA PRECLUDES PRESSURIZER LEVEL AS PRIMARY INDICATOR OF SYSTEM INVENTORY

. LONGER TERM STUDY UNDERWAY OF MORE DIRECT AND EASILY INTERPRETED INDICATORS OF WATER INVENTORY (E.G., LEVEL DETECTION)

279 300

SMALL BREAK ISOLATION/REPRESSURIZATION

- ISOLATION OF SMALL BREAKS CAN CAUSE SYSTEM REPRESSURIZATION.
  - NO NATURAL CIRCULATION
  - HPSI REPRESSURIZATION
- WOULD RESULT IN OPENING PORV W/POSSIBLE PORV FAILURE.

- PORV FAILURE WOULD APPEAR AS SMALL BREAK IN PRESSURIZER STEAM SPACE
- ACCIDENT (FAILURE OF PORV) DISCUSSED BUT NOT SPECIFICALLY ANALYZED IN SARs
- DO NOT EXPECT NEW AND/OR UNUSUAL BEHAVIOR
- SPECIFIC ANALYSIS OF ISOLATION OF SMALL BREAKS W/PORV FAILURE WILL BE REQUIRED
- OPERATOR ACTION TO TURN OFF HPSI AFTER CRITERIA MET REQUIRED

PRESSURE BOUNDARY DAMAGE DUE TO BUBBLE COLLAPSE

- COLLAPSING STEAM BUBBLES IN SUBCOOLED LIQUID PRODUCE PRESSURE LOADINGS ON PRIMARY COOLANT BOUNDARIES.

- INJECTING COLD ECC INTO STEAM-FILLED PIPE PRODUCES PRESSURE LOADS ON STRUCTURES.

- INJECTION COLD ECC INTO STEAM-FILLED PIPE
  - INJECTION OF ECC IN LOFT & SEMISCALE HAVE NOT SHOWN EXCESSIVE PRESSURE OSCILLATIONS (~10 PSI).
  - TESTS BY CE, W, AND EPRI SHOWED OSCILLATIONS OCCURRED WHEN INJECTION FLOW WAS SUFFICIENT TO PRODUCE SLUG OF WATER IN COLD LEG.
  - HPSI FLOW NOT HIGH ENOUGH TO PRODUCE WATER SLUGS.

- COLLAPSING STEAM BUBBLES
  - PRESSURE WAVES WOULD BE NON-DIRECTIONAL.
  - SYSTEM W/BUBBLES IS HYDRAULICALLY "SOFT" - ATTENUATION EXPECTED.

- LOADS EXPECTED TO BE LESS THAN LARGE BREAK LOCA LOADS.

- WILL REQUIRE LICENSEES AND APPLICANTS TO ANALYZE TO CONFIRM CONCLUSION.

BREAK ENERGY NOT REPRESENTATIVE OF CORE EXIT ENERGY

- BREAK CANNOT REMOVE FULL DECAY HEAT LOAD UNLESS BREAK ENERGY IS CORE EXIT ENERGY.
- HPSI BYPASS

- CODES ACCOUNT FOR DISTRIBUTION OF ENERGY
- ASSUME HPSI CAN CONDENSE W/100% EFFICIENCY
- ANY NON-EQUILIBRIUM EFFECTS EXPECTED TO BE SMALL

NON-CONDENSIBLE GASES

STAFF ESTIMATES (BSAR-205)

SOURCE	CUBIC FEET AT STP
DISSOLVED H_2 IN PRIMARY COOLANT	437
DISSOLVED AIR IN REFUELING WATER TANK	1214
H_2/% ZIRC. REACTED	4344
FLOOD TANKS	
DISSOLVED N_2	1456
FREE N_2	33,101
PRESSURIZER GAS SPACE	~700
RADIOLYTIC DECOMPOSITION OF INJECTED ECC WATER	NEGLIGIBLE FOR H_2 CONCENTRATIONS ABOVE 5CC/K_GH_2O
HE FILL GAS + GAP FISSION GAS @ EOC	~1500

279 304

- FOR VERY SMALL BREAKS IN WHICH SG MUST REMOVE DECAY HEAT, ACCUMULATORS DO NOT TURN ON.

- FOR BREAKS WHICH DO TURN ON ACCUMULATORS, PRESSURE MUST DROP TO ~150 PSI BEFORE SIGNIFICANT QUANTITIES OF N_2 WILL ENTER SYSTEM.

- MOST LIKELY ACCUMULATION OF GASES IS UPPER PLENUM AND HEAD.

- WITHOUT ACCUMULATOR ACTUATION & SIGNIFICANT CORE OXIDATION, NON-CONDENSIBLE GASES SHOULD NOT HINDER DECAY HEAT REMOVAL BY STEAM GENERATORS.

279 305

SUMMARY

. NO DISAGREEMENT ON PHENOMENA DESCRIBED BY C. MICHELSON.

. CONCERNS UNDERSCORE IMPORTANCE OF NATURAL CIRCULATION FOR DECAY HEAT REMOVAL DURING SMALL BREAKS.

. B&W HAS PERFORMED DETAILED ANALYSES TO ADDRESS CONCERNS.

. RESULTS SHOW PHENOMENA OCCUR, BUTTHAT DECAY HEAT REMOVAL IS NOT UNACCEPTABLY IMPACTED.

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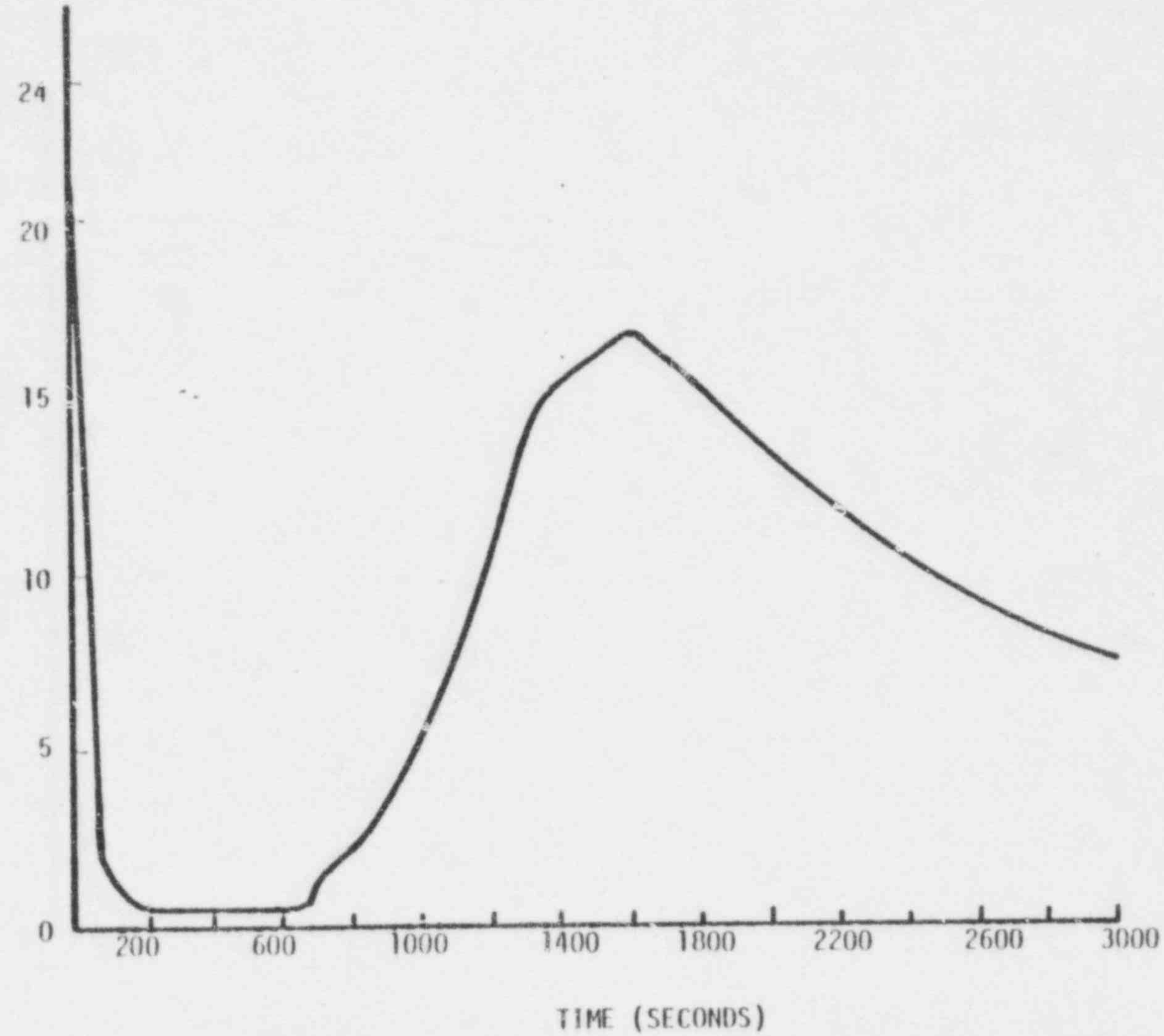
279 307

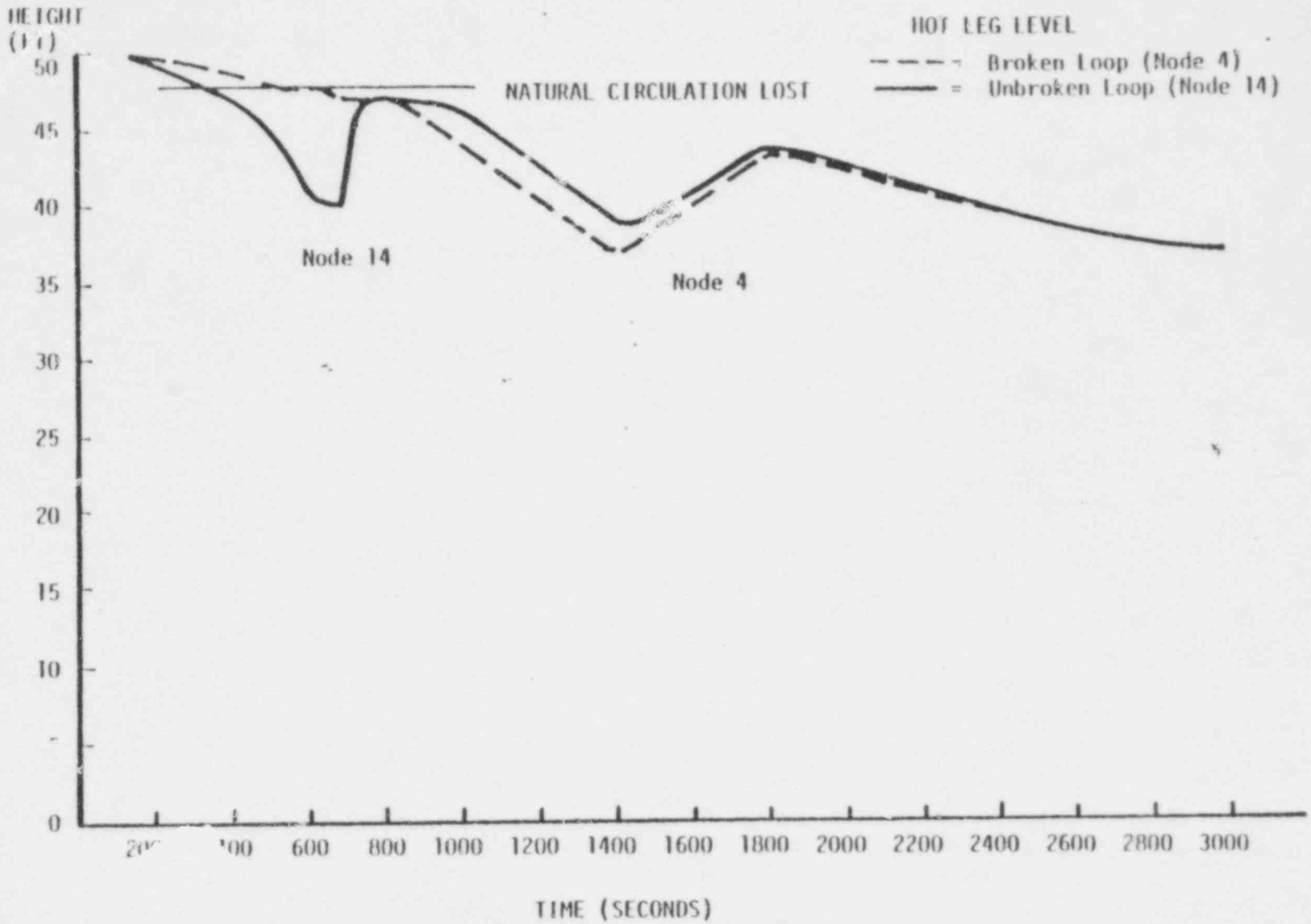
Figure 6-3.95

PRESSURIZER LEVEL



279 308

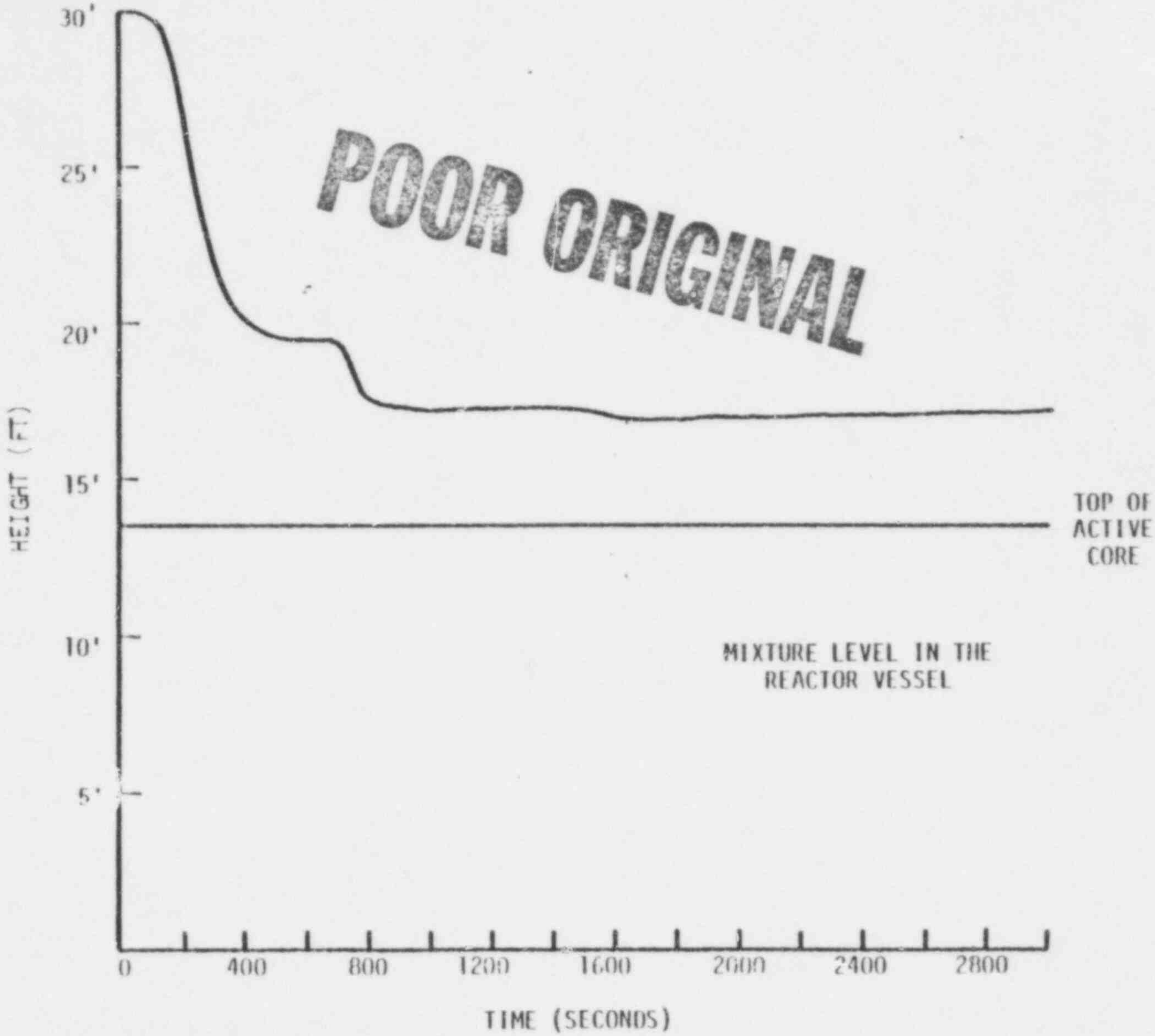
Figure 6.2.98



279 309

55

Figure 6.2.49

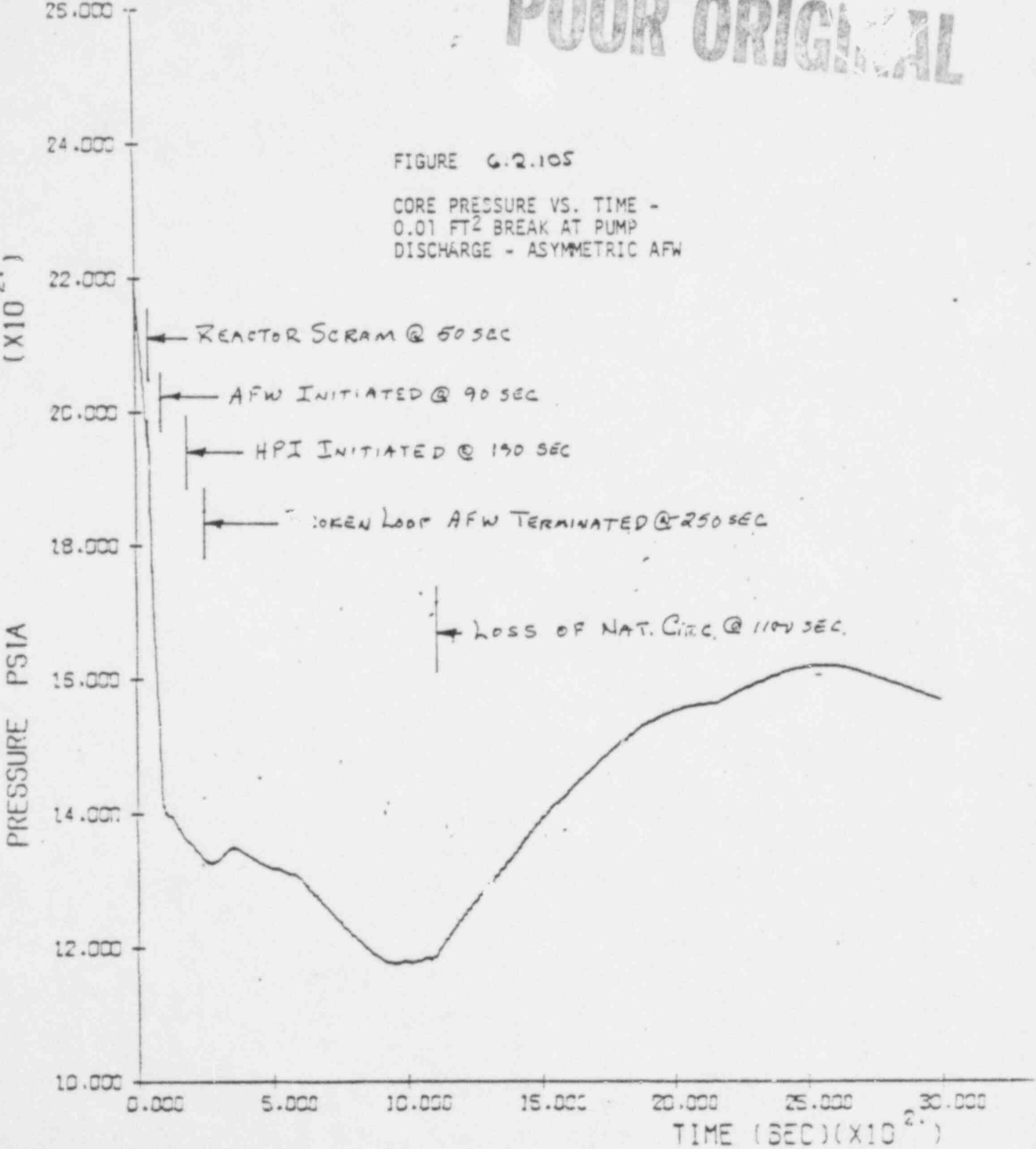


279 310

59

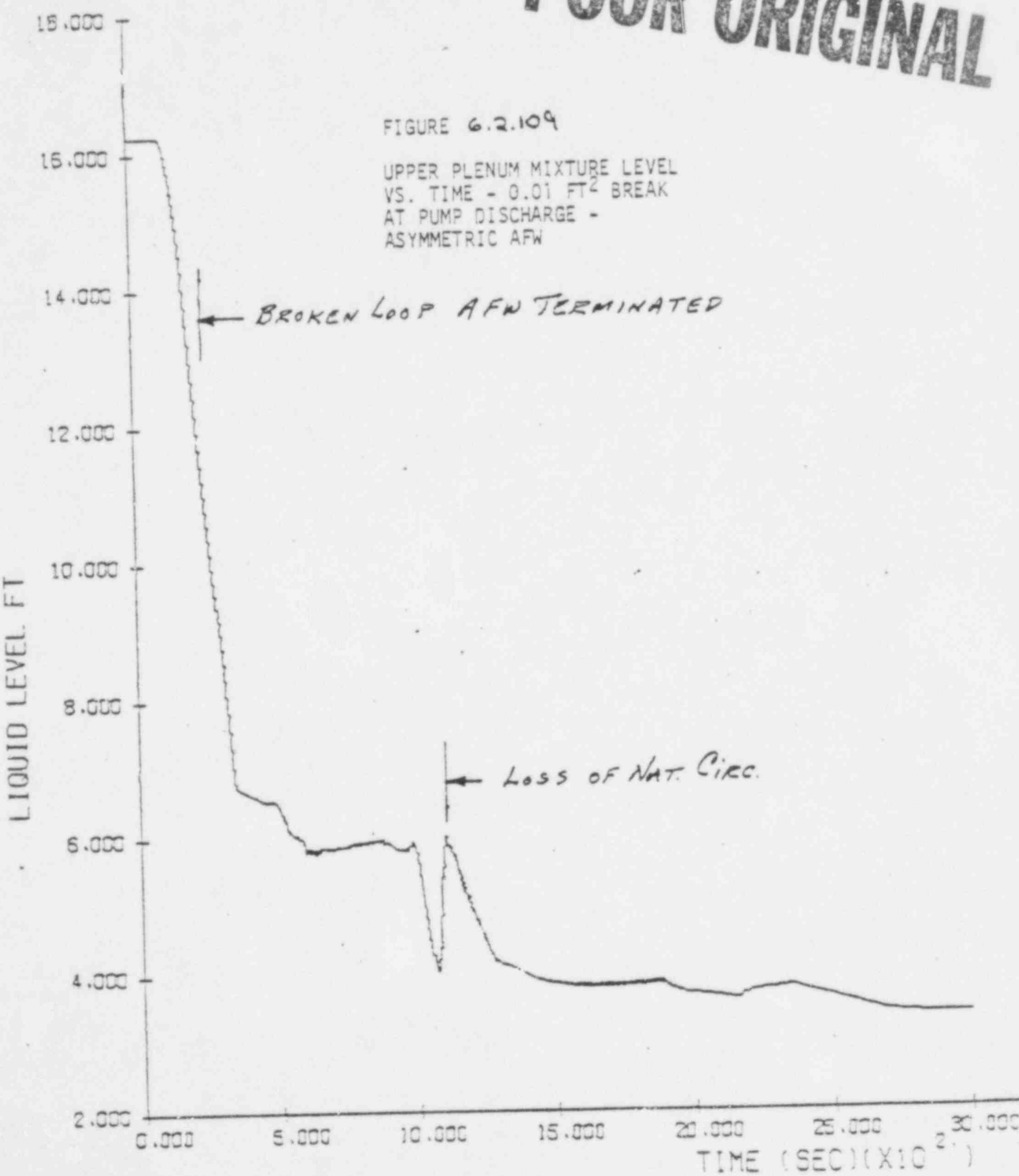
FIGURE 6.2.105

CORE PRESSURE VS. TIME -
0.01 FT² BREAK AT PUMP
DISCHARGE - ASYMMETRIC AFW



MI101G2 1 AUX FEED

279 311 NODE 60 3



MI101C2 1 AUX FEED

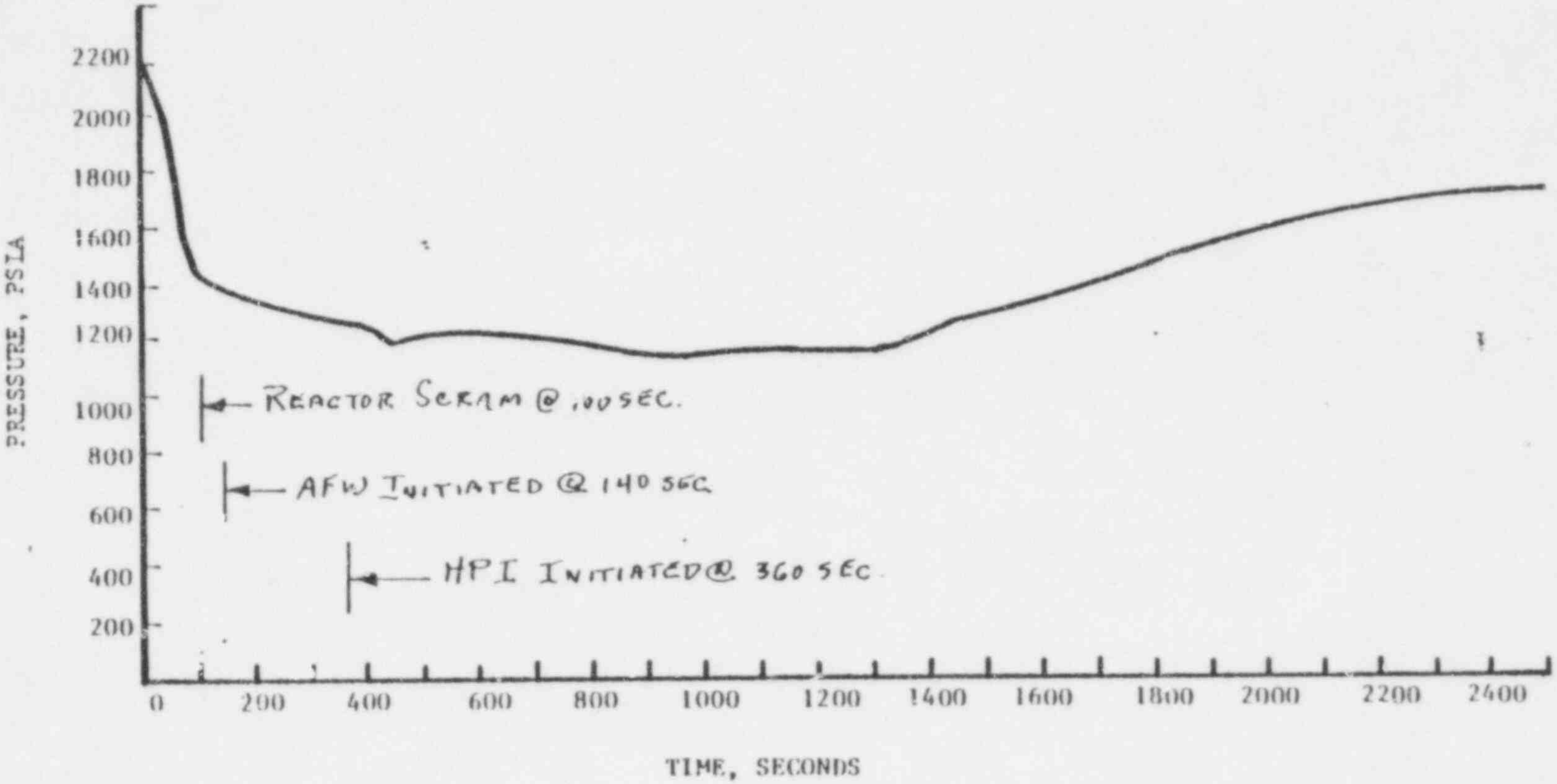
279 312 NODE 23

61

FIGURE 6.2.148

CORE PRESSURE VERSUS TIME

0.005 FT^2 BREAK AT PUMP DISCHARGE

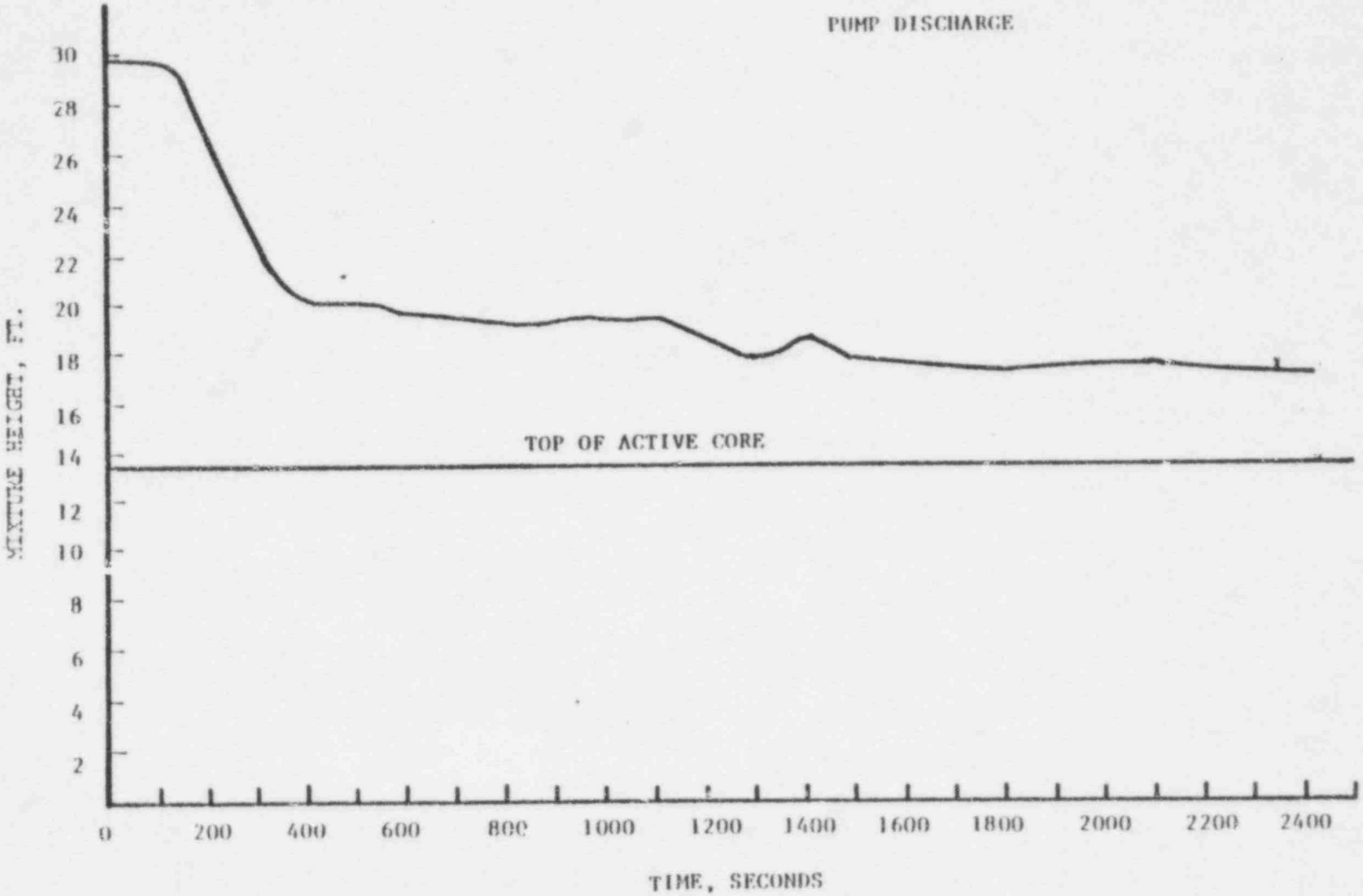


279 313

POOR ORIGINAL

FIGURE 6.2.149

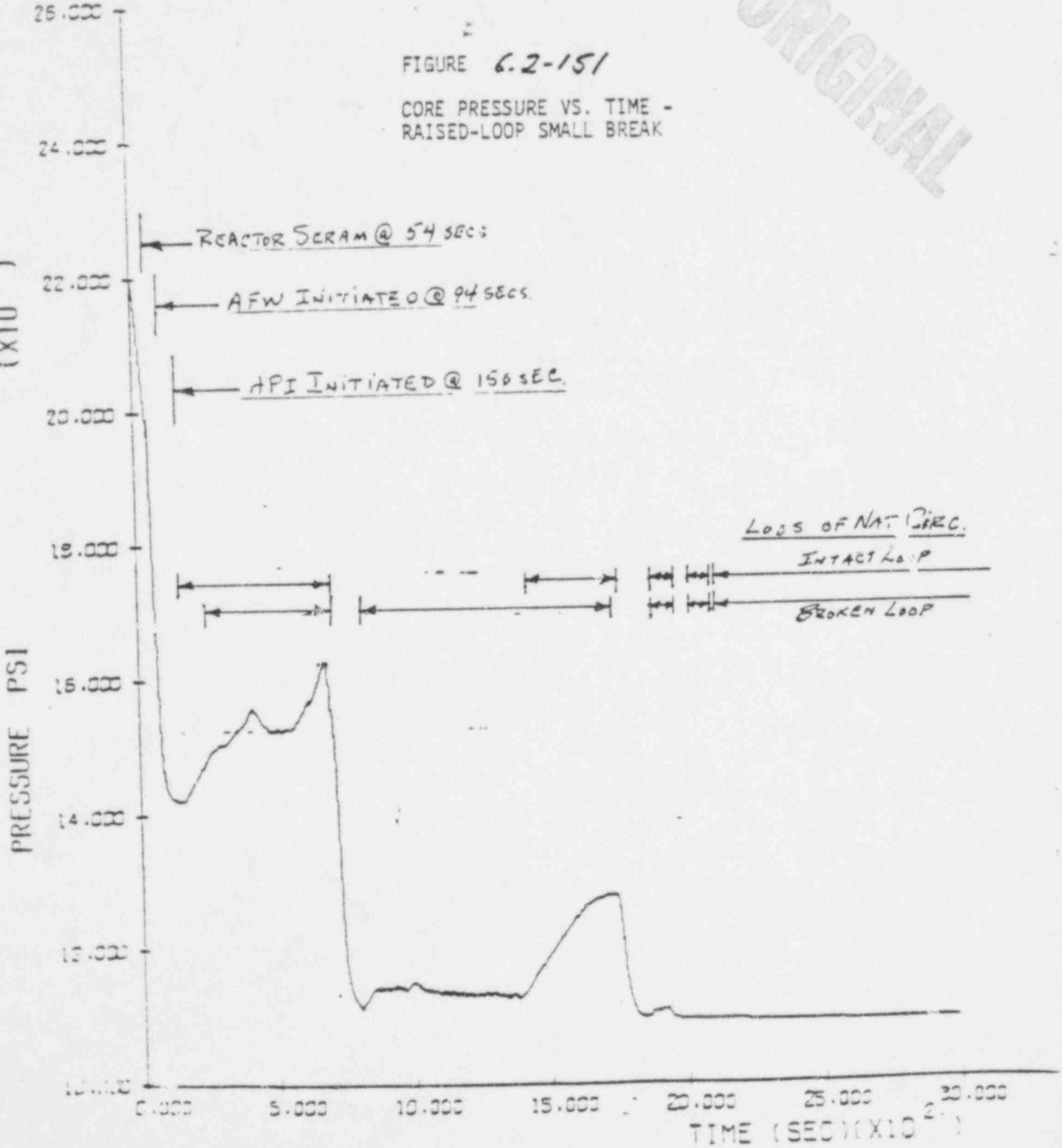
MIXTURE HEIGHT VS. TIME
0.005 FT^2 BREAK AT
PUMP DISCHARGE



279 314 63

FIGURE 6.2-151

CORE PRESSURE VS. TIME -
RAISED-LOOP SMALL BREAK



.01FT2 PD NEW EM

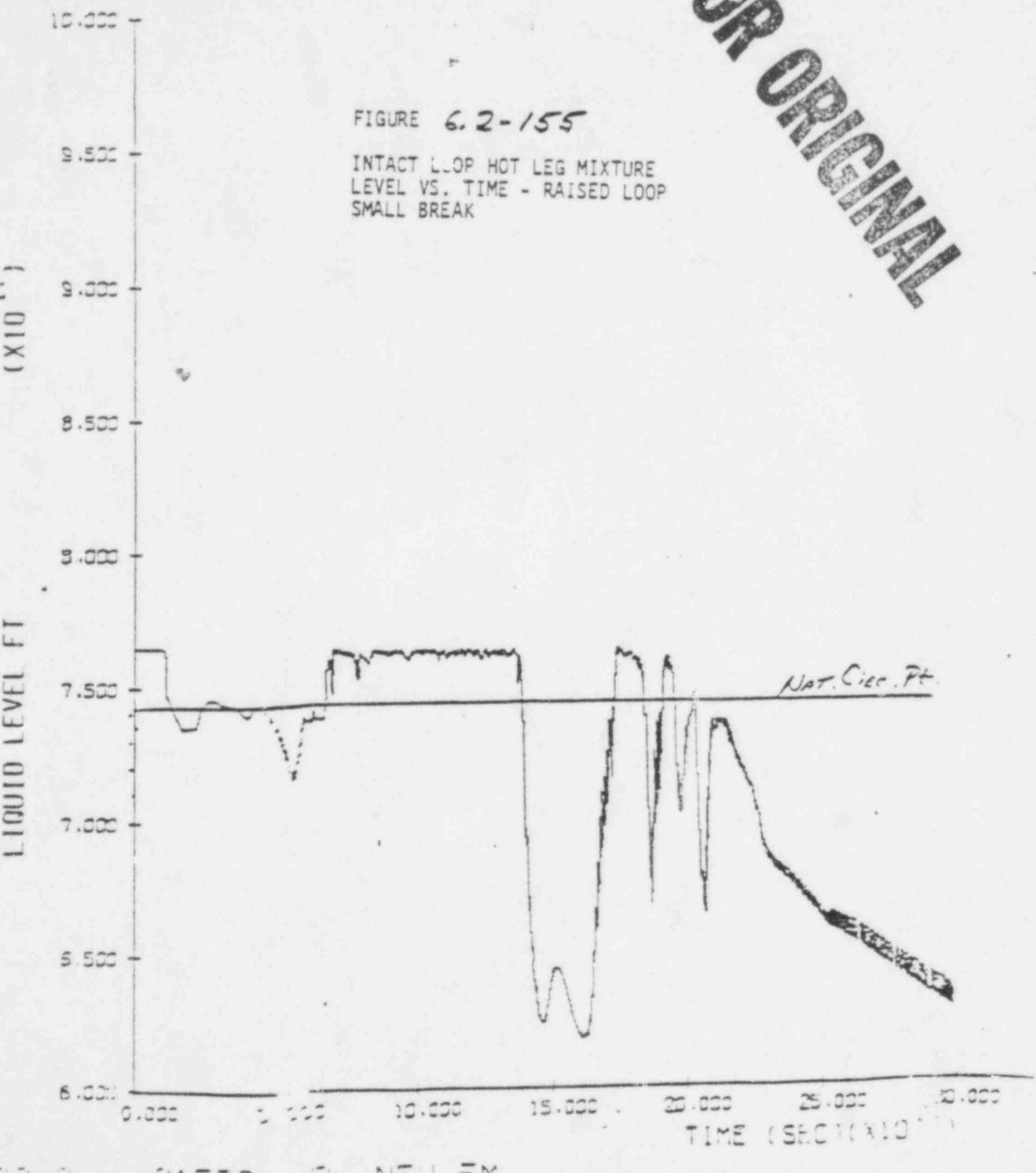
NODE 2

279 315

64

FIGURE 6.2-155

INTACT LOOP HOT LEG MIXTURE
LEVEL VS. TIME - RAISED LOOP
SMALL BREAK



.01FT2 NEW EM

NODE 16

279 316

45

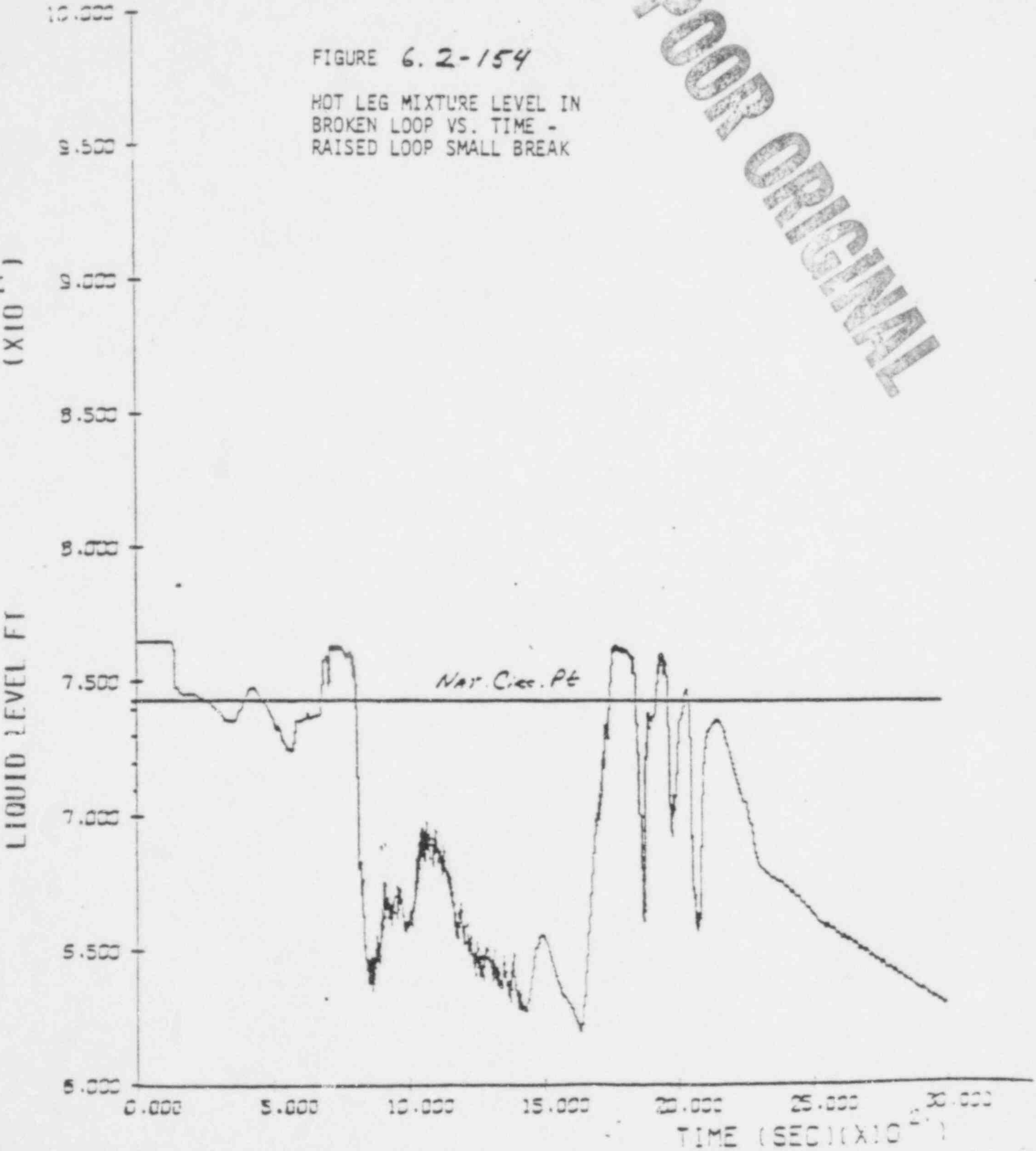


FIGURE 6.2-154

HOT LEG MIXTURE LEVEL IN BROKEN LOOP VS. TIME - RAISED LOOP SMALL BREAK

00030 .01FT2 PD NEW EM

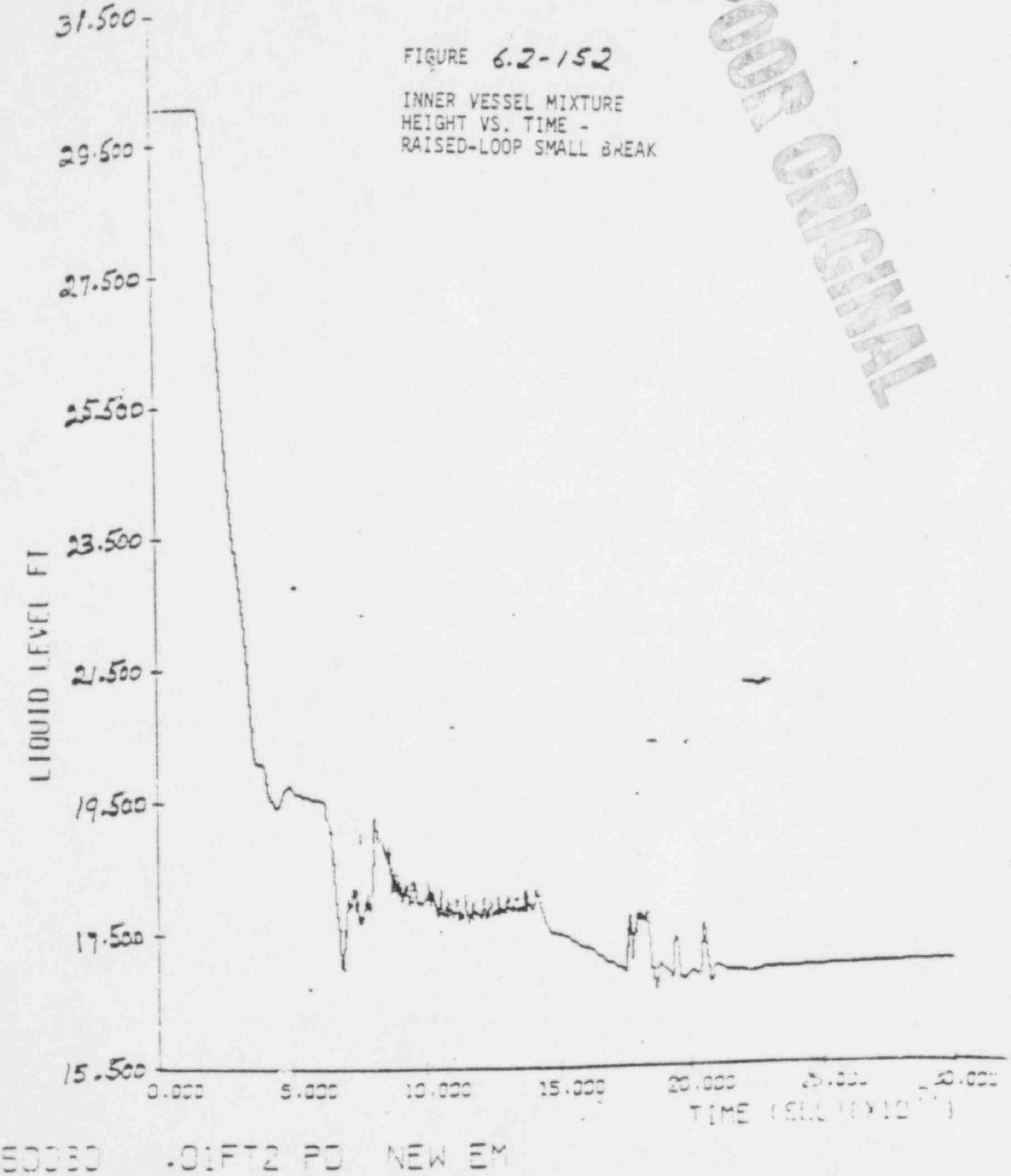
NODE 3

279 317

66

FIGURE 6.2-152

INNER VESSEL MIXTURE HEIGHT VS. TIME - RAISED-LOOP SMALL BREAK



279 318

CONCLUSIONS

1. AFW AT 20 MINUTES PROVIDE CORE COVERING FOR LOWERED AND RAISED LOOP PLNTS FOR BREAKS SMALLER THAN .02 FT^2.

2. HPI ONLY AT 20 MINUTES PROVIDE CORE COVERING FOR LOWERED LOOPS FOR BREAKS SMALLER THAN .02 FT^2.

3. 1 HPI TRAIN PROVIDES CORE COVERING FOR STUCK PORV IN LOWERED AND RAISED LOOPS.

4. HOT LEG BREAKS BOUNDED BY RESULTS FOR COLD LEG BREAKS DUE TO ACTION OF VENT VALVES.

5. SINGLE STEAM GENERATOR OPERATION IS ADEQUATE TO MAINTAIN CORE COVERING FOR SMALL BREAKS.

279 319

PURPOSE : AUDIT B & W SMALL BREAK CALCULATIONS WHICH MAY REPRESSURIZE OR EXHIBIT HEAT REMOVAL PROBLEMS

TWO CASES WERE CHOSEN FOR E.G.&G., IDAHO TO CALCULATE USING A PRELIMINARY VERSION OF RELAP4/MOD7.

279 320

CASE 1 : 0.01 SQ. FT. - AUXILIARY FEEDWATER DELAYED 20 MINUTES TWO HPI PUMPS. FOR THIS SIZE BREAK, WITHOUT AUX. FEED, SYSTEM MAY NOT DEPRESSURIZE TO THE HPI ACTUATION POINT AND REPRESSURIZATION WILL OCCUR

CASE 2 : 0.01 SQ. FT. - NORMAL AUX. FEED DELAY (36 SECONDS AFTER REACTOR TRIP), ONE HPI PUMP. AS VOIDS FORM IN THE "CANDY CANE" , LOSS OF NATURAL CIRCULATION CAN OCCUR.

279 321

INITIAL CONDITIONS FOR BOTH CALCULATIONS

0.01 SQ. FT. PUMP DISCHARGE BREAK

102% NOMINAL POWER (2827 MW)

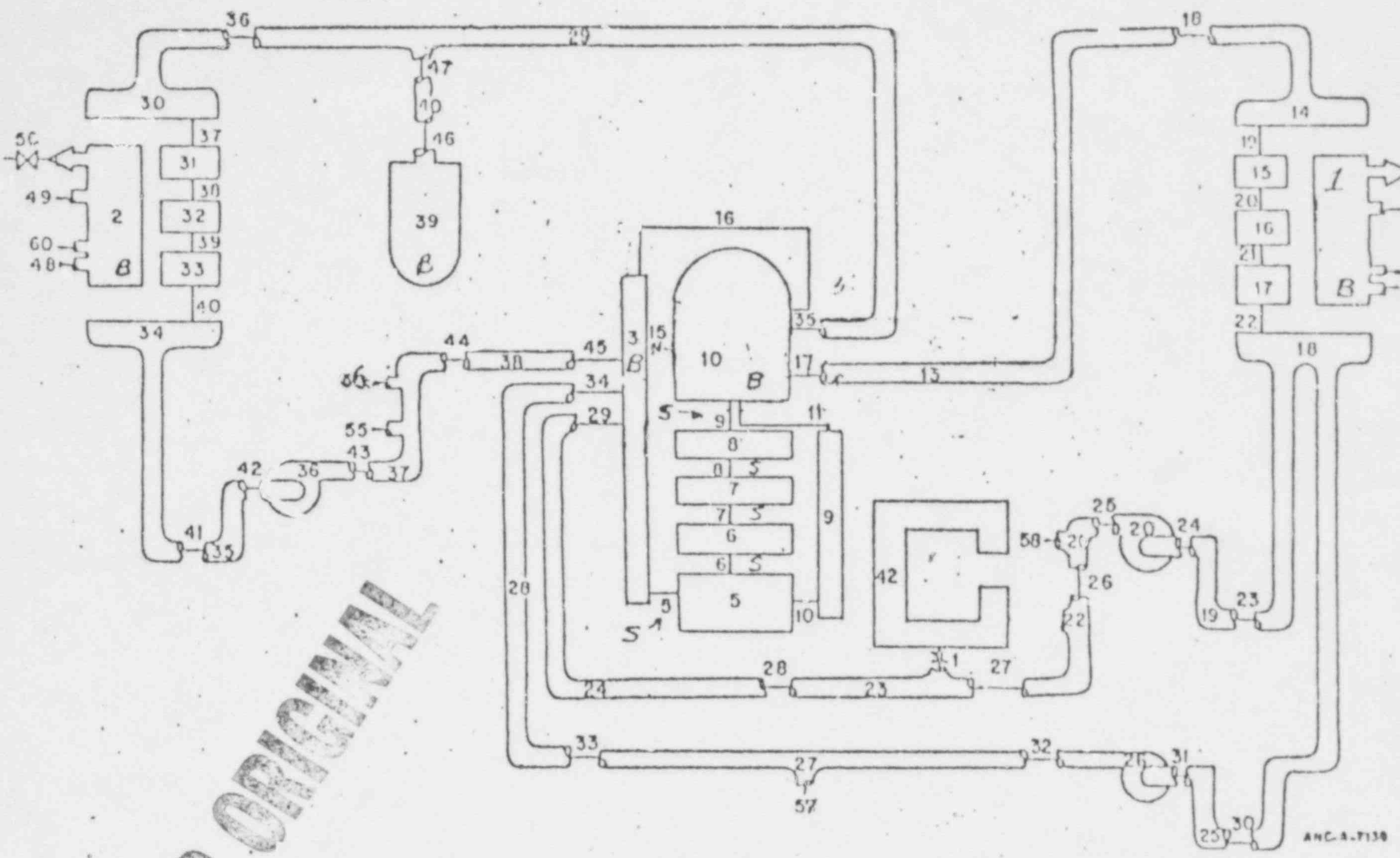
1.2 TIMES ANS DECAY HEAT

REACTOR SCRAM AT 1900 PSIA PLUS 0.5 SECOND DELAY

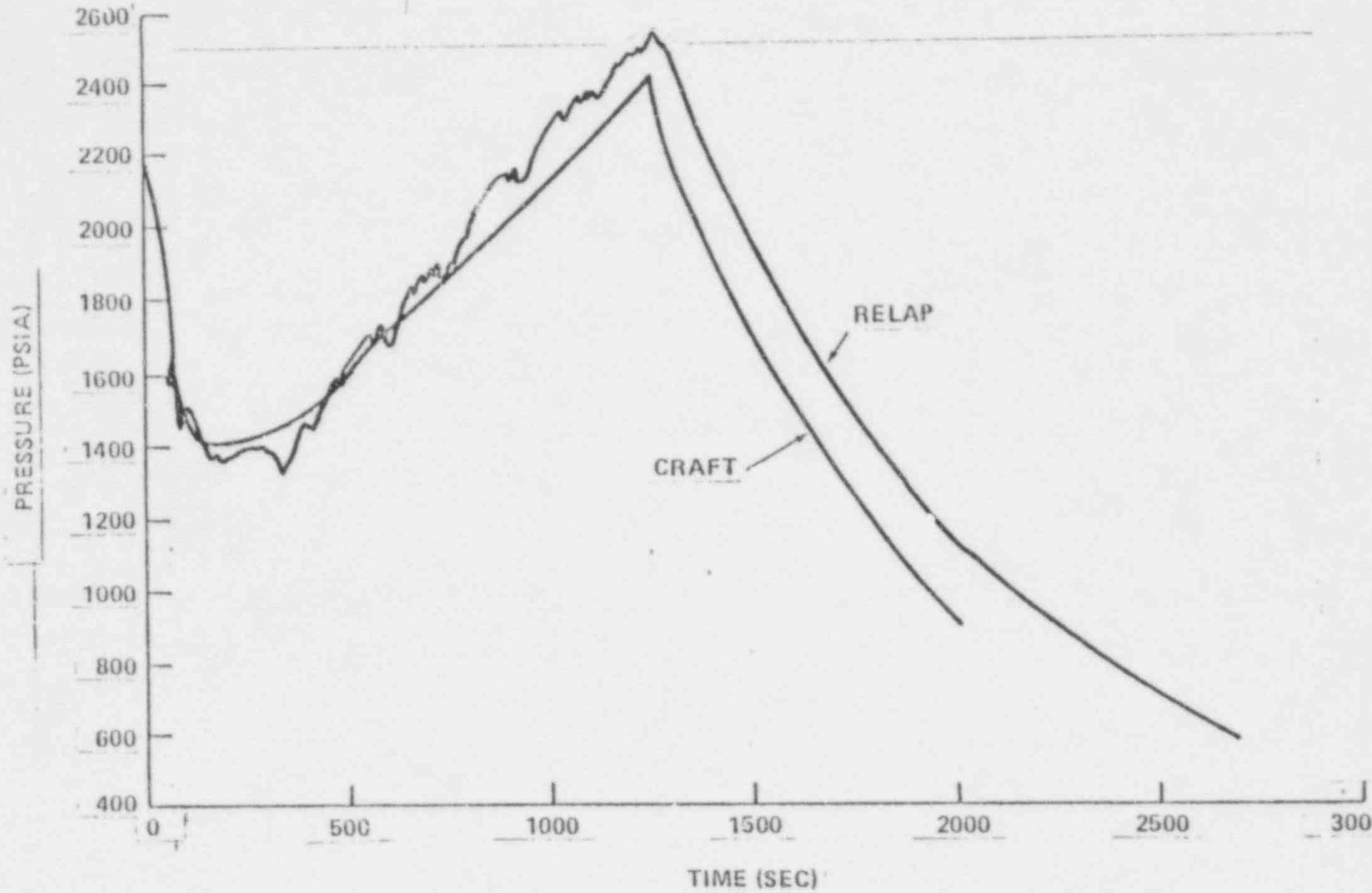
CONCURRENT TRIP OF TURBINE AND REACTOR COOLANT PUMPS

HPI ACTUATION AT 1365 PSIA PLUS 35 SECOND DELAY

USED B & W HPI AND AUX. FEED CURVES

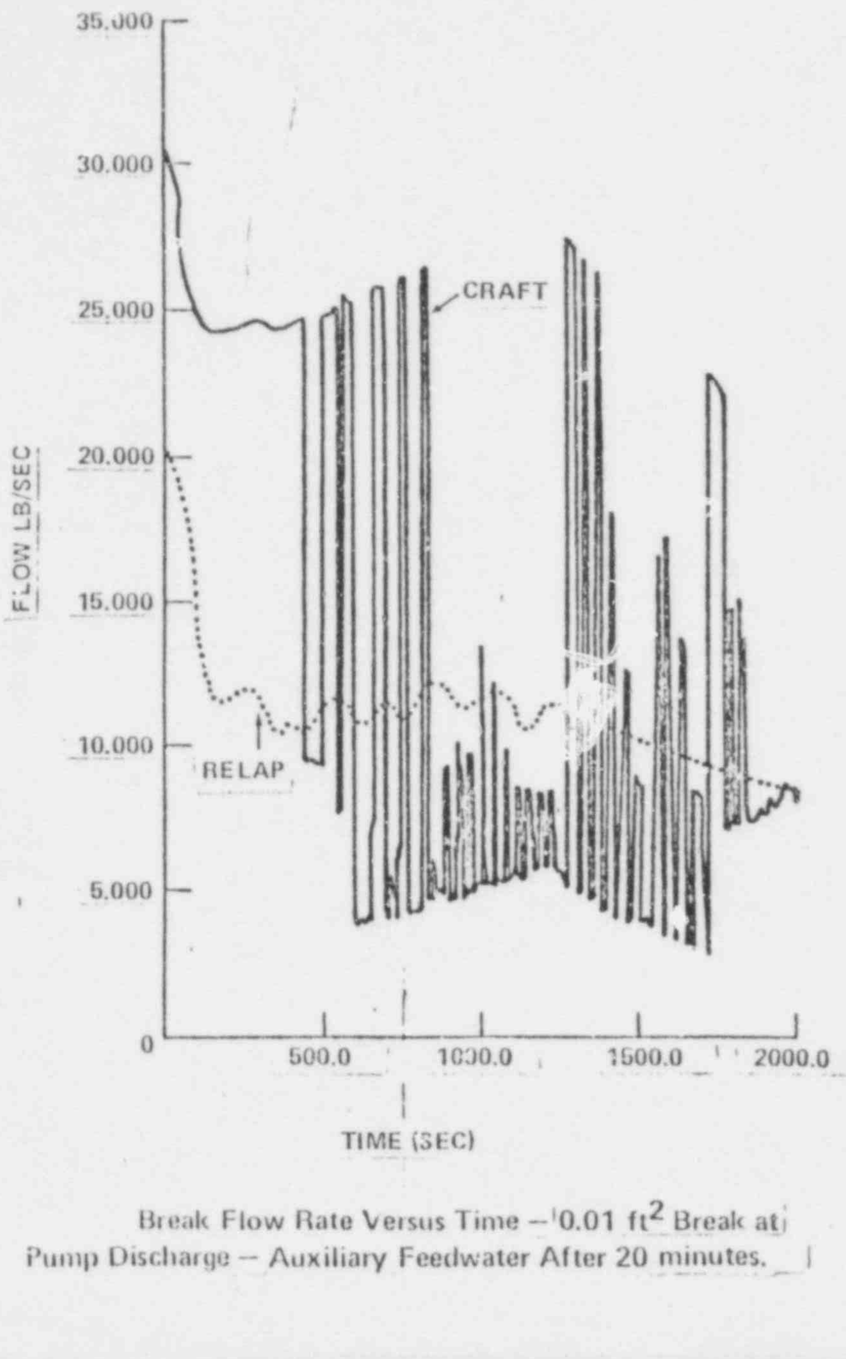


Nodalization diagram for the B&W Oconee reactor.



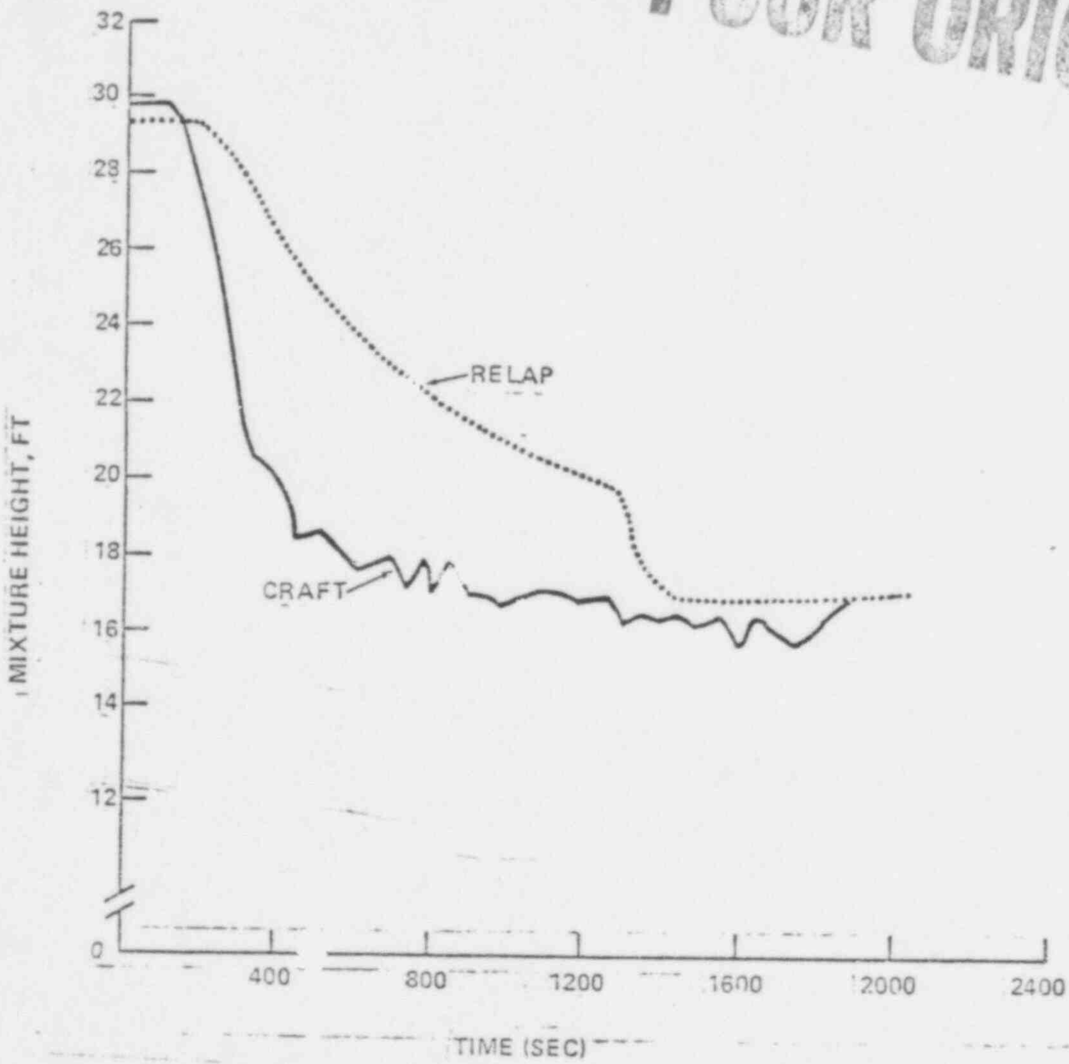
Hot leg Pressure (Intact Loop) –
0.01 ft^2 Break at Pump Discharge – Auxiliary Feedwater After 20 minutes

279 324

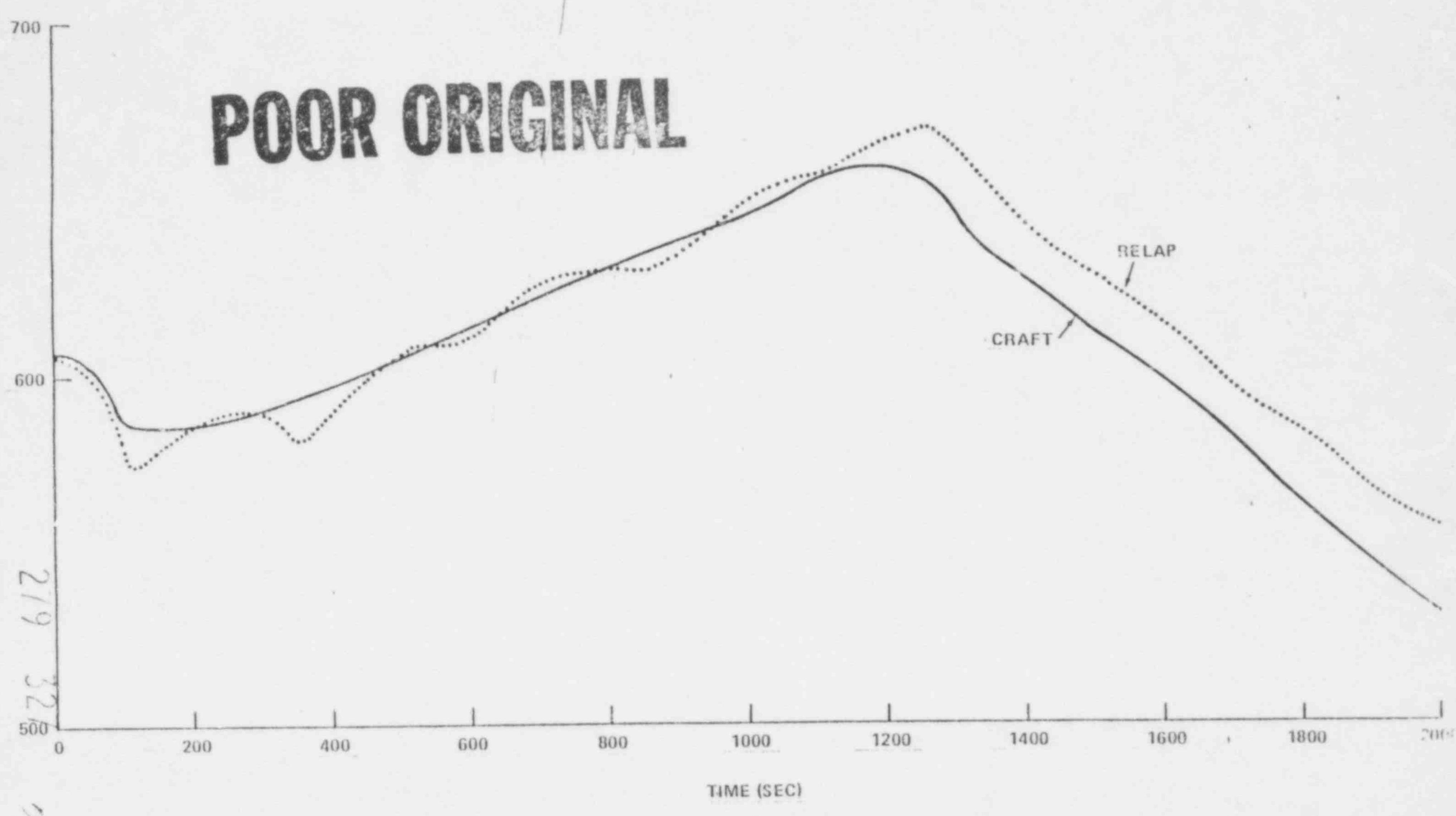


Break Flow Rate Versus Time — 0.01 ft^2 Break at Pump Discharge — Auxiliary Feedwater After 20 minutes.

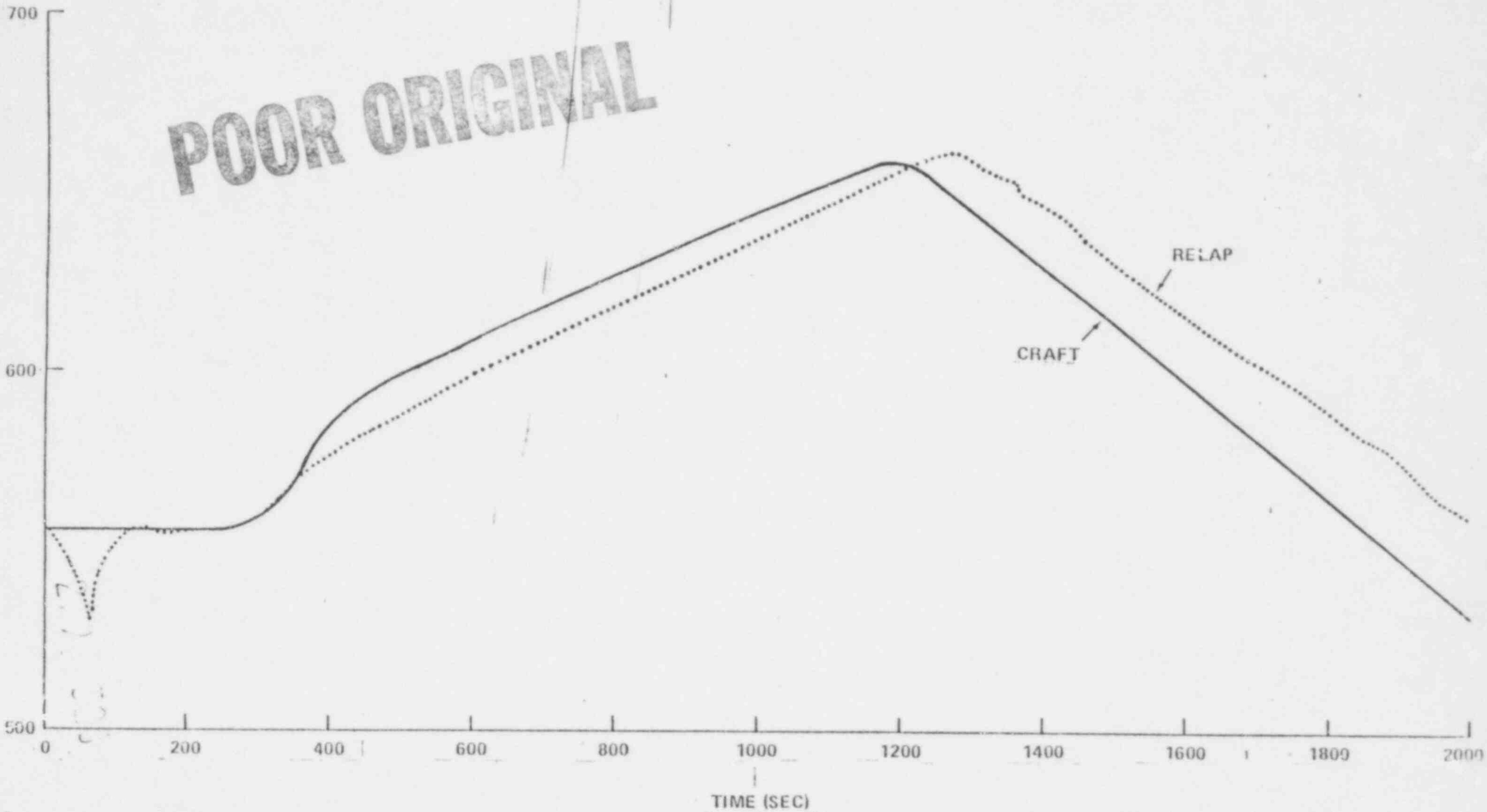
279 325



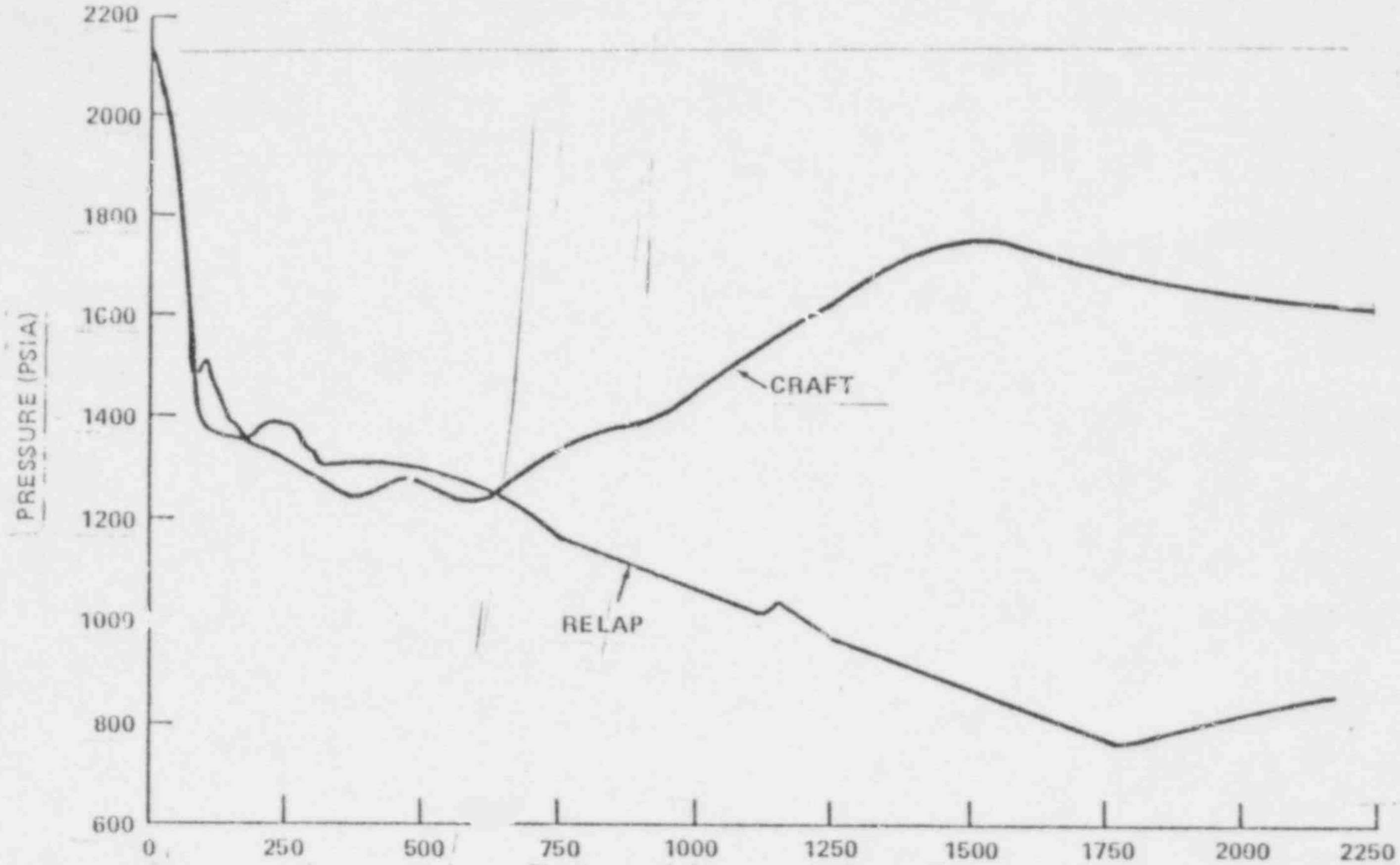
Mixture Height Versus Time – 0.01 ft^2 Break at Pump Discharge – Auxiliary Feedwater After 20 minutes.



Hot Leg Temperature Versus Time – 0.01 ft^2 Break at Pump Discharge – Auxiliary Feedwater After 20 minutes.



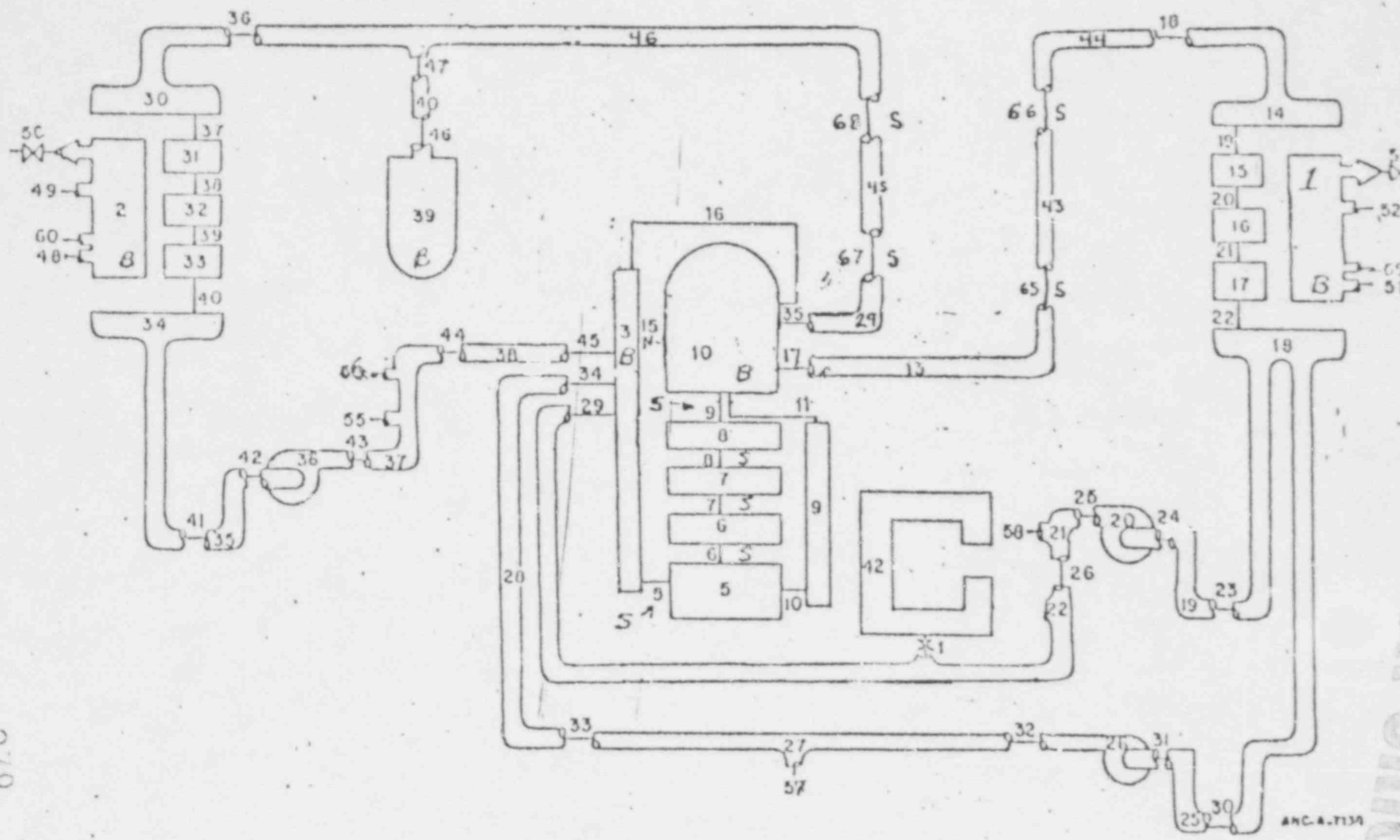
Cold Leg Temperature Versus Time – 0.01 ft^2 Break at Pump Discharge – Auxiliary Feedwater After 20 minutes.



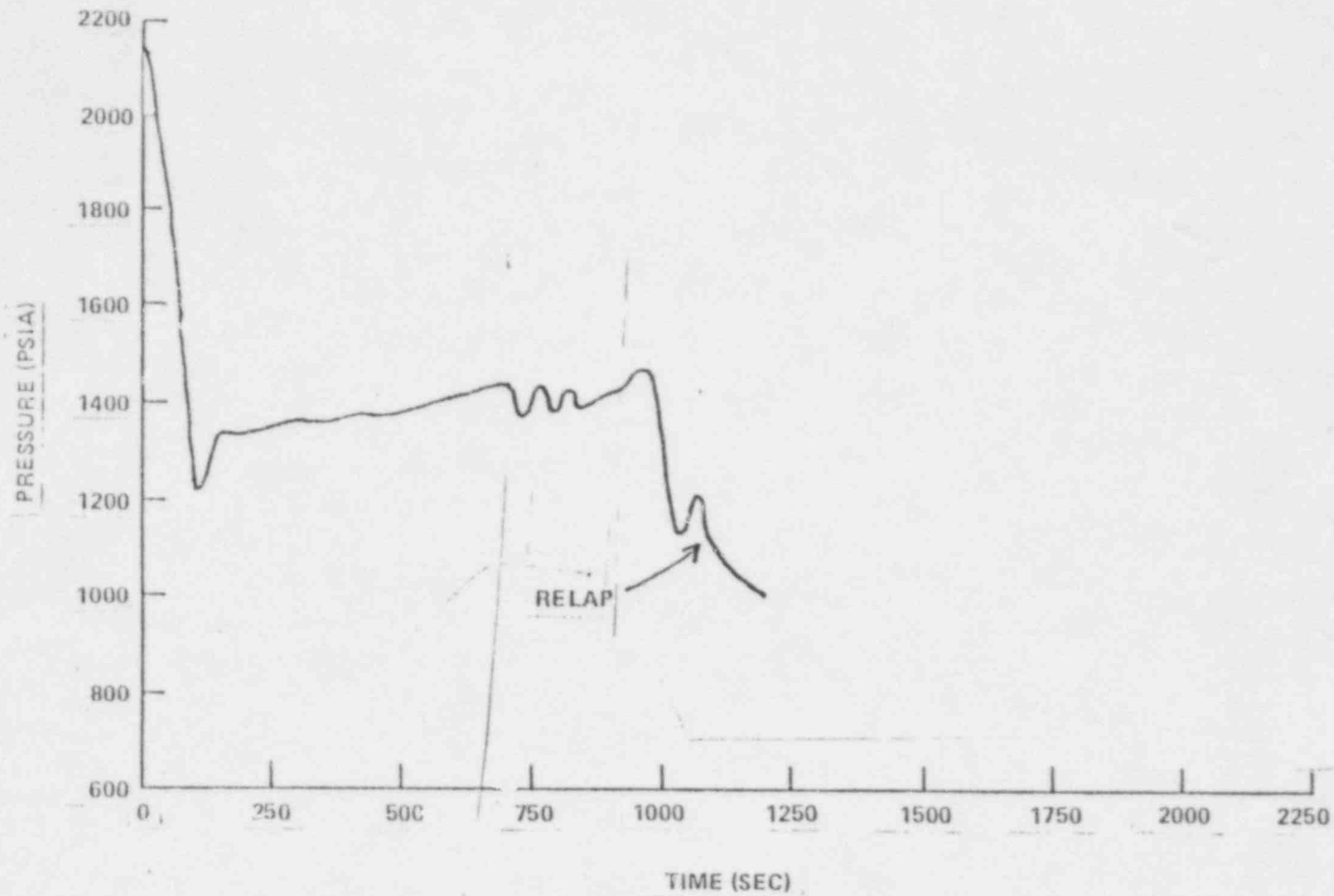
Hot Leg Pressure (Inact Loop) —
0.01 ft^2 Break - No Auxiliary Feedwater Delay.

279 329

38



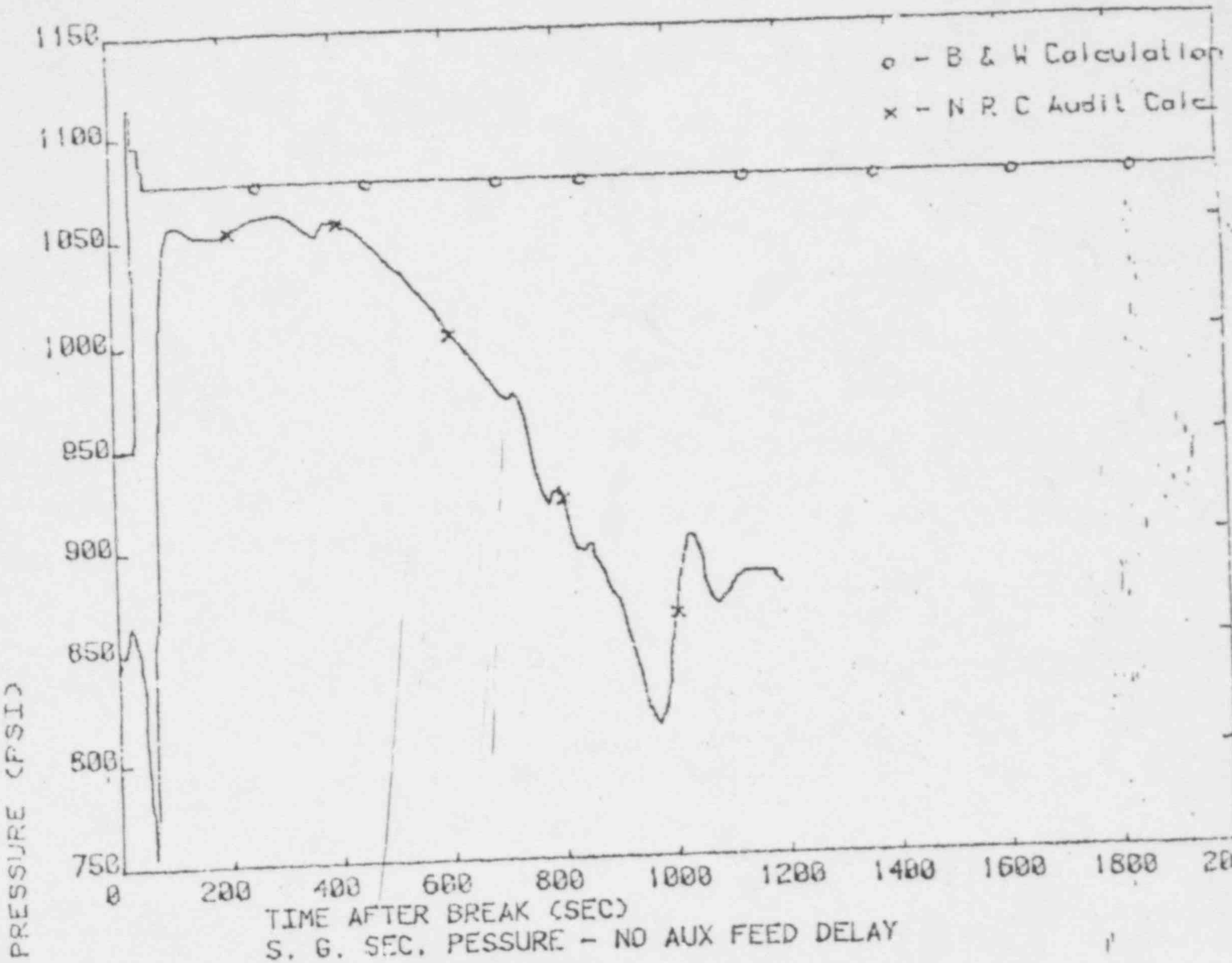
Revised Nodalization diagram for the B&W Oconee reactor.



Hot Leg Pressure (Inact Loop) –
0.01 ft^2 Break - No Auxiliary Feedwater Delay.

279 331

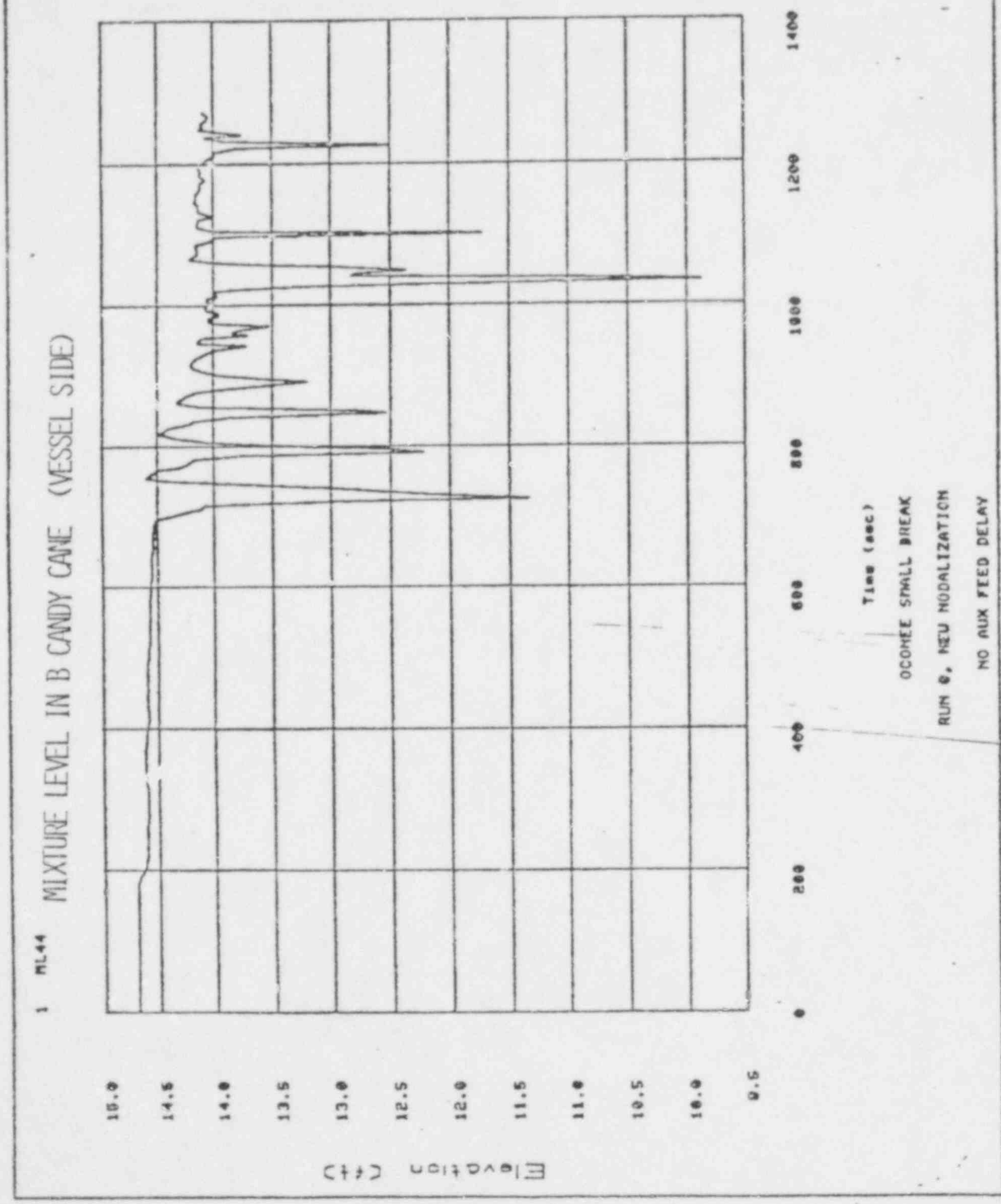
80



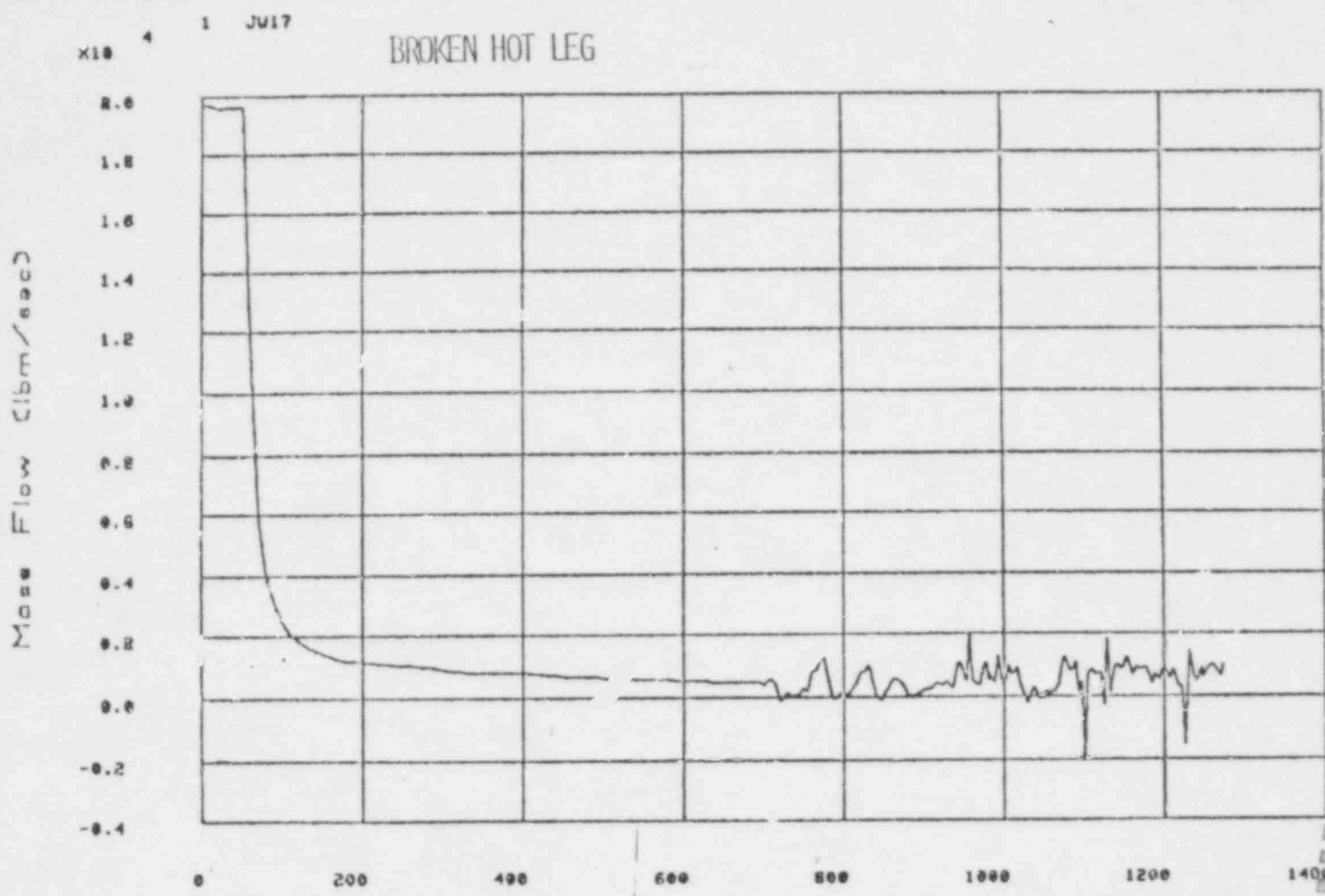
Steam generator secondary side pressure - no uxiliary feedwater delay.

279 332

81.


1 ML44
MIXTURE LEVEL IN B CANDY CANE (VESSEL SIDE)
Elevation (ft)
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
0
200
400
600
800
1000
1200
1400
Time (sec)
OCONEE SMALL BREAK
RUN 0, NEW NODALIZATION
NO AUX FEED DELAY

279 333

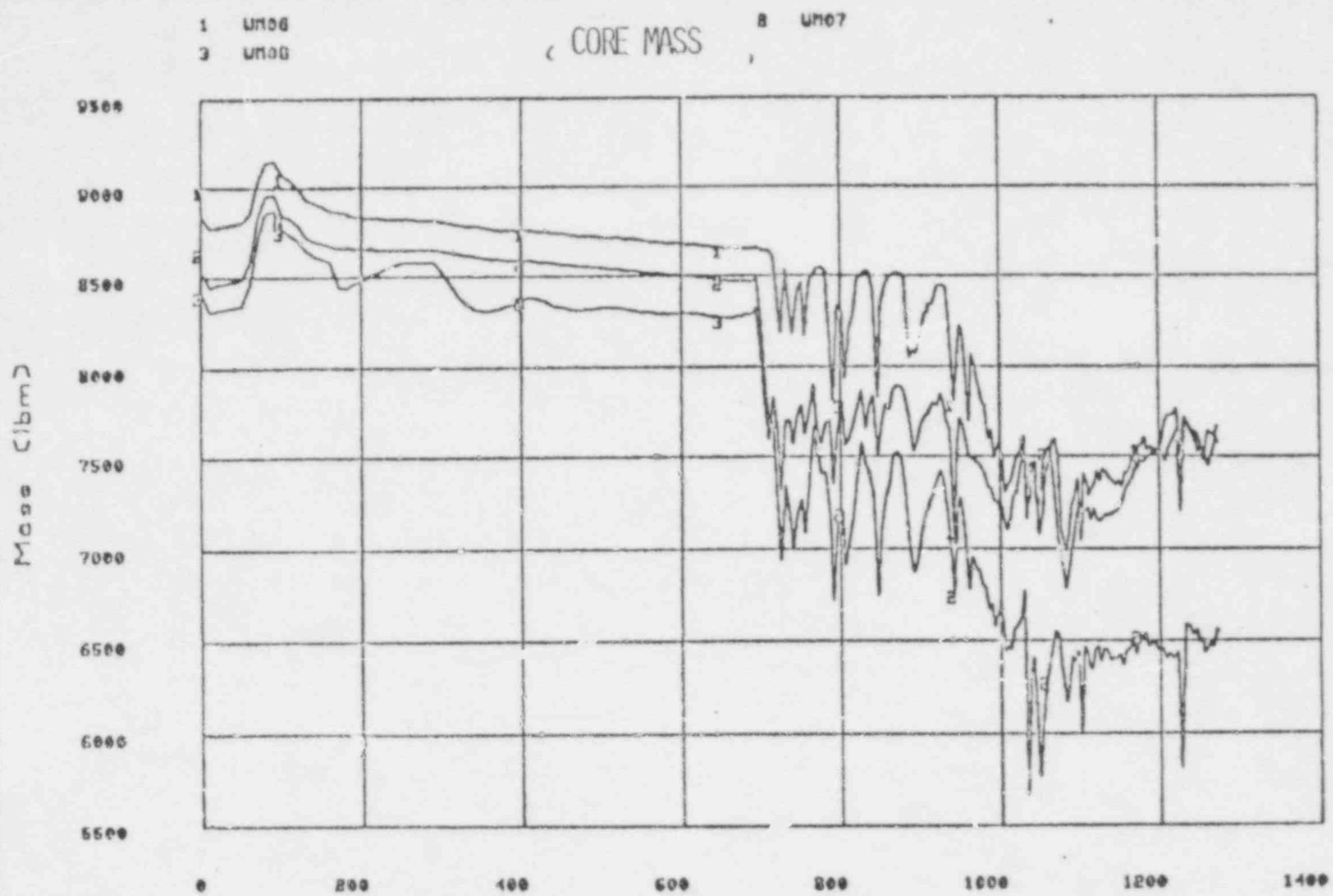


Time (sec)

OCONEE SMALL BREAK

RUN 0, NEW NODALIZATION

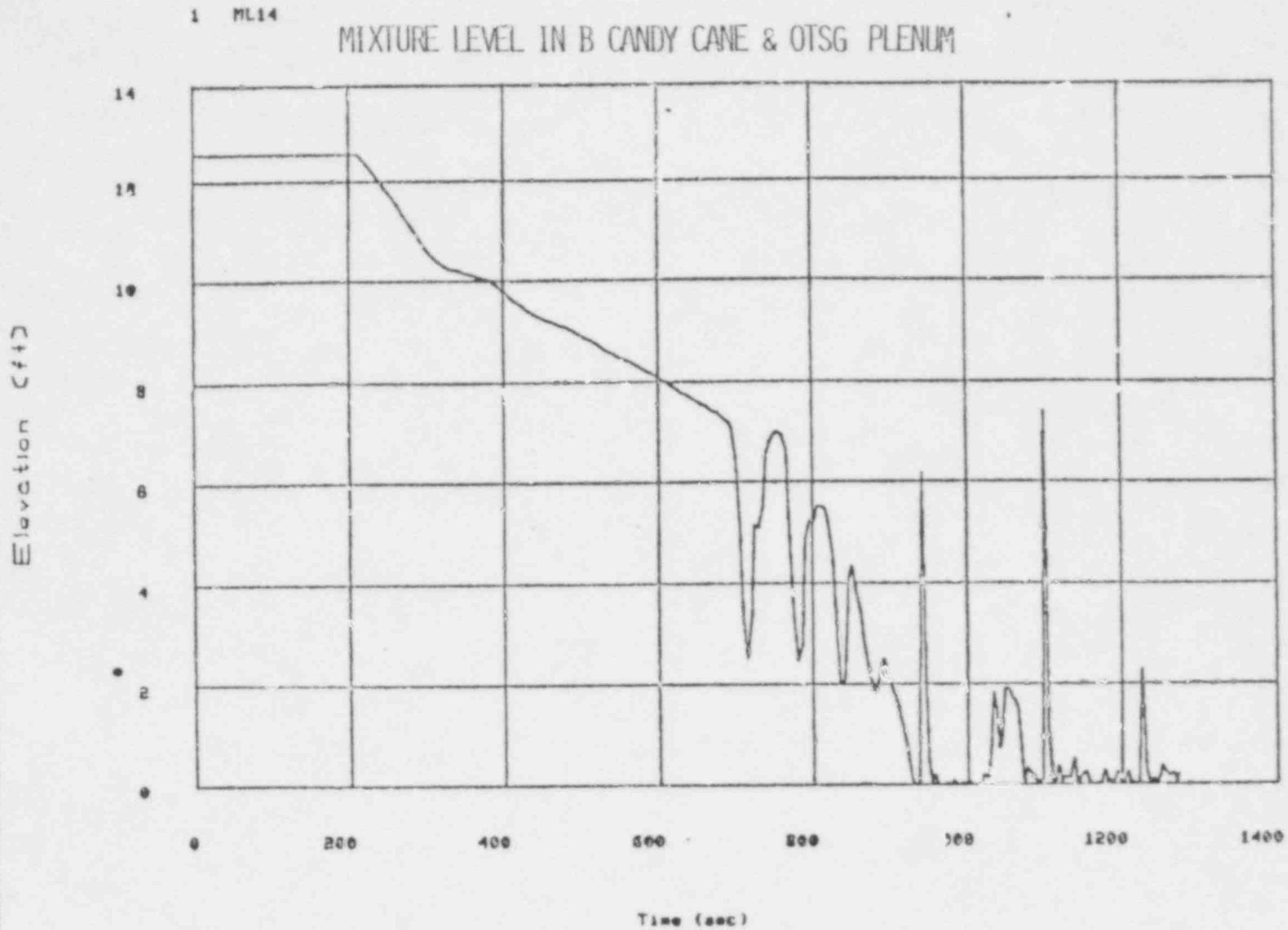
NO AUX FEED DELAY



OCONEE SMALL BREAK

RUN 0, NEW MODALIZATION

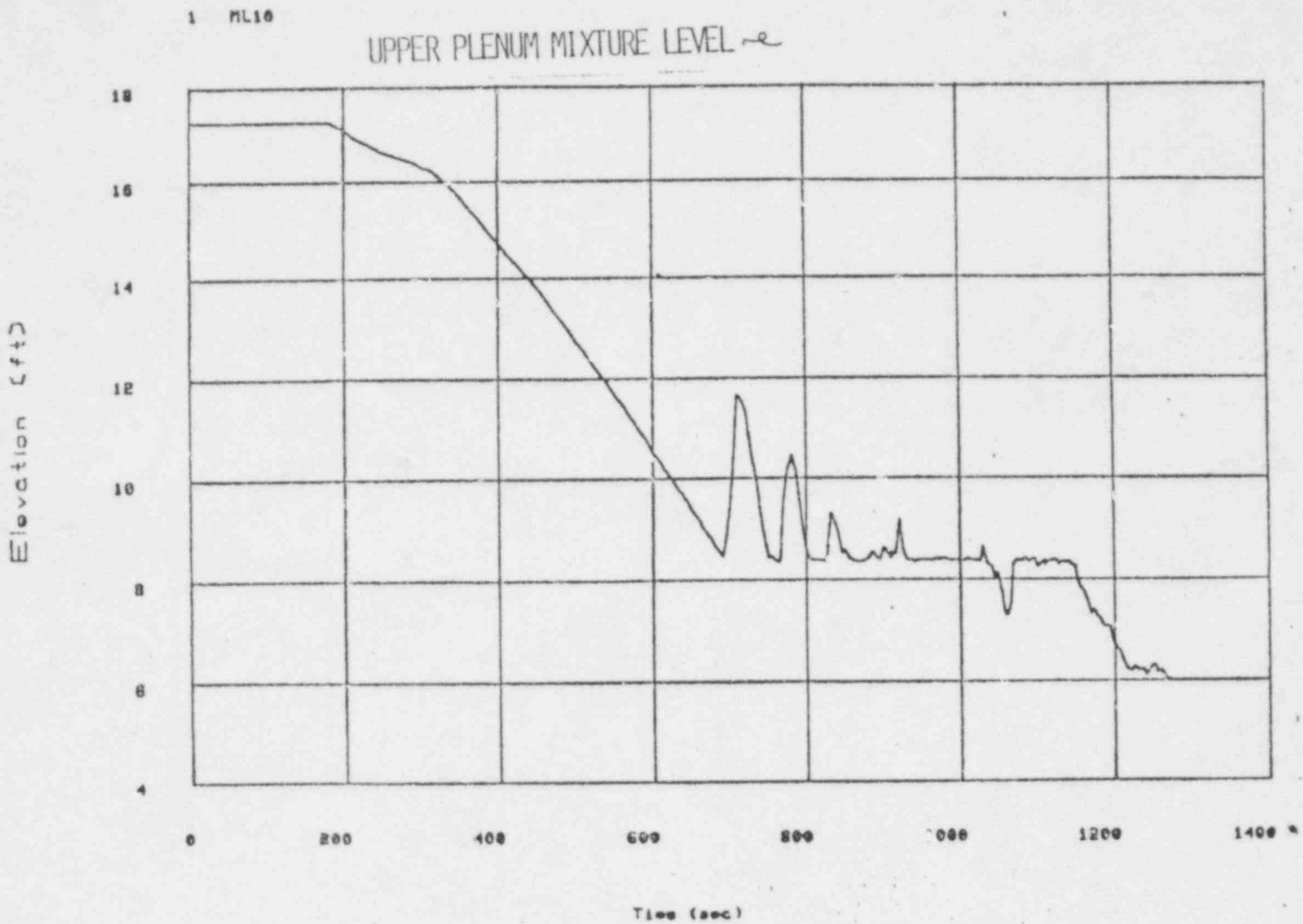
NO AUX FEED DEL/ /



OCONEE SMALL BREAK

RUN 0, NEW NODALIZATION

NO AUX FEED DELAY



OCONEE SMALL BREAK

RUN 0, NEW NODALIZATION

NO AUX FEED DELAY

CONCLUSIONS

RELAP4/MOD7 CALCULATION WITH 20 MINUTE AUX. FEED DELAY COMPARED VERY WELL WHEN STANDARD METHODS WERE USED.

NO CORE UNCOVERY WAS SHOWN

CONCLUSIONS

(NO AUX. FEED DELAY)

RELAP AND CRAFT IN KEY VARIABLES WHEN ANALYSING THIS CASE.

DIFFERENCES MAY BE DUE TO DIFFERENCES IN AUX. FEED CONTROL.

NO CORE UNCOVERY INDICATED.

CASE SHOULD BE STUDIED FURTHER.

REVIEW OBJECTIVES

1. CONFORMANCE WITH GUIDELINES

2. WORKABILITY FOR OPERATORS

279 340 8

PROBLEMS ENCOUNTERED

1. KNOWLEDGE OF SMALL BREAK PHENOMENON

2. EXCEPTIONS TO GUIDELINES

3. ADAPTING TO EXISTING PROCEDURES

OPERATING PROCEDURE GUIDELINES FOR SMALL BREAKS

PART I - BACKGROUND INFORMATION FOR A SPECTRUM OF LOSS-OF-COOLANT ACCIDENT

PART II - OPERATING GUIDELINES FOR SMALL BREAKS

279 342

GUIDELINES

SYMPTOMS AND INDICATIONS

IMMEDIATE ACTIONS

PRECAUTIONS

FOLLOWUP ACTIONS

279 343

IF THE HPI SYSTEM HAS BEEN ACTUATED BECAUSE OF A LOW PRESSURE CONDITION, IT MUST REMAIN IN OPERATION UNTIL ONE OF THE FOLLOWING CRITERIA IS SATISFIED.

1. THE LPI SYSTEM IS IN OPERATION AND FLOWING AT A RATE IN EXCESS OF 1000 GPM IN EACH LINE AND THE SITUATION HAS BEEN STABLE FOR 20 MINUTES.

OR

2. ALL HOT AND COLD LEG TEMPERATURES ARE AT LEAST 50° BELOW THE SATURATION TEMPERATURE FOR THE EXISTING RCS PRESSURE. IF THE 50° SUBCOOLING CANNOT BE MAINTAINED, THE HPI SHALL BE REACTIVATED.

279 344

SMALL BREAK ACCIDENTS

RCP's	FW	RECOMMENDED ACTION
1. YES	YES	STOP ONE RCP PER LOOP. USE OTSG's TO COOLDOWN AT 100°/HOUR.
2. YES	NO	MAINTAIN MAX. HPI FLOW. STOP ONE RCP/LOOP. OPEN PORV IF RCS PRESSURE INCREASES. RESTORE FW ASAP.
3. NO	YES	COOLDOWN WITH NATURAL CIRCULATION. IF UNABLE, ATTEMPT TO RESTORE FORCED CIRCULATION WITH RCP's. IF UNABLE, CYCLE PRESSURE BETWEEN 2300 PSIG AND 100 PSI ABOVE OTSG PRESSURE.
4. NO	NO	OPEN PORV. MAINTAIN HEAT REMOVAL PATH FROM HPI THRU BREAK AND PRESSURIZER. RESTORE RW AND ECP's.

279 345

/3

B&W SMALL BREAK GENERIC STUDY

BREAK	AFW	HPI	EC PUMPS	LONG-TERM COOLING
.07 FT^2	OFF	2	OFF	390 SEC.
.02	OFF	"	"	650
.01	1 @ 20 MIN.	"	"	1730
.01	OFF	2 @ 20 MIN.	"	2774
LOFW	2	1 HPI	ON	1000
PORV	"	"	OFF	1000
PORV (ANS*1.2)	OFF	"	"	--
PORV (ANS*1.0)	OFF	"	"	4700
.01	2	"	"	4900
.01 (ASYM)	1	"	"	4975
.005	2	"	"	5000
.01 (DB-1)	2	"	"	6000

279 346

14

TVA (C. MICHELSON) CONCERNS ON B&W 205-FA PLANTS

- CONCERNS ON B&W 205-FA PLANTS DURING VERY SMALL BREAK LOCAs DOCUMENTED IN REPORT BY C. MICHELSON (TVA)
- CONCERNS TRANSMITTED TO B&W BY LETTER ON APRIL 26, 1978
- B&W EVALUATED AND RESPONDED IN LETTER TO TVA ON JANUARY 23, 1979.
- B&W SUBMITTED MORE COMPREHENSIVE REPORT ON MAY 7, 1979 WITH ADDITIONAL INFORMATION ON B&W PLANT RESPONSE TO SMALL BREAKS

279 347

CONCERNS

1. ACCEPTABILITY OF INTERMITTANT NATURAL CIRCULATION
2. TIME DELAY IN TRANSITIONING FROM NATURAL CIRCULATION TO POOL BOILING
3. PRESSURIZER LEVEL WAS NOT CORRECT INDICATION OF WATER LEVEL IN CORE
4. CONSEQUENCES OF SMALL BREAK ISOLATION/REPRESSURIZATION
5. PRESSURE BOUNDARY DAMAGE DUE TO BUBBLE COLLAPSE
6. BREAK ENERGY NOT REPRESENTATIVE OF CORE EXIT ENERGY
7. EFFECT OF NON-CONDENSIBLE GASES (FROM CE SYSTEM 80 REPORT)

INTERMITTANT NATURAL CIRCULATION

- STEAM BUBBLES FORMED IN CORE OR HOT LEG ACCUMULATE AT TOP OF HOT LEG U-BEND

- WHEN STEAM VOLUME EXCEEDS VOLUME OF U-BEND, FLOW PATH IS BROKEN AND NATURAL CIRCULATION STOPS

- LOSS OF HEAT SINK CAUSES SYSTEM TO REPRESSURIZE

- REPRESSURIZATION CONDENSES STEAM IN U-BEND AND NATURAL CIRCULATION RESTORED

- STEAM BUBBLES REFORM, COLLECT IN HOT LEG U-BEND, AND PROCESS STARTS OVER

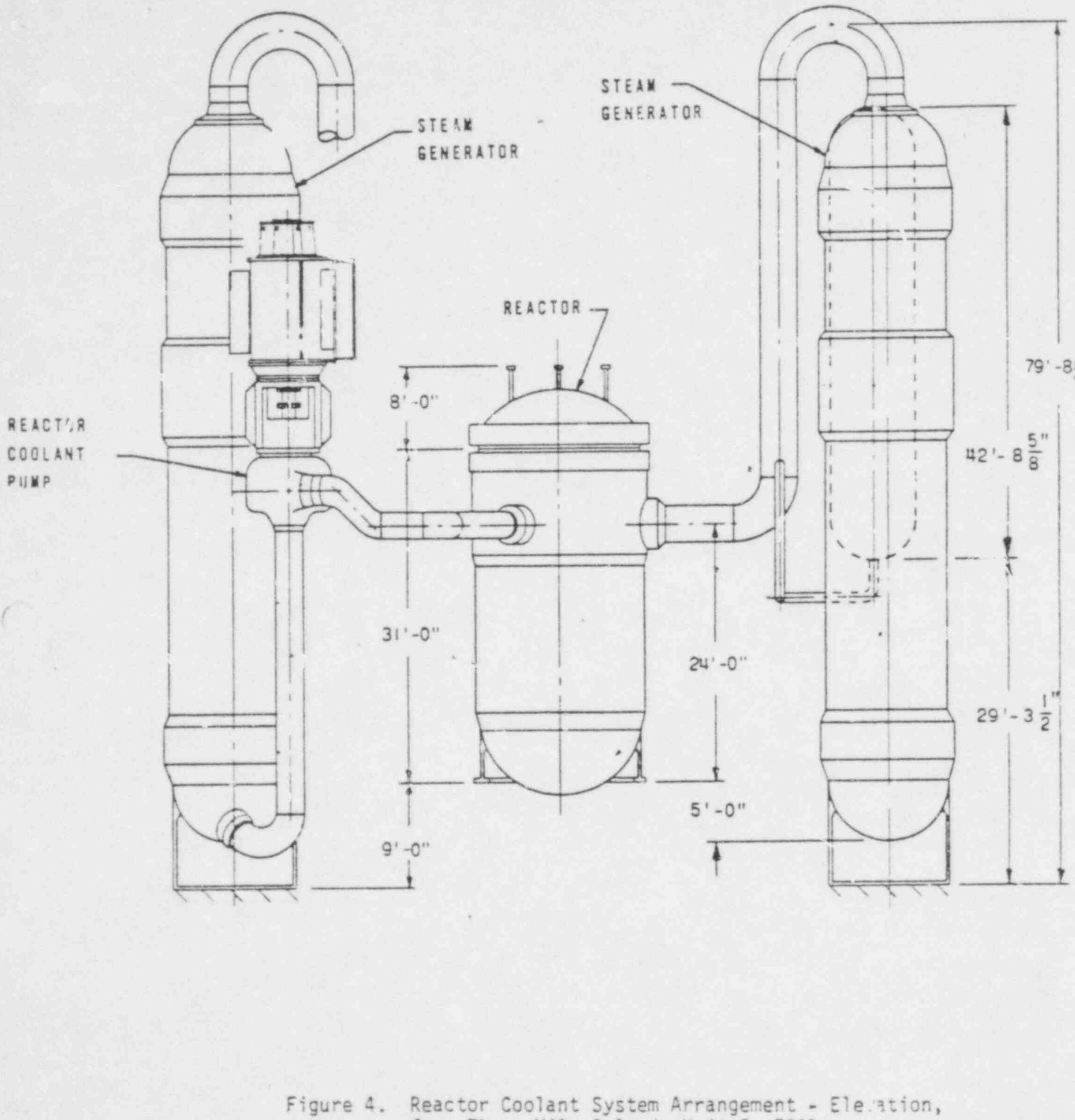


Figure 4. Reactor Coolant System Arrangement - Elevation, from Three Mile Island, Unit 2, FSAR.

279 310

18

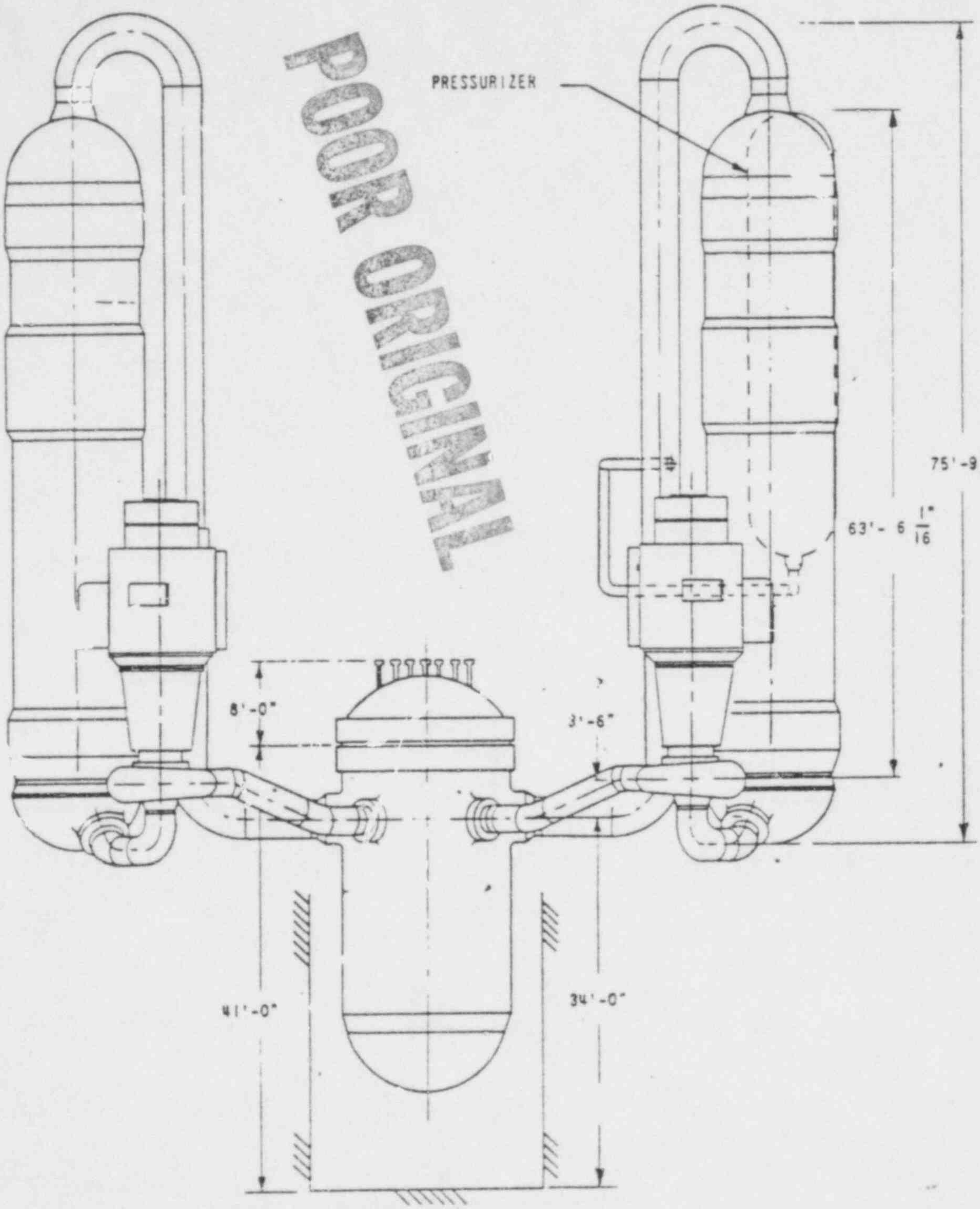


Figure 6. Reactor Coolant System Arrangement - Elevation, from Davis-Besse, Unit 1, FSAR.

279 351

. B&W PERFORMED ANALYSES FOR 0.01 FT^2 AND 0.005 FT^2 BREAKS FOR 177-FA LOWERED LOOP PLANTS & 0.02 FT^2 BREAK FOR 177-FA RAISED LOOP PLANT

. USED CRAFT CODE/SIMULATIONS TO 3000 SECONDS

. FOR LOWERED LOOP PLANTS, NO CYCLIC REPRESSURIZATION OBSERVED - ONCE NATURAL CIRCULATION INITIALLY LOST, HOT LEG U-BEND DID NOT REFILL

. FOR RAISED LOOP PLANTS, CYCLIC REPRESSURIZATION WAS CALCULATED TO OCCUR

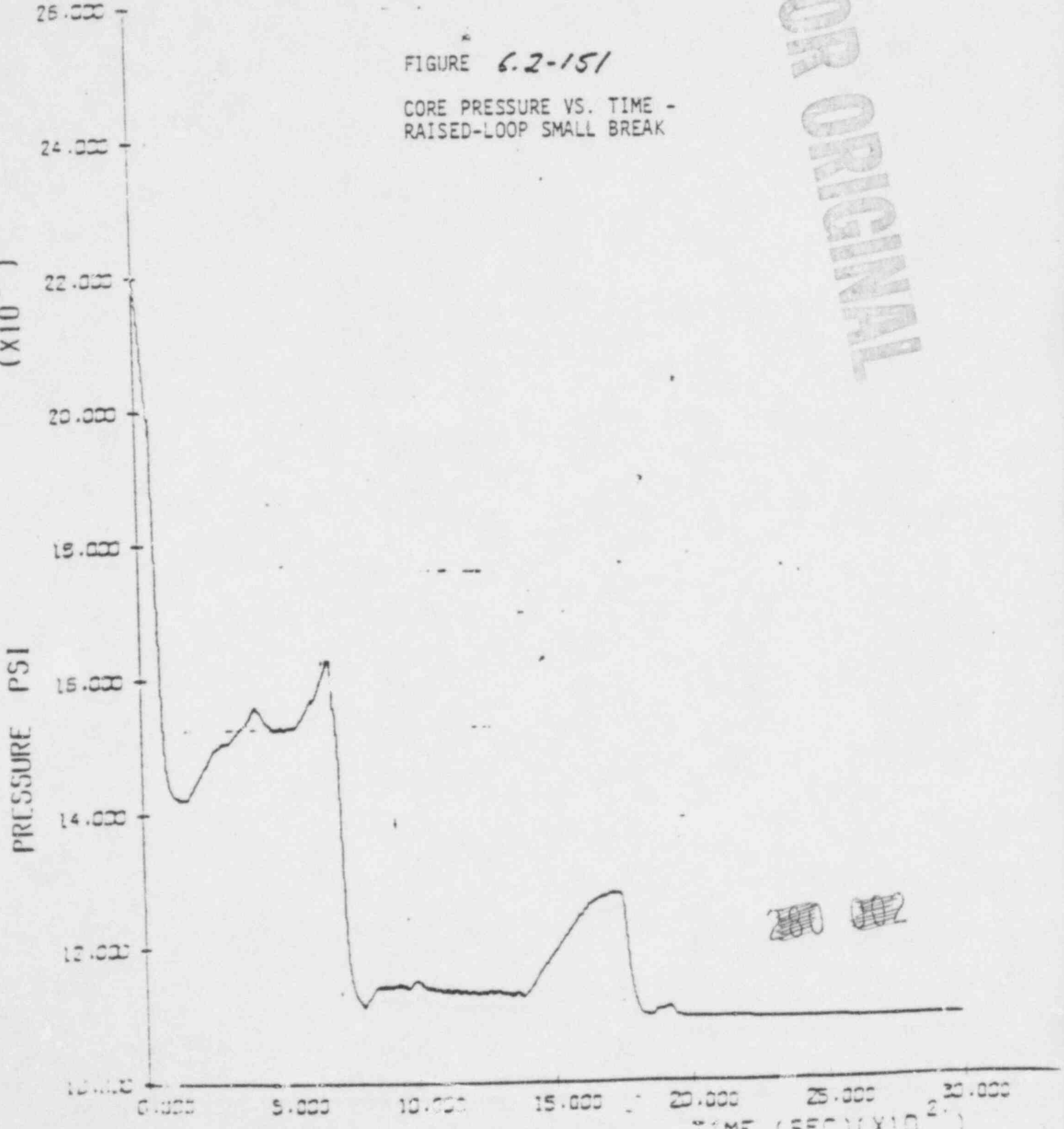
. ANALYSIS PREDICTED TRANSITION TO REFLUX BOILING AND CORE UNCOVERY WAS NOT CALCULATED TO OCCUR.

279

279 352
~~280 001~~

FIGURE 6.2-151

CORE PRESSURE VS. TIME - RAISED-LOOP SMALL BREAK



POOR ORIGINAL

280 002

.01FT2 PD NEW EM

279 353

NODE 2

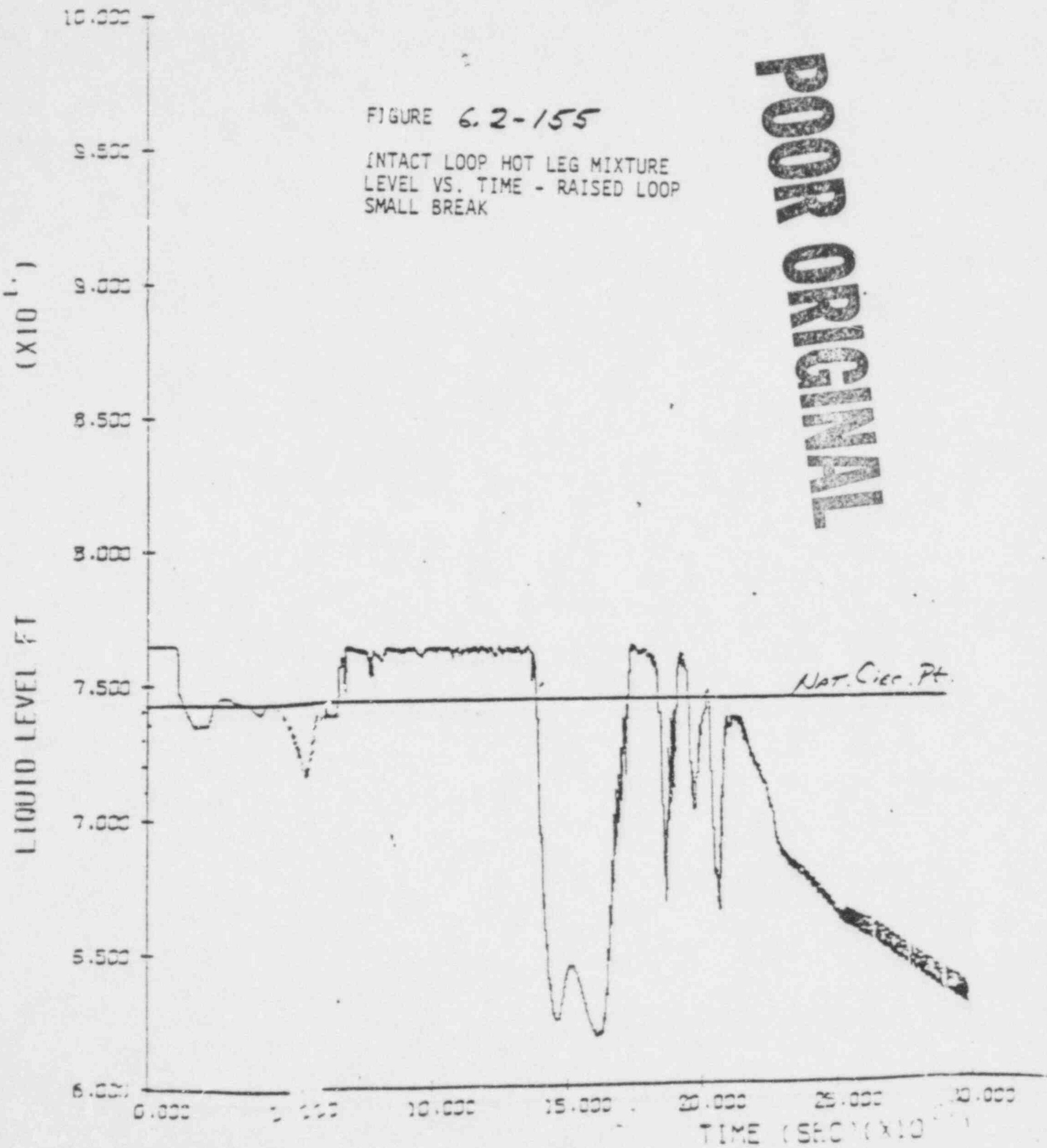


FIGURE 6.2-155

INTACT LOOP HOT LEG MIXTURE LEVEL VS. TIME - RAISED LOOP SMALL BREAK

.01FT2 ·D NEW EM

NODE 16

279 354

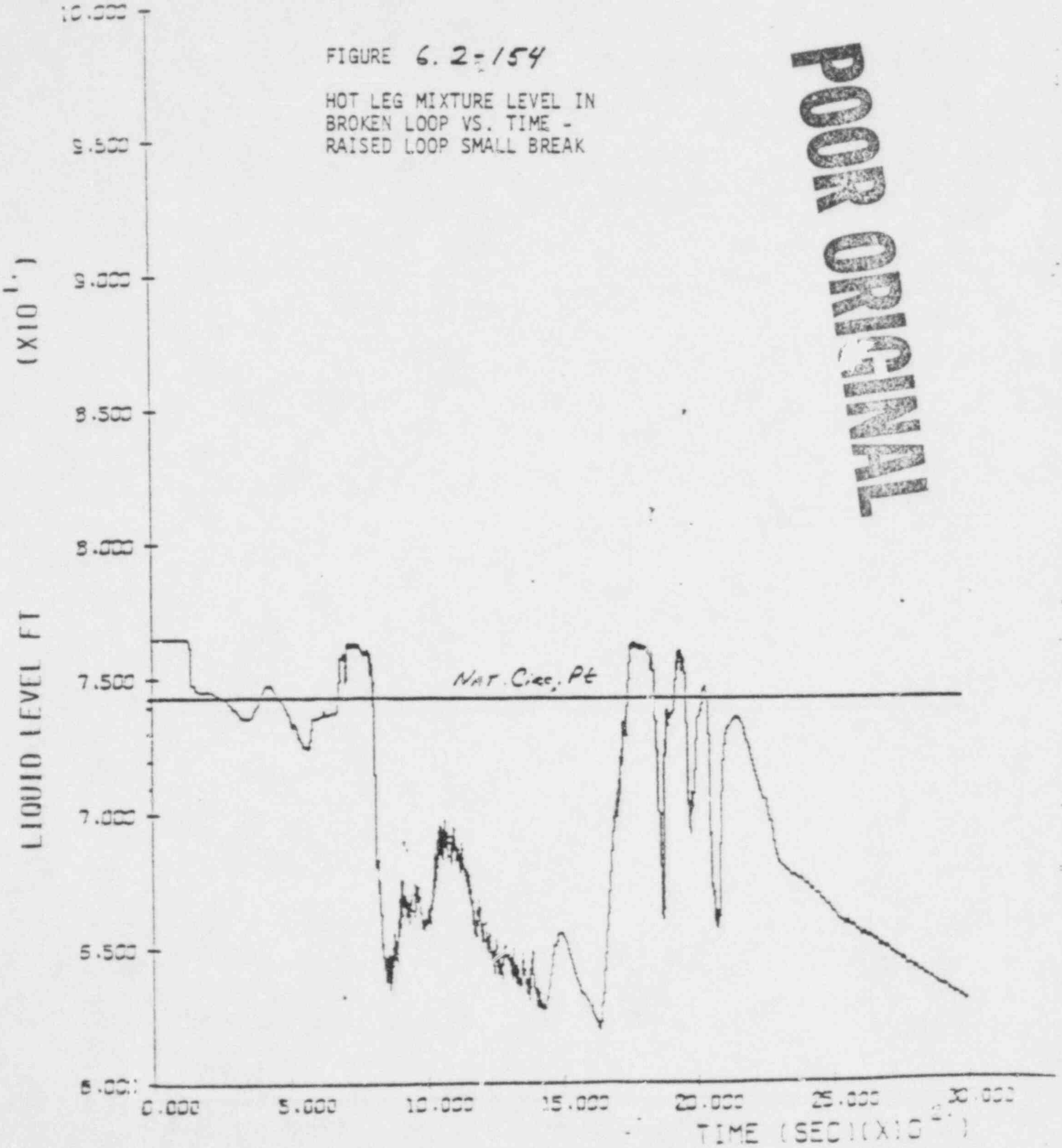


FIGURE 6.2-154

HOT LEG MIXTURE LEVEL IN BROKEN LOOP VS. TIME - RAISED LOOP SMALL BREAK

00030 .01FT2 PD NEW EM

NODE 3

279 355

TIME DELAY IN TRANSITIONING FROM NATURAL CIRCULATION TO POOL BOILING

- ONCE NATURAL CIRCULATION LOST, SG LEVEL MUST DROP BELOW SECONDARY LEVEL IN ORDER TO COMMENCE WITH REFLUX BOILING.

- WOULD REPRESSURIZATION INCREASE BREAK FLOW AND LEAD TO CORE UNCOVERY?

- REPRESSURIZATION DETERMINED BY BALANCE BETWEEN STEAM GENERATED IN CORE AND STEAM RELIEVED BY BREAK.

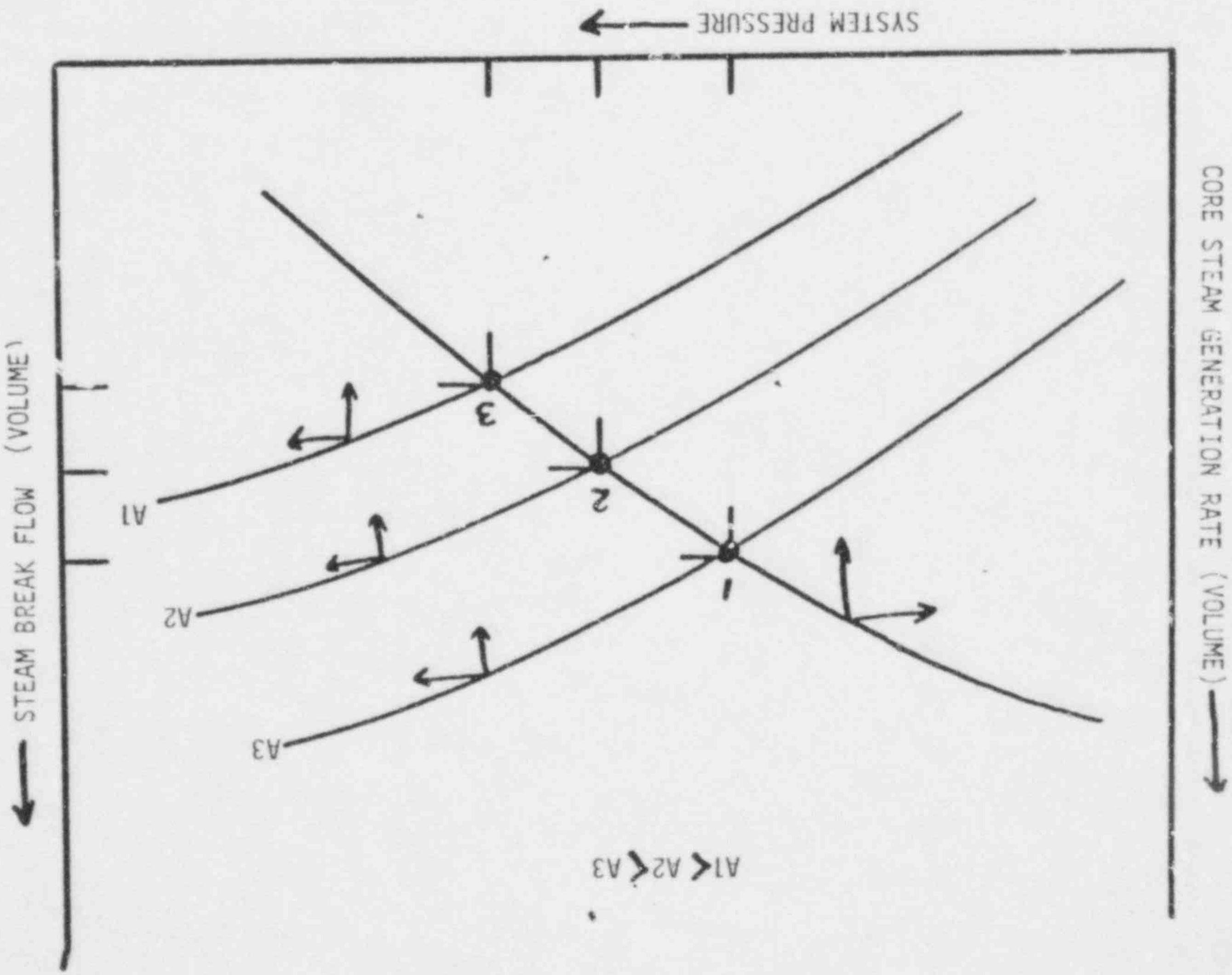
- FOR DECREASING BREAK SIZE, MASS FLOW OUT BREAK DECREASES, MAXIMUM REPRESSURIZATION INCREASES. STEAM VOLUME GENERATION DECREASES.

- FOR RAISED LOOP PLANTS, CONDENSING SURFACE MUST BE ESTABLISHED BEFORE CORE UNCOVERY.

FOR LOWERED-LOOP PLANTS, AUXILIARY FEEDWATER ENTERS FROM THE TOP OF THE SG. AUXILIARY FEEDWATER STARTED WHEN SECONDARY SIDE LEVEL DROPS BELOW 1/2 NORMAL OPERATING LEVEL WITH PUMPS NOT RUNNING. (BELOW 3 FEET WITH PUMPS RUNNING).

279 356

POOR ORIGINAL



279 357

25

PRESSURIZER LEVEL AS A CORRECT INDICATION
OF WATER LEVEL IN CORE

- FOR PRESSURIZER BREAKS, FLOW INTO PRESSURIZER WOULD PREVENT DRAINING AND MAINTAIN PRESSURIZER LIQUID INVENTORY
- REVISED PROCEDURES INSTRUCT OPERATORS TO CHECK OTHER SYSTEM PARAMETERS/HPSI SHUTOFF CRITERIA PRECLUDES PRESSURIZER LEVEL AS PRIMARY INDICATOR OF SYSTEM INVENTORY
- LONGER TERM STUDY UNDERWAY OF MORE DIRECT AND EASILY INTERPRETED INDICATORS OF WATER INVENTORY (E.G., LEVEL DETECTION)

279 358

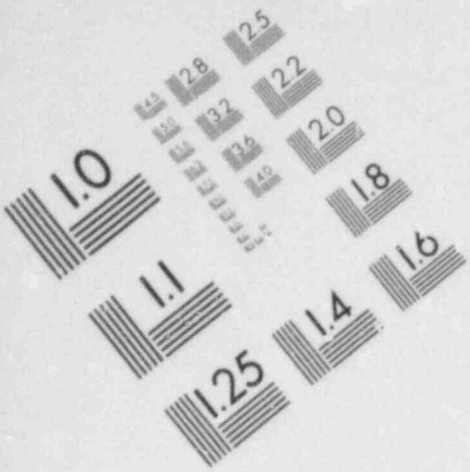
SMALL BREAK ISOLATION/REPRESSURIZATION

- ISOLATION OF SMALL BREAKS CAN CAUSE SYSTEM REPRESSURIZATION.
  - NO NATURAL CIRCULATION
  - HPSI REPRESSURIZATION
- WOULD RESULT IN OPENING PORV W/POSSIBLE PORV FAILURE.

- PORV FAILURE WOULD APPEAR AS SMALL BREAK IN PRESSURIZER STEAM SPACE
- ACCIDENT (FAILURE OF PORV) DISCUSSED BUT NOT SPECIFICALLY ANALYZED IN SARs
- DO NOT EXPECT NEW AND/OR UNUSUAL BEHAVIOR
- SPECIFIC ANALYSIS OF ISOLATION OF SMALL BREAKS W/PORV FAILURE WILL BE REQUIRED
- OPERATOR ACTION TO TURN OFF HPSI AFTER CRITERIA MET REQUIRED

279 359

27



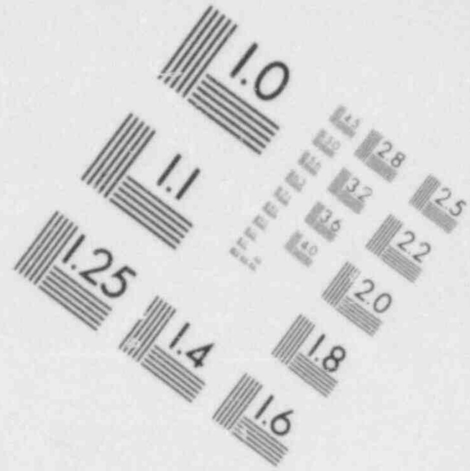
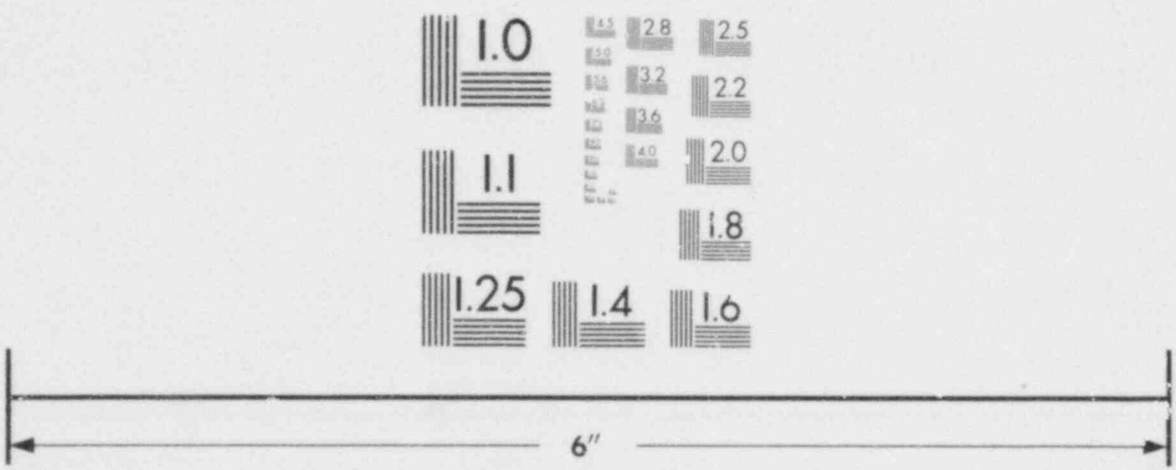
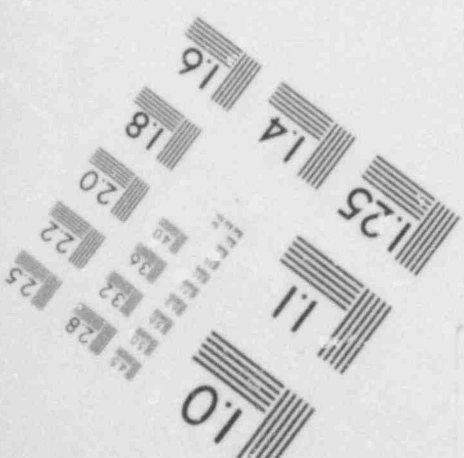


IMAGE EVALUATION
TEST TARGET (MT-3)





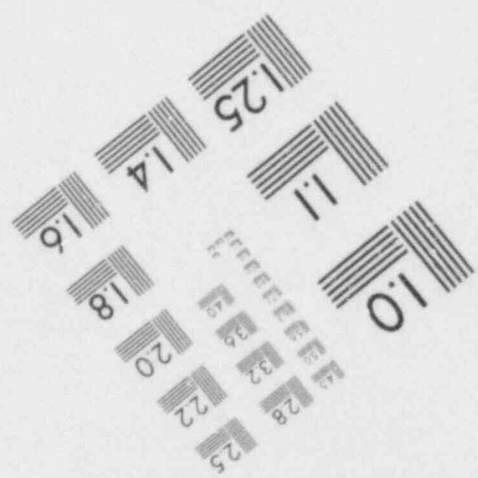
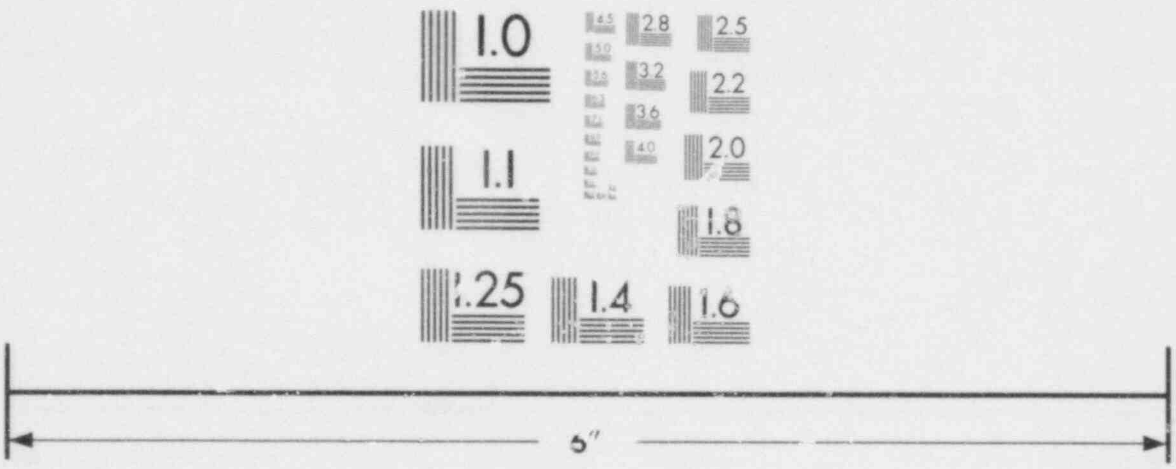
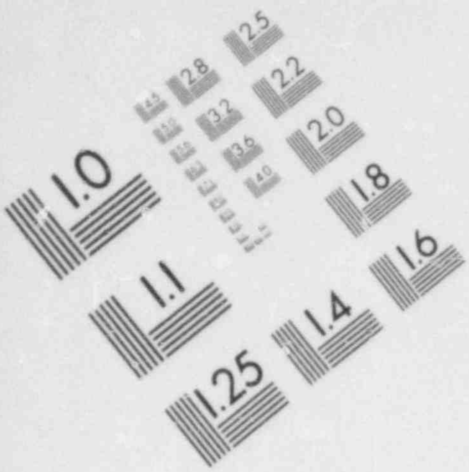


IMAGE EVALUATION TEST TARGET (MT-3)





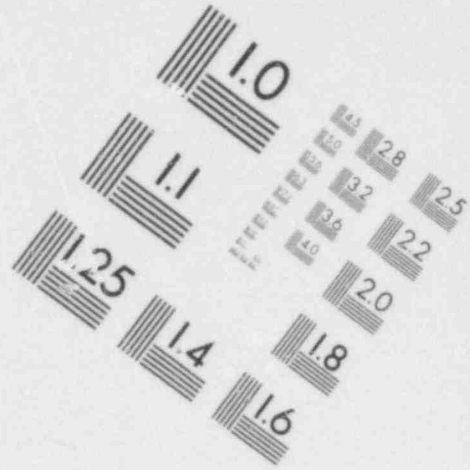
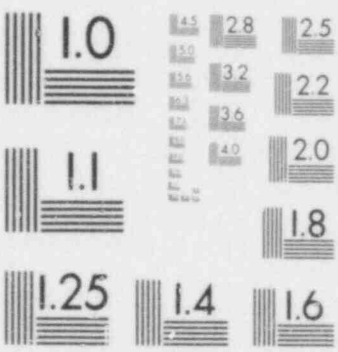
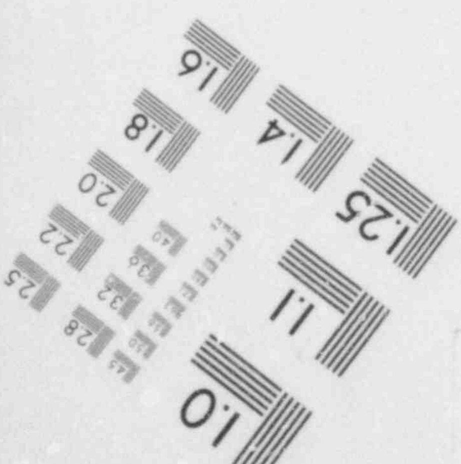


IMAGE EVALUATION TEST TARGET (MT-3)



6″



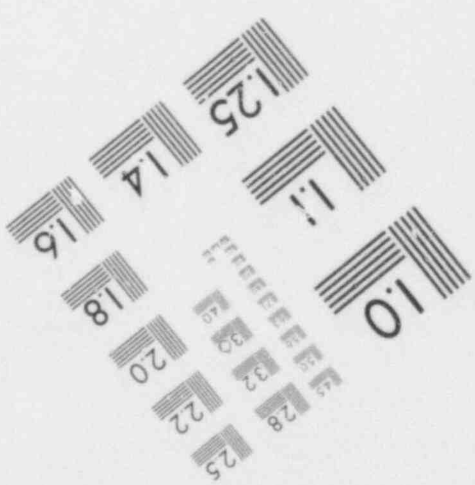


IMAGE EVALUATION
TEST TARGET (MT-3)

6″

IMAGE EVALUATION
TEST TARGET (MT-3)

6"

PRESSURE BOUNDARY DAMAGE DUE TO BUBBLE COLLAPSE

- COLLAPSING STEAM BUBBLES IN SUBCOOLED LIQUID PRODUCE PRESSURE LOADINGS ON PRIMARY COOLANT BOUNDARIES.

- INJECTING COLD ECC INTO STEAM-FILLED PIPE PRODUCES PRESSURE LOADS ON STRUCTURES.

- INJECTION COLD ECC INTO STEAM-FILLED PIPE
  - INJECTION OF ECC IN LOFT & SEMISCALE HAVE NOT SHOWN EXCESSIVE PRESSURE OSCILLATIONS ($\sim$10 PSI).
  - TESTS BY CE, W, AND EPRI SHOWED OSCILLATIONS OCCURRED WHEN INJECTION FLOW WAS SUFFICIENT TO PRODUCE SLUG OF WATER IN COLD LEG.
  - HPSI FLOW NOT HIGH ENOUGH TO PRODUCE WATER SLUGS.

- <u>COLLAPSING STEAM BUBBLES</u>
  - PRESSURE WAVES WOULD BE NON-DIRECTIONAL.
  - SYSTEM W/BUBBLES IS HYDRAULICALLY "SOFT" - ATTENUATION EXPECTED.

- LOADS EXPECTED TO BE LESS THAN LARGE BREAK LOCA LOADS.

- WILL REQUIRE LICENSEES AND APPLICANTS TO ANALYZE TO CONFIRM CONCLUSION.

280 001

BREAK ENERGY NOT REPRESENTATIVE OF CORE EXIT ENERGY

. BREAK CANNOT REMOVE FULL DECAY HEAT LOAD UNLESS BREAK ENERGY IS CORE EXIT ENERGY.

. HPSI BYPASS

. CODES ACCOUNT FOR DISTRIBUTION OF ENERGY

. ASSUME HPSI CAN CONDENSE W/100% EFFICIENCY

. ANY NON-EQUILIBRIUM EFFECTS EXPECTED TO BE SMALL

2

280 [illegible]

NON-CONDENSIBLE GASES

STAFF ESTIMATES (BSAR-205)

SOURCE	CUBIC FEET AT STP
DISSOLVED H_2 IN PRIMARY COOLANT	437
DISSOLVED AIR IN REFUELING WATER TANK	1214
H_2/% ZIRC. REACTED	4344
FLOOD TANKS	
DISSOLVED N_2	1456
FREE N_2	33,101
PRESSURIZER GAS SPACE	~700
RADIOLYTIC DECOMPOSITION OF INJECTED ECC WATER	NEGLIGIBLE FOR H_2 CONCENTRATIONS ABOVE $5CC/K_GH_2O$
HE FILL GAS + GAP FISSION GAS @ EOC	~1500

280 3

- FOR VERY SMALL BREAKS IN WHICH SG MUST REMOVE DECAY HEAT, ACCUMULATORS DO NOT TURN ON.

- FOR BREAKS WHICH DO TURN ON ACCUMULATORS, PRESSURE MUST DROP TO ~150 PSI BEFORE SIGNIFICANT QUANTITIES OF N_2 WILL ENTER SYSTEM.

- MOST LIKELY ACCUMULATION OF GASES IS UPPER PLENUM AND HEAD.

- WITHOUT ACCUMULATOR ACTUATION & SIGNIFICANT CORE OXIDATION, NON-CONDENSIBLE GASES SHOULD NOT HINDER DECAY HEAT REMOVAL BY STEAM GENERATORS.

SUMMARY

- NO DISAGREEMENT ON PHENOMENA DESCRIBED BY C. MICHELSON.
- CONCERNS UNDERSCORED IMPORTANCE OF NATURAL CIRCULATION FOR DECAY HEAT REMOVAL DURING SMALL BREAKS.
- B&W HAS PERFORMED DETAILED ANALYSES TO ADDRESS CONCERNS.
- RESULTS SHOW PHENOMENA OCCUR, BUT THAT DECAY HEAT REMOVAL IS NOT UNACCEPTABLY IMPACTED.

Figure 1-1. Reactor Coolant System — Isometric Drawing for Oconee-Type Plant

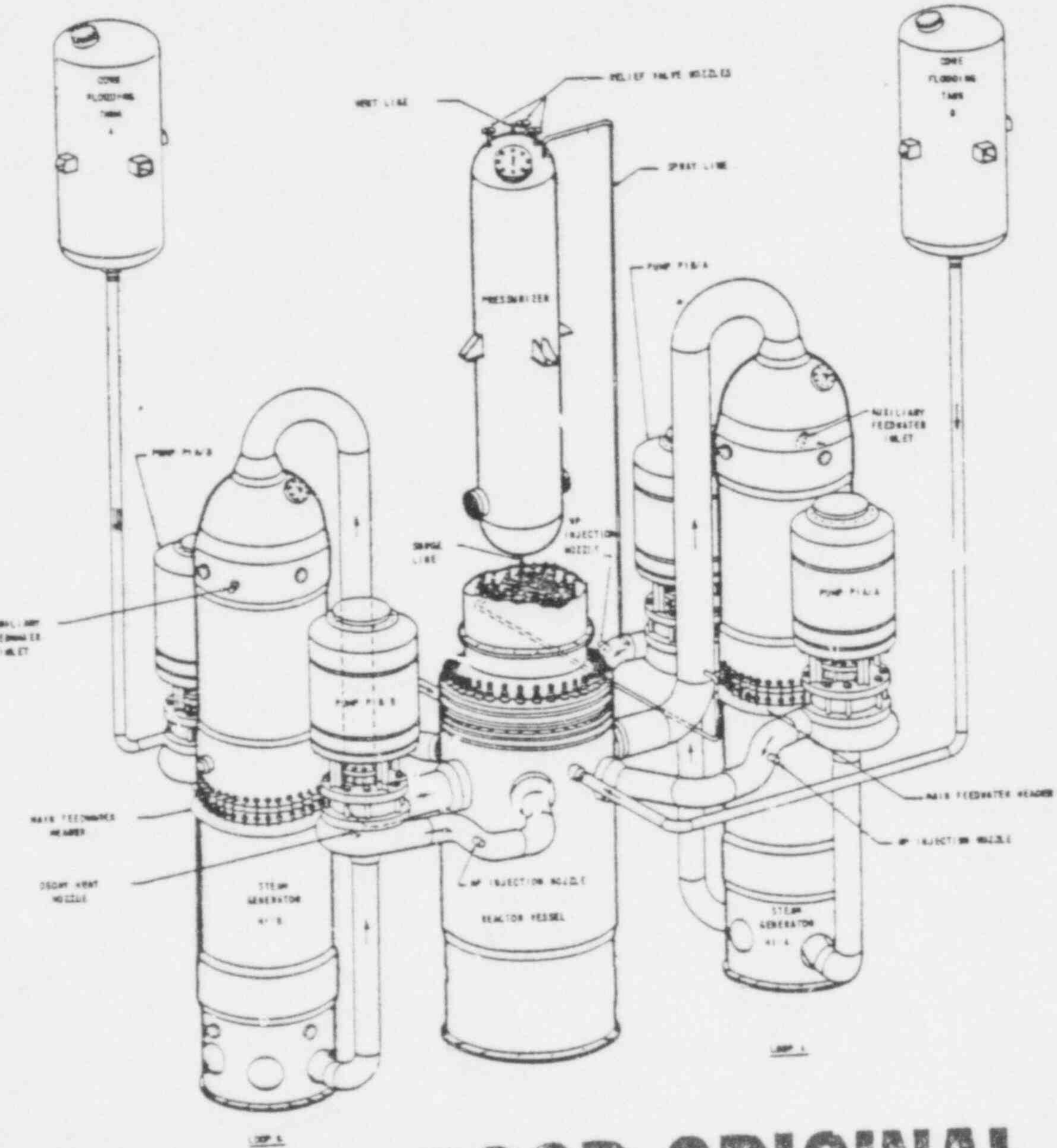


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Figure 6-3.15

PRESSURIZER LEVEL

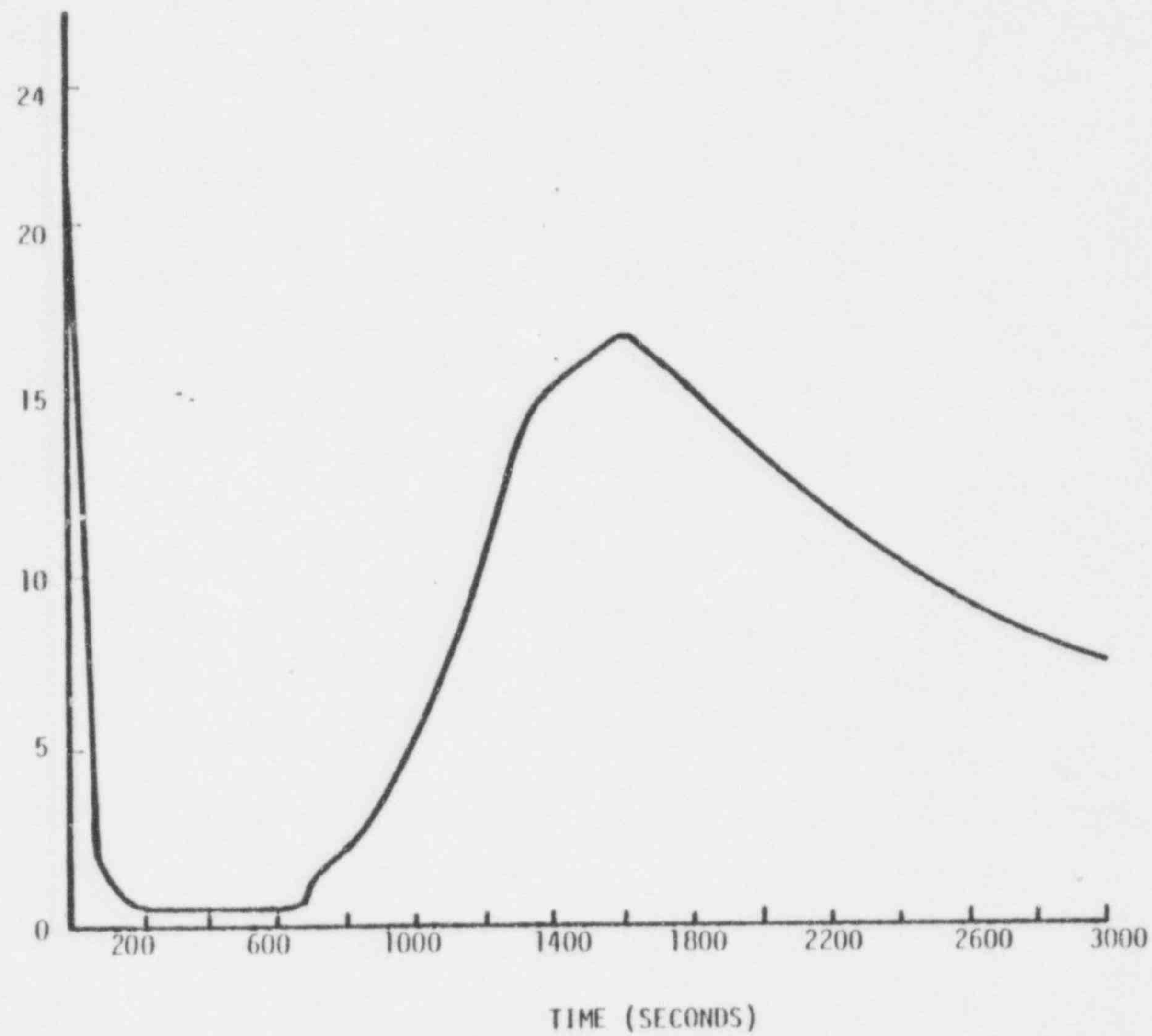

Figure 6.2.48

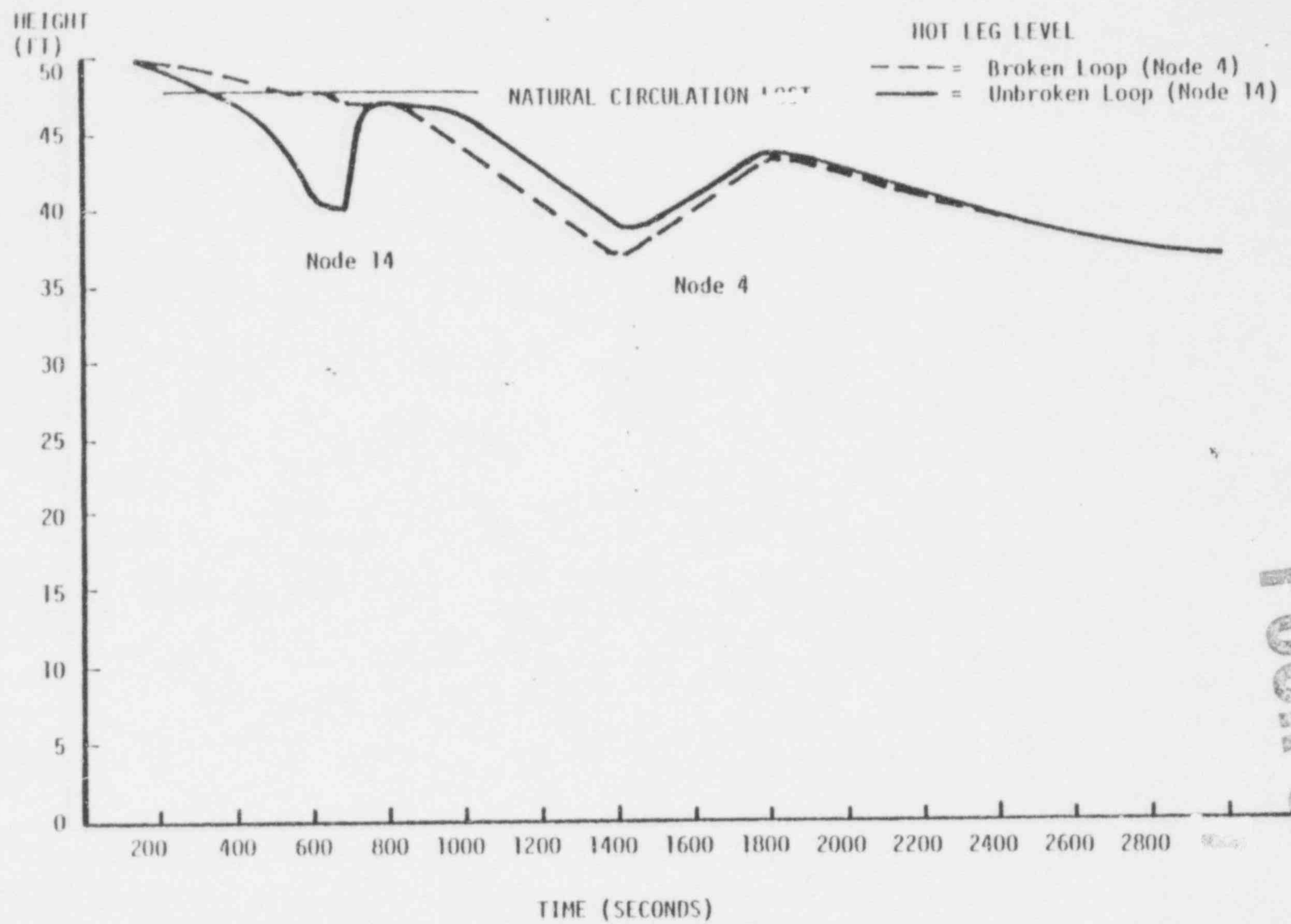

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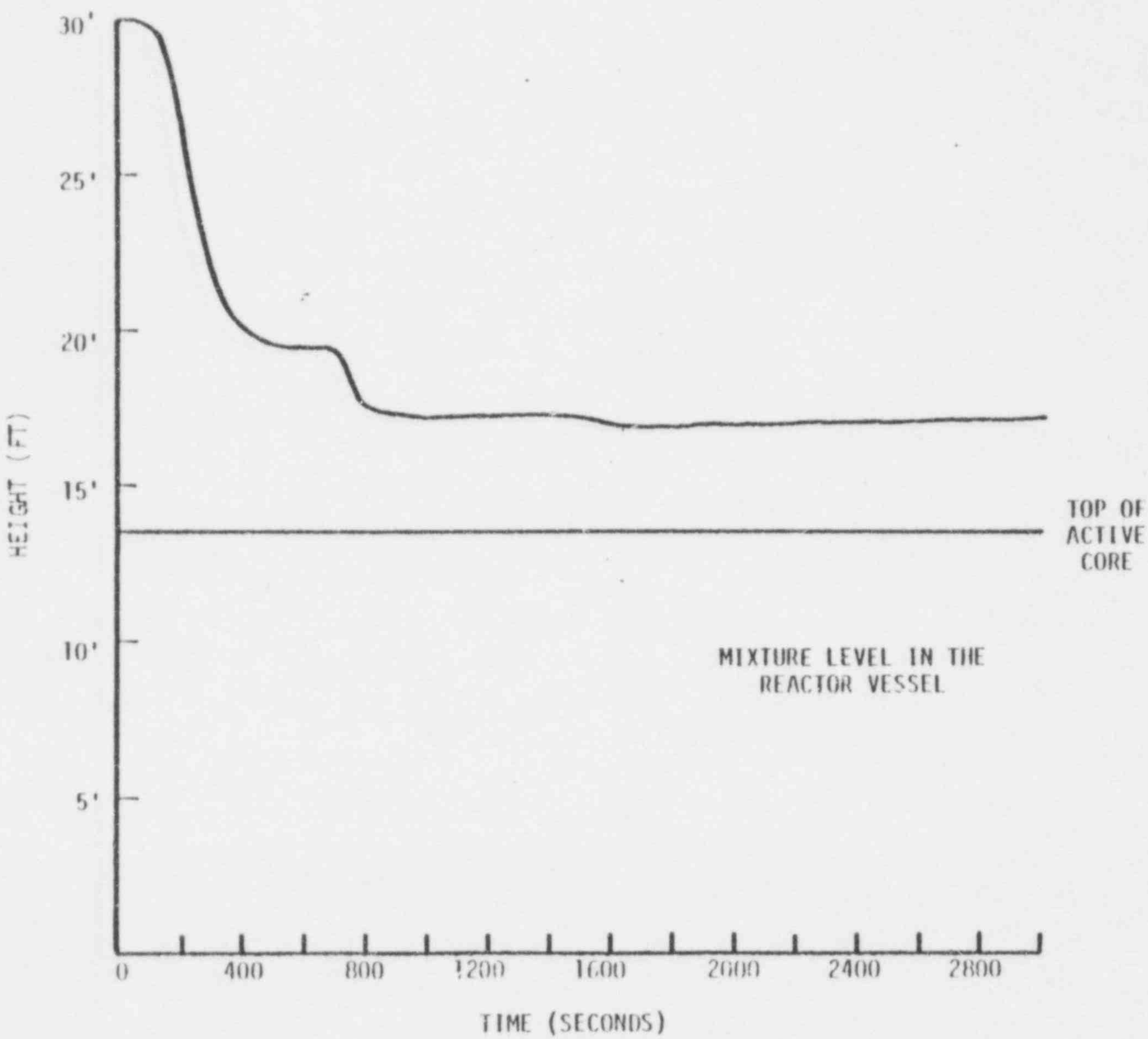
Figure 6.2.99



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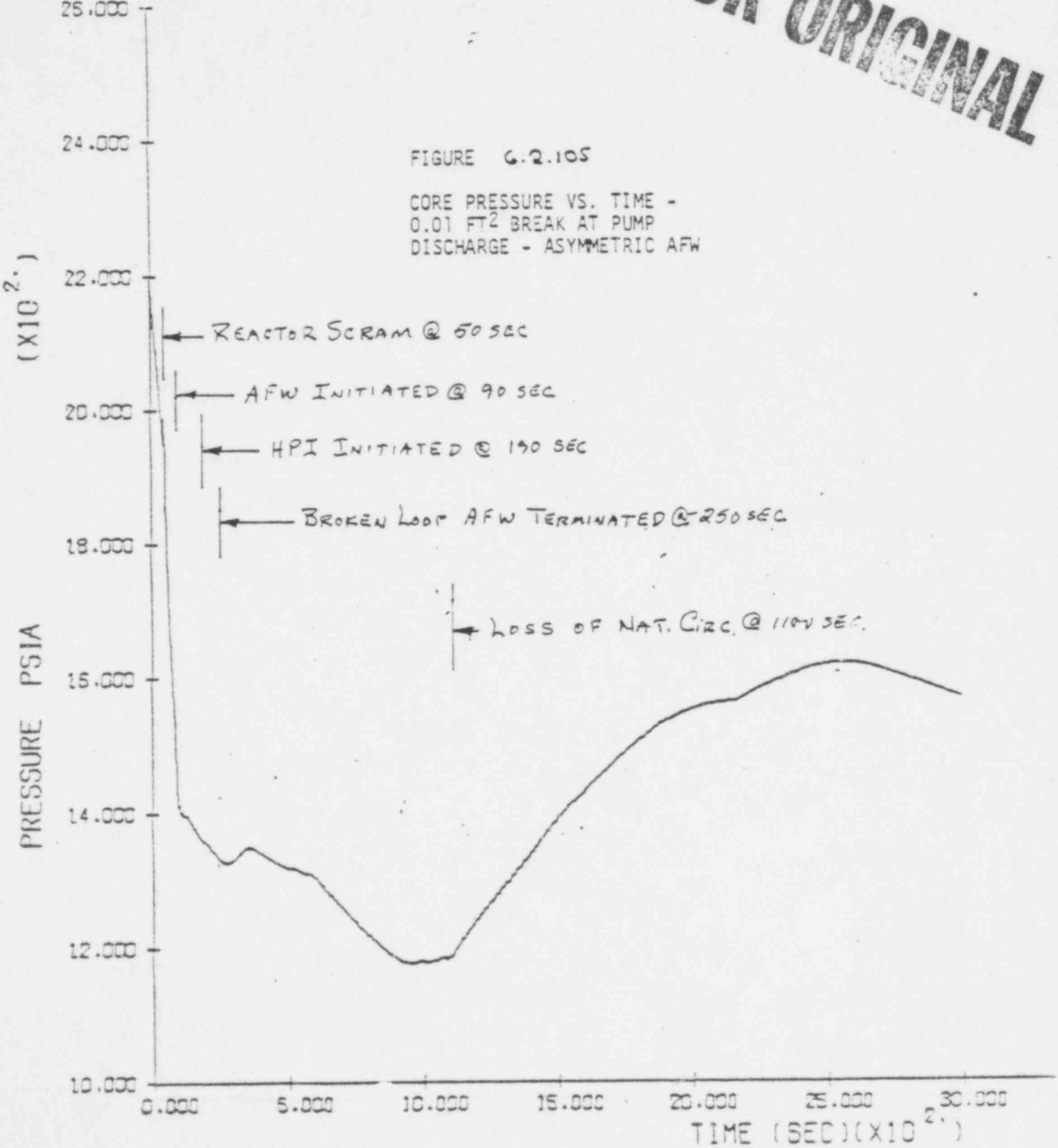


FIGURE 6.2.105

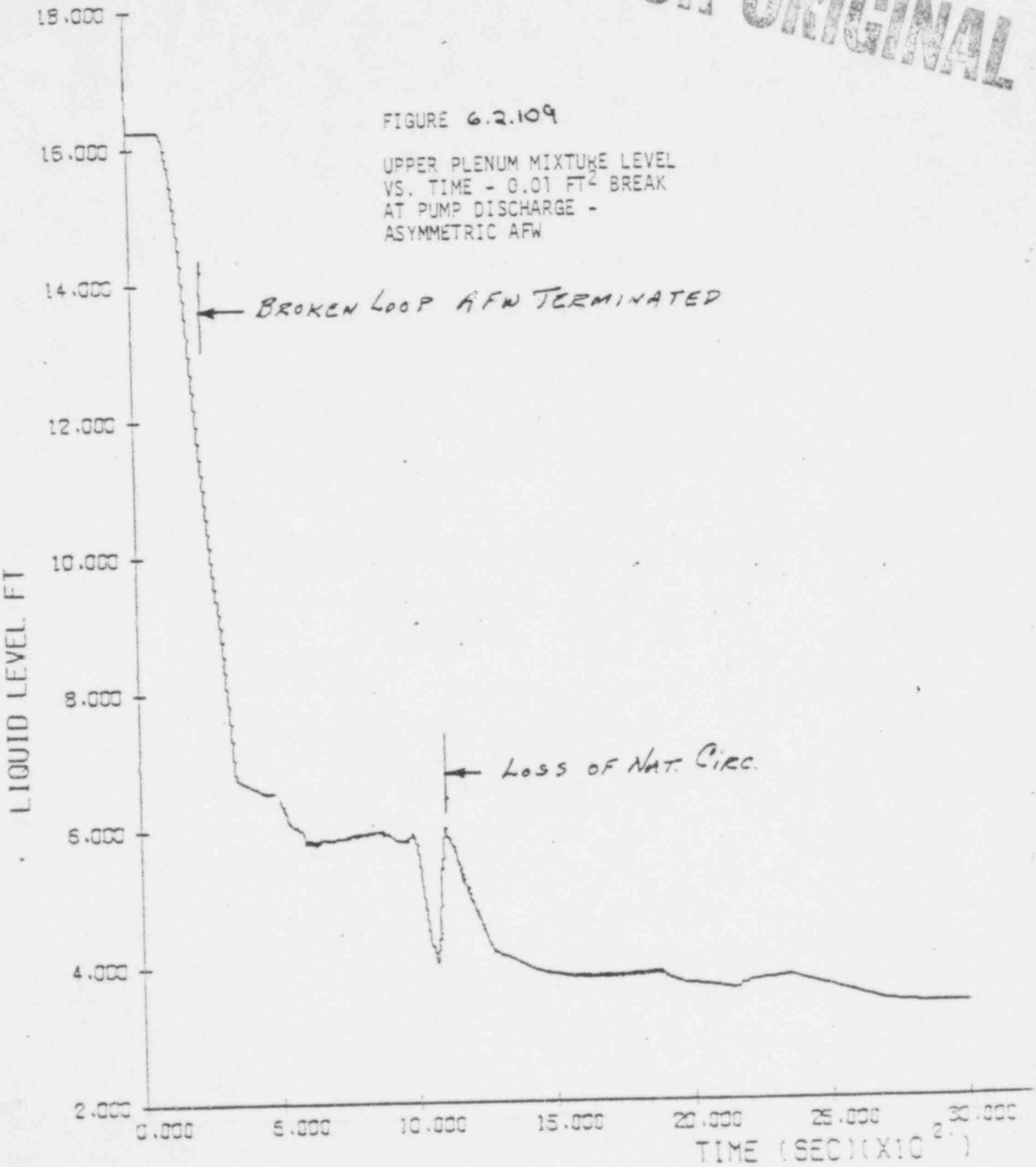
CORE PRESSURE VS. TIME - 0.01 FT^2 BREAK AT PUMP DISCHARGE - ASYMMETRIC AFW

MI101G2 1 AUX FEED

280 011

NODE 3

60



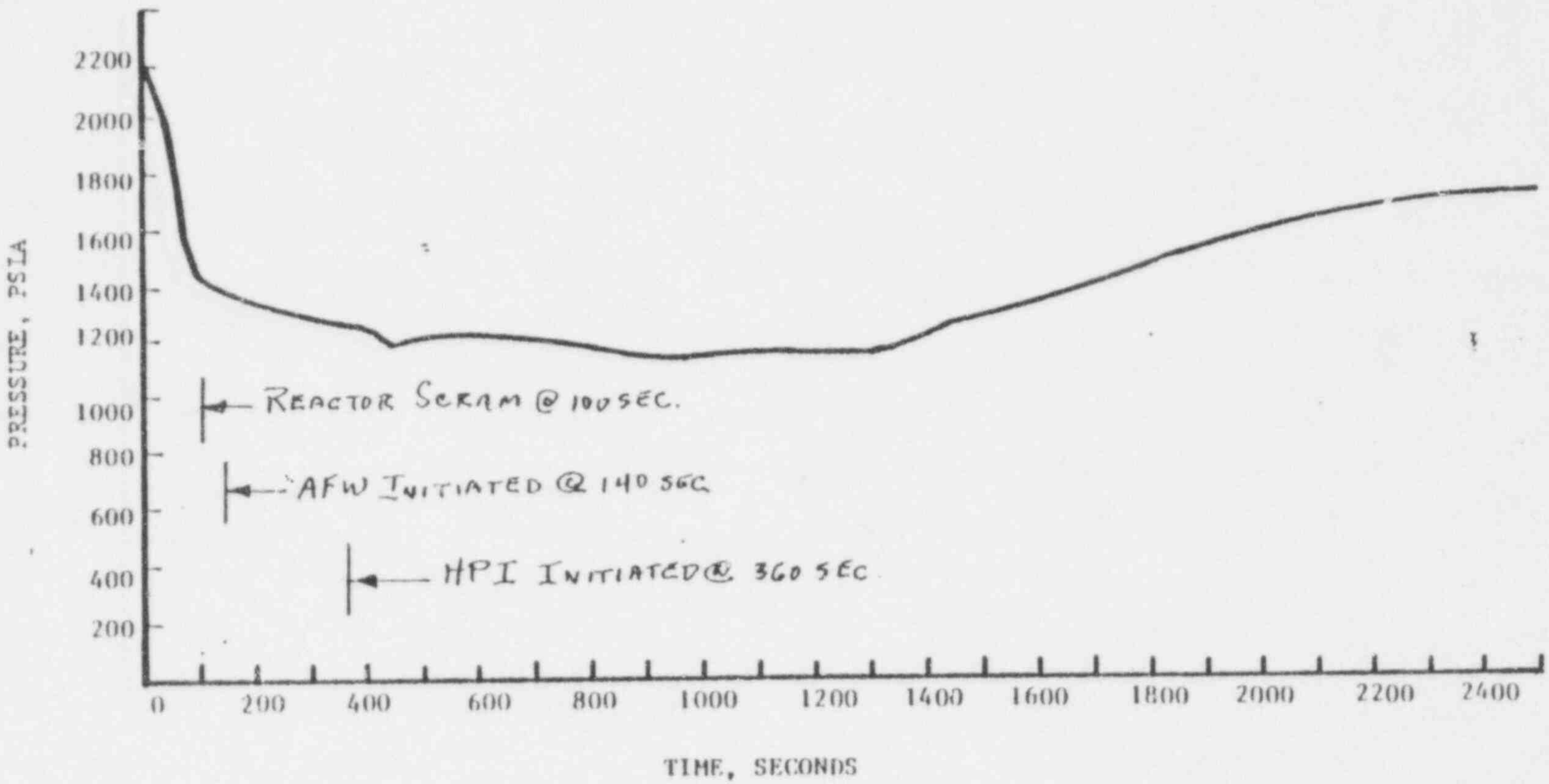
MI101C2 1 AUX FEED 280 12 NODE 23

61

FIGURE 6.2.148

CORE PRESSURE VERSUS TIME

0.005 FT^2 BREAK AT PUMP DISCHARGE

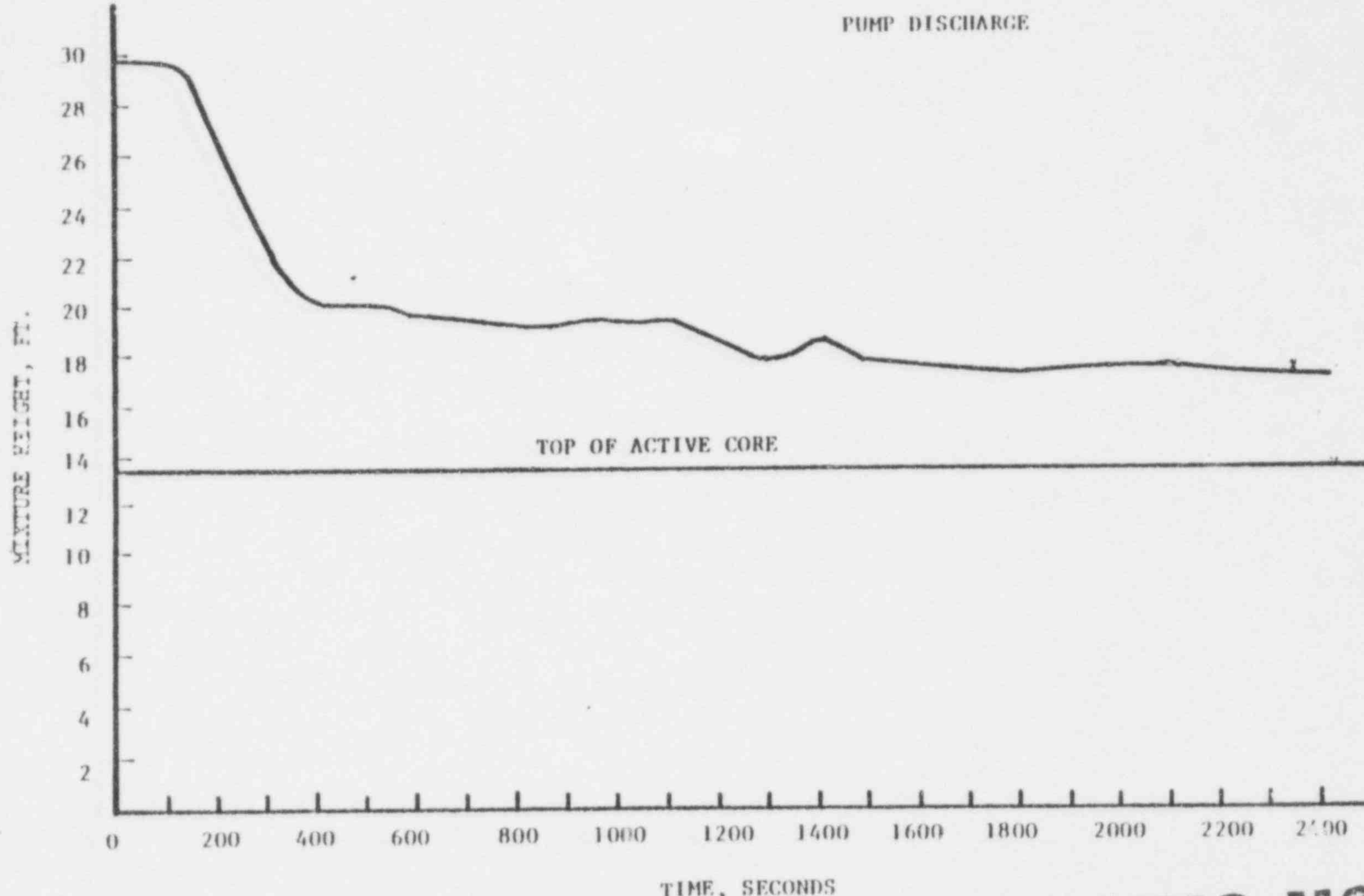


POOR ORIGINAL

280 0013

FIGURE 6.2.149

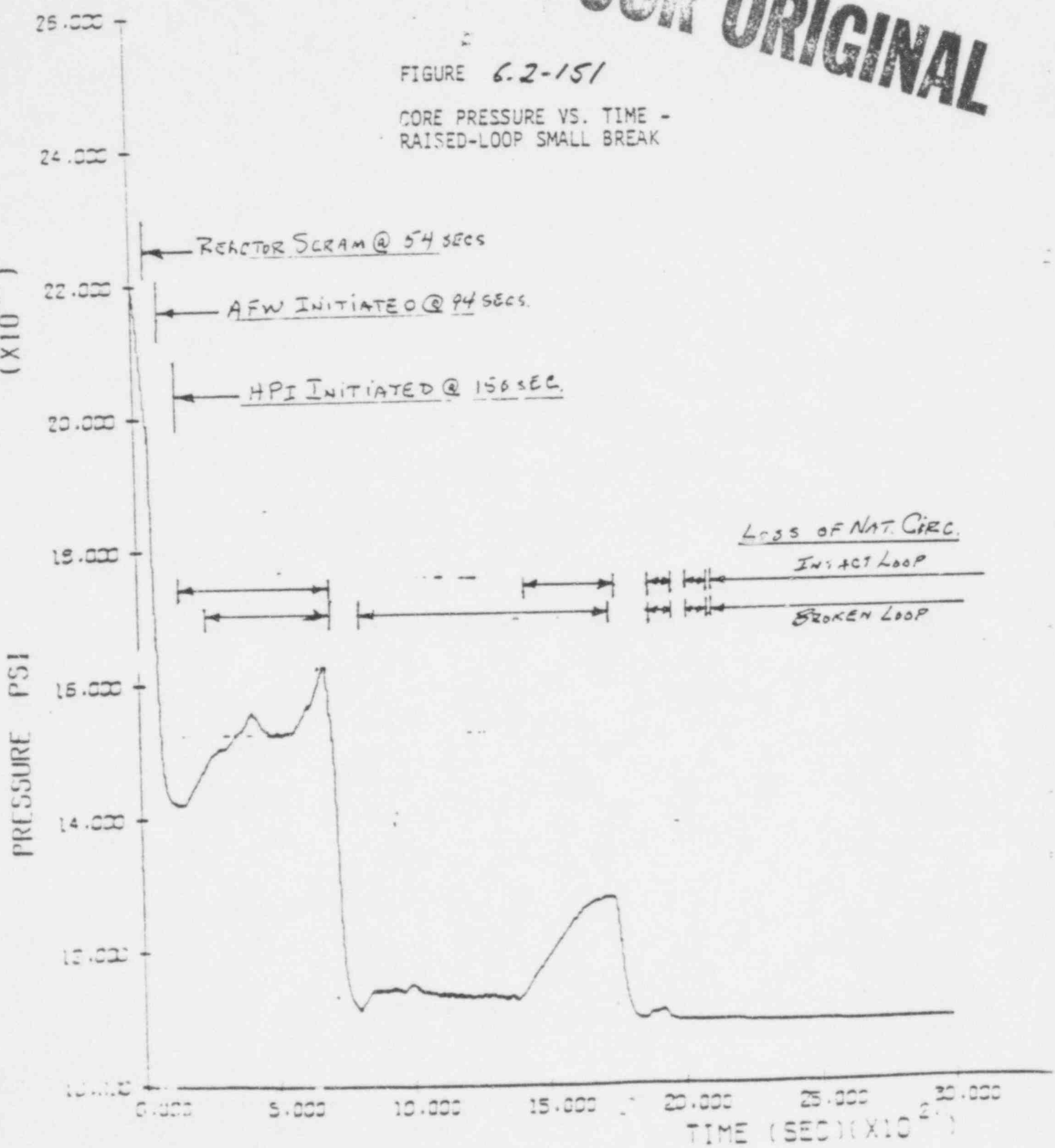
MIXTURE HEIGHT VS. TIME
$0.005\ FT^2$ BREAK AT
PUMP DISCHARGE



280 014

FIGURE 6.2-151

CORE PRESSURE VS. TIME - RAISED-LOOP SMALL BREAK



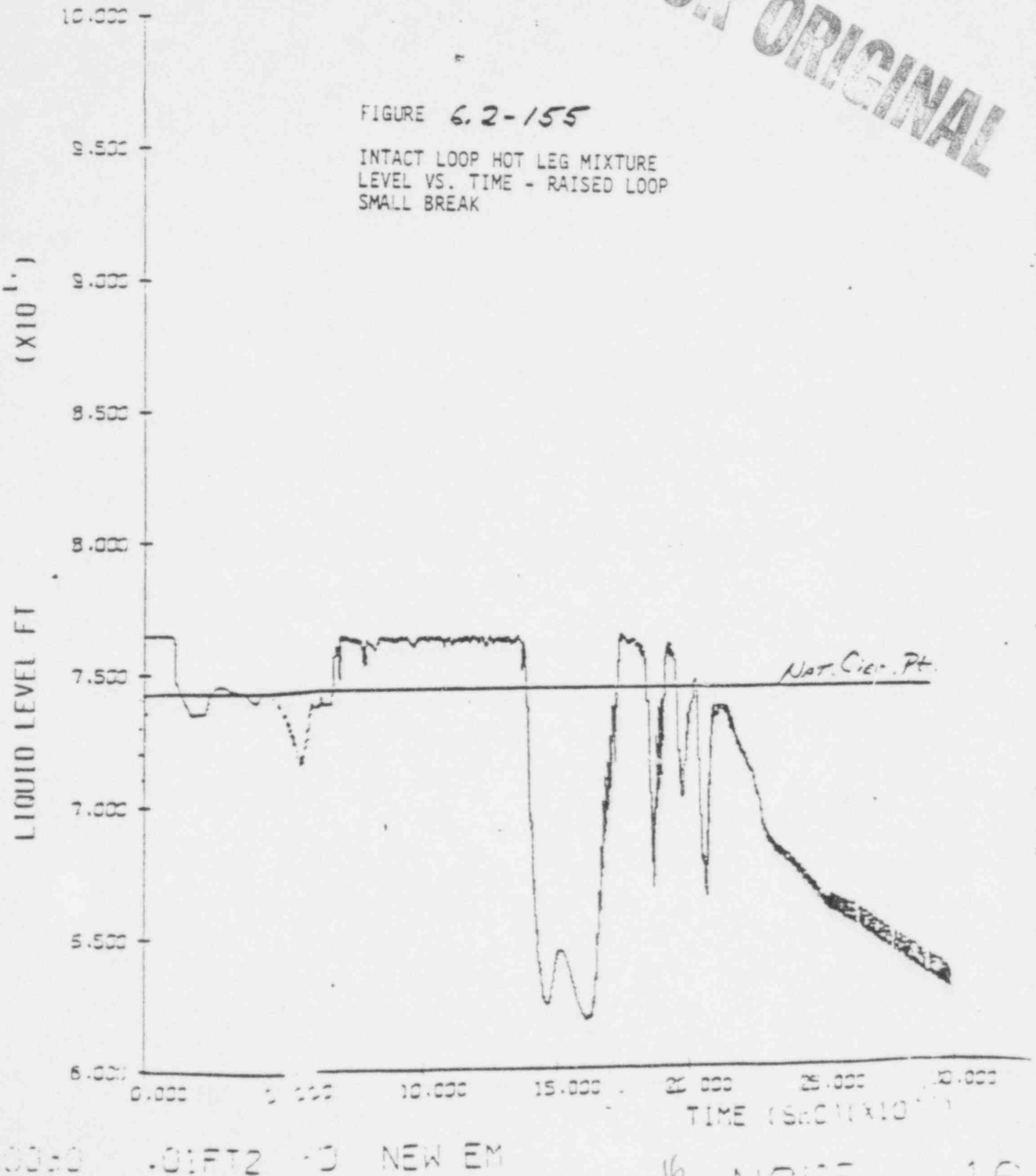
NODE 2

280 15

64

FIGURE 6.2-155

INTACT LOOP HOT LEG MIXTURE LEVEL VS. TIME - RAISED LOOP SMALL BREAK



280 16

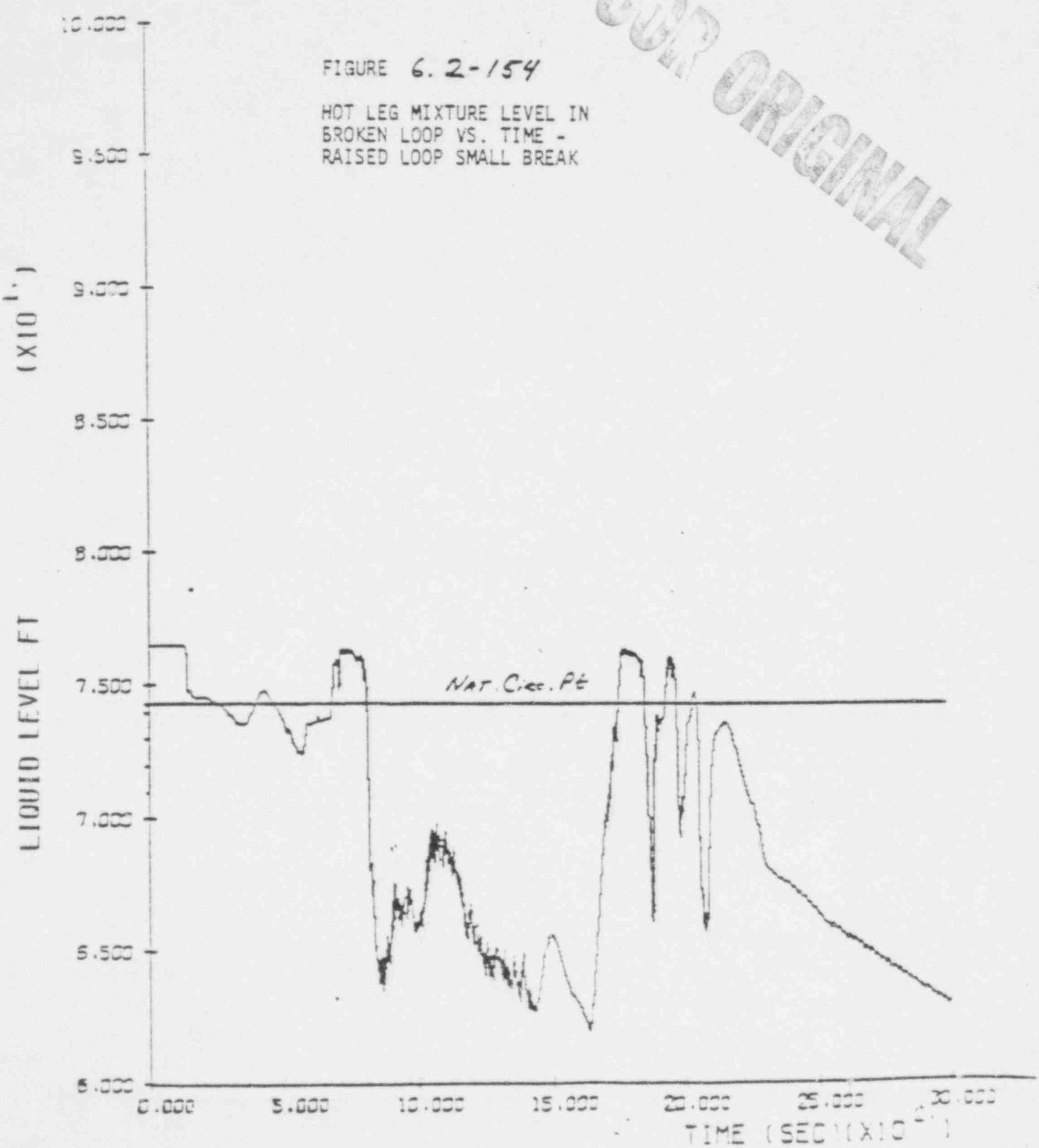


FIGURE 6.2-154

HOT LEG MIXTURE LEVEL IN BROKEN LOOP VS. TIME - RAISED LOOP SMALL BREAK

J0030 .01FT2 PD NEW EM

17 NODE 3

280 [illegible]

66

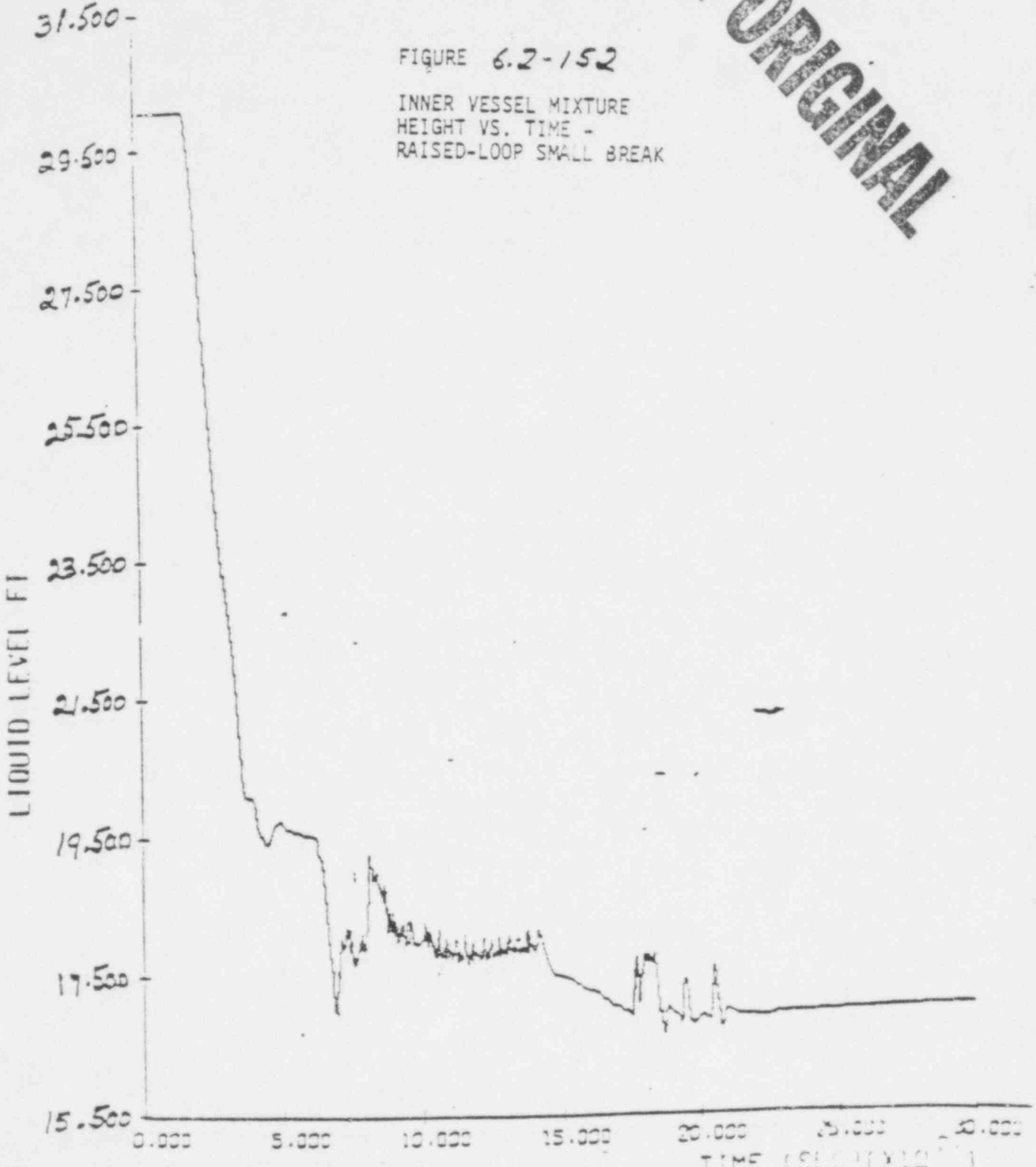


FIGURE 6.2-152

INNER VESSEL MIXTURE HEIGHT VS. TIME - RAISED-LOOP SMALL BREAK

.01FT2 PD NEW EM

18

280

CONCLUSIONS

1. AFW AT 20 MINUTES PROVIDE CORE COVERING FOR LOWERED AND RAISED LOOP PLNTS FOR BREAKS SMALLER THAN .02 FT^2.

2. HPI ONLY AT 20 MINUTES PROVIDE CORE COVERING FOR LOWERED LOOPS FOR BREAKS SMALLER THAN .02 FT^2.

3. 1 HPI TRAIN PROVIDES CORE COVERING FOR STUCK PORV IN LOWERED AND RAISED LOOPS.

4. HOT LEG BREAKS BOUNDED BY RESULTS FOR COLD LEG BREAKS DUE TO ACTION OF VENT VALVES.

5. SINGLE STEAM GENERATOR OPERATION IS ADEQUATE TO MAINTAIN CORE COVERING FOR SMALL BREAKS.

PURPOSE : AUDIT B & W SMALL BREAK CALCULATIONS WHICH MAY REPRESSURIZE OR EXHIBIT HEAT REMOVAL PROBLEMS

TWO CASES WERE CHOSEN FOR E.G.&G., IDAHO TO CALCULATE USING A PRELIMINARY VERSION OF RELAP4/MOD7.

CASE 1 : 0.01 SQ. FT. - AUXILIARY FEEDWATER DELAYED 20 MINUTES TWO HPI PUMPS. FOR THIS SIZE BREAK, WITHOUT AUX. FEED, SYSTEM MAY NOT DEPRESSURIZE TO THE HPI ACTUATION POINT AND REPRESSURIZATION WILL OCCUR

CASE 2 : 0.01 SQ. FT. - NORMAL AUX. FEED DELAY (36 SECONDS AFTER REACTOR TRIP), ONE HPI PUMP. AS VOIDS FORM IN THE "CANDY CANE" , LOSS OF NATURAL CIRCULATION CAN OCCUR.

INITIAL CONDITIONS FOR BOTH CALCULATIONS

0.01 SQ. FT. PUMP DISCHARGE BREAK

102% NOMINAL POWER (2827 MW)

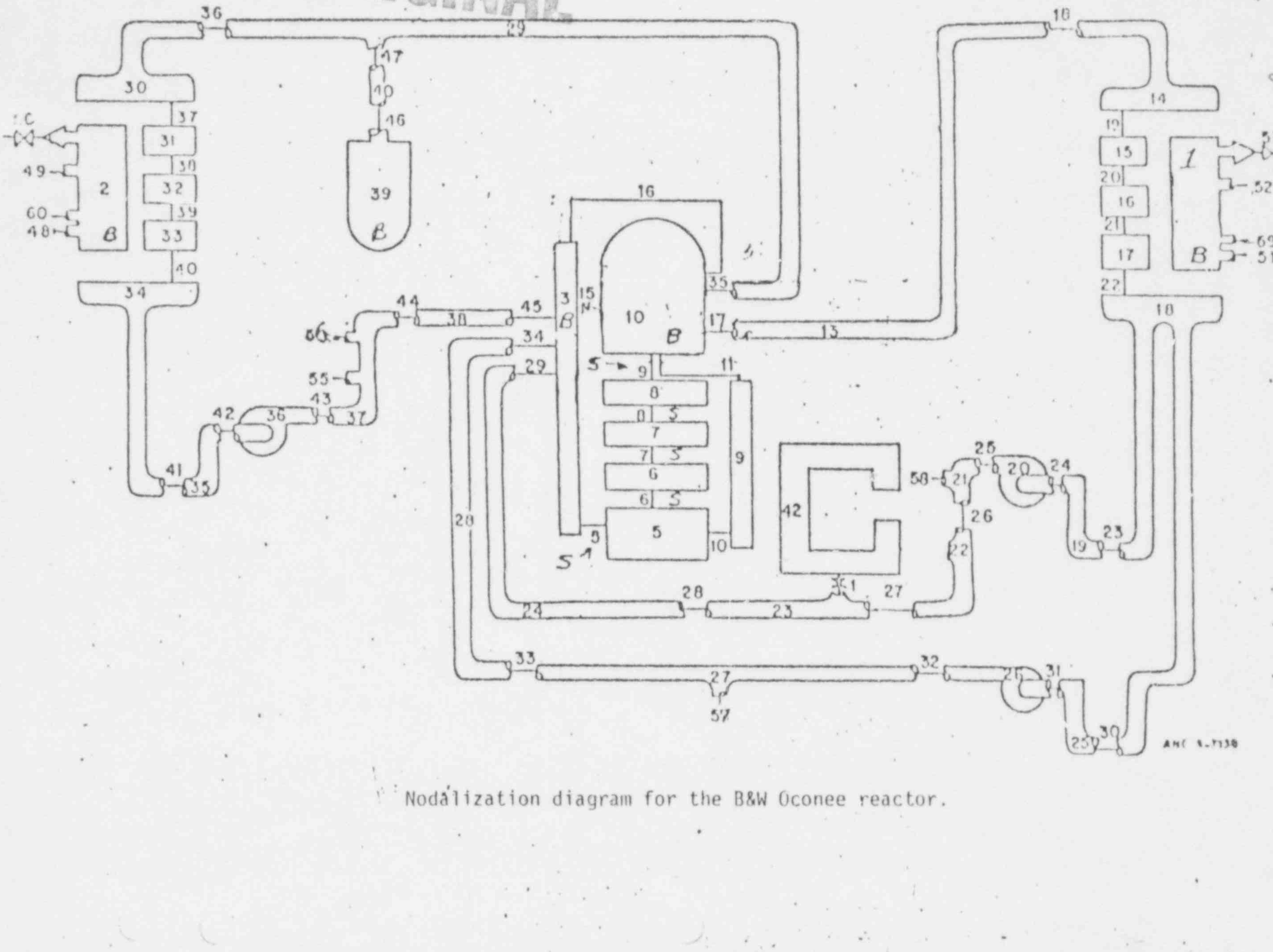
1.2 TIMES ANS DECAY HEAT

REACTOR SCRAM AT 1900 PSIA PLUS 0.5 SECOND DELAY

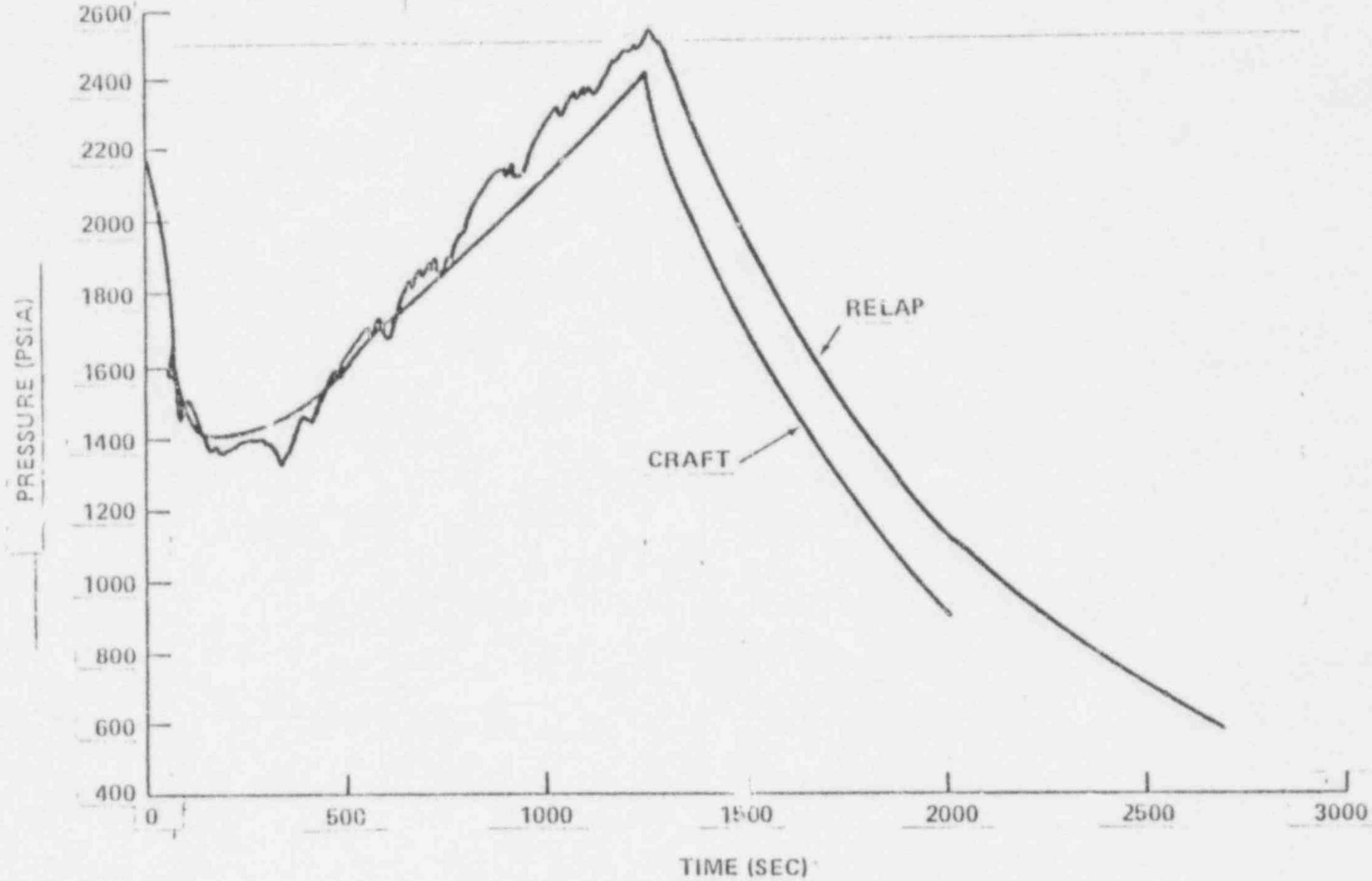
CONCURRENT TRIP OF TURBINE AND REACTOR COOLANT PUMPS

HPI ACTUATION AT 1365 PSIA PLUS 35 SECOND DELAY

USED B & W HPI AND AUX. FEED CURVES

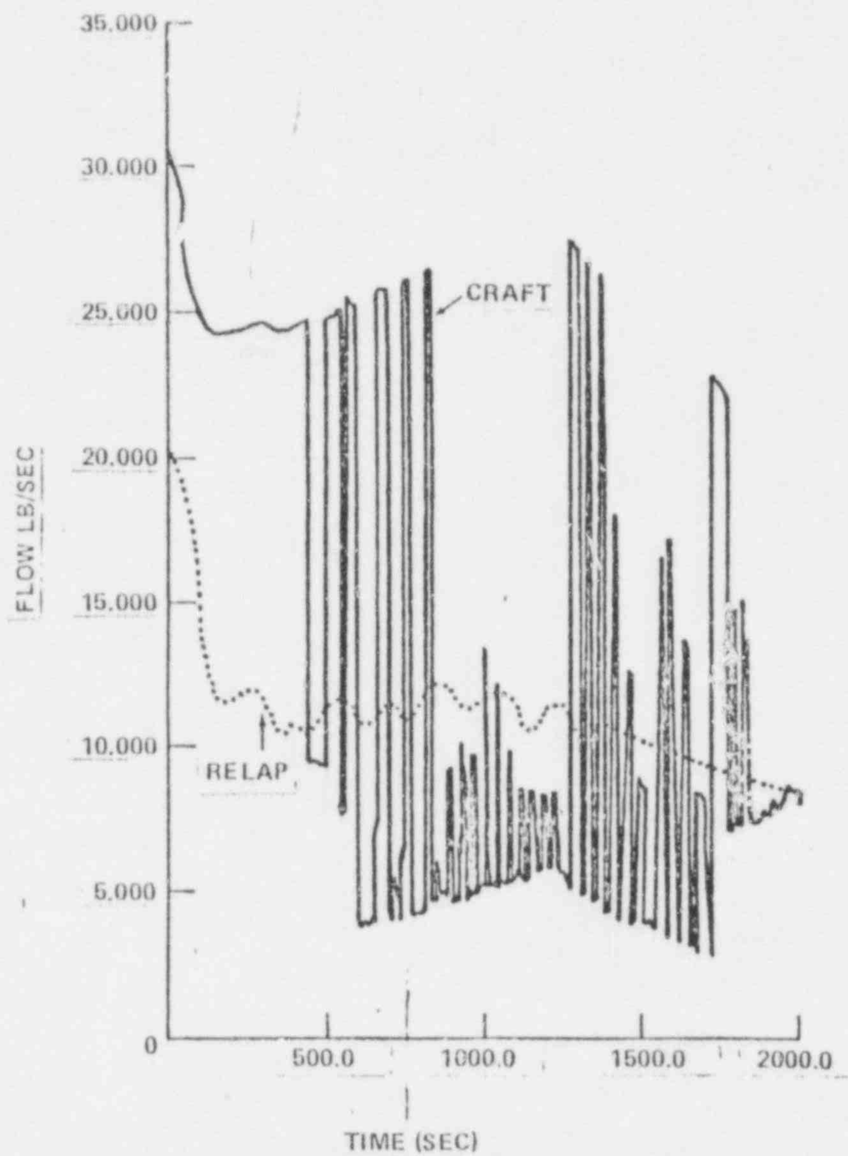


Nodalization diagram for the B&W Oconee reactor.



Hot leg Pressure (Intact Loop) –
0.01 ft^2 Break at Pump Discharge – Auxiliary Feedwater After 20 minutes

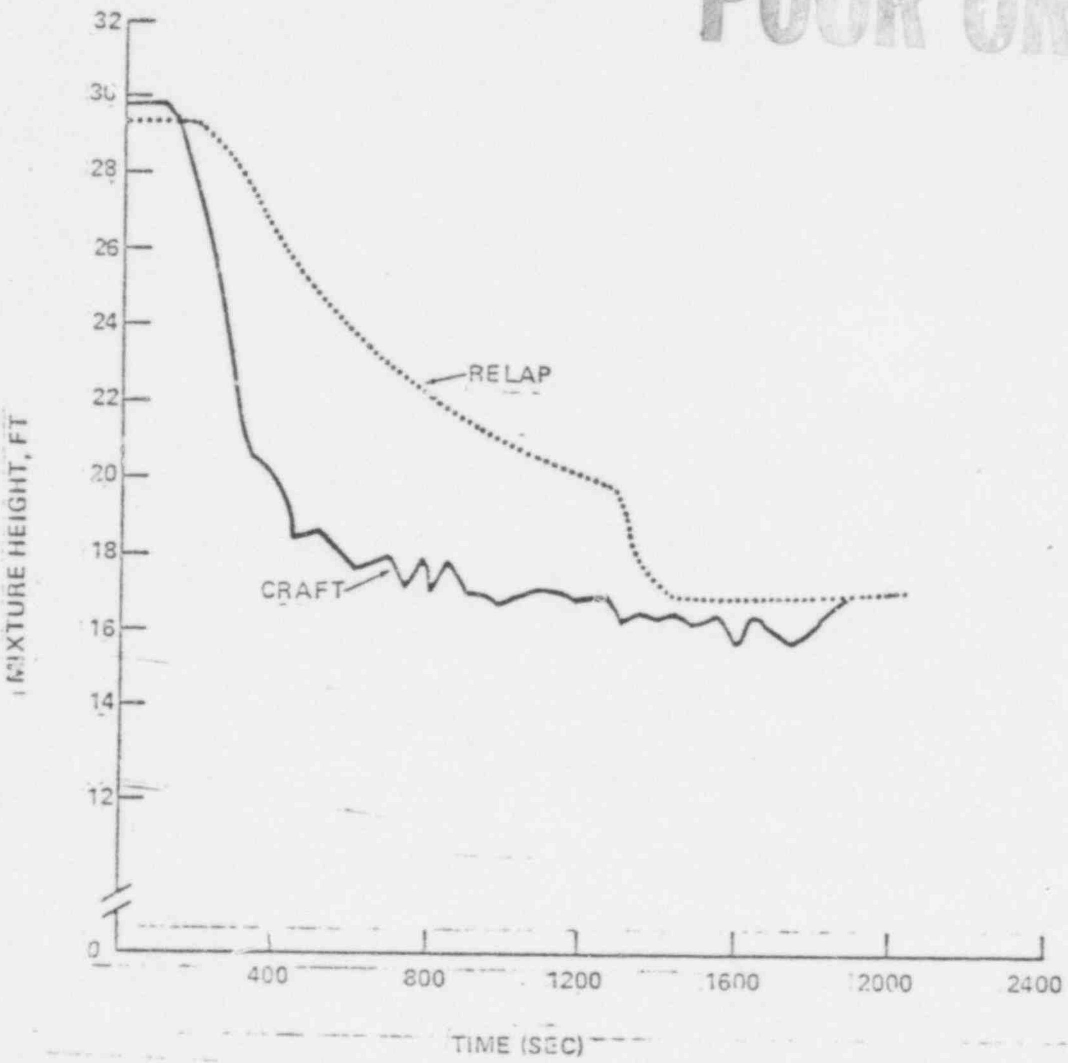
280 024



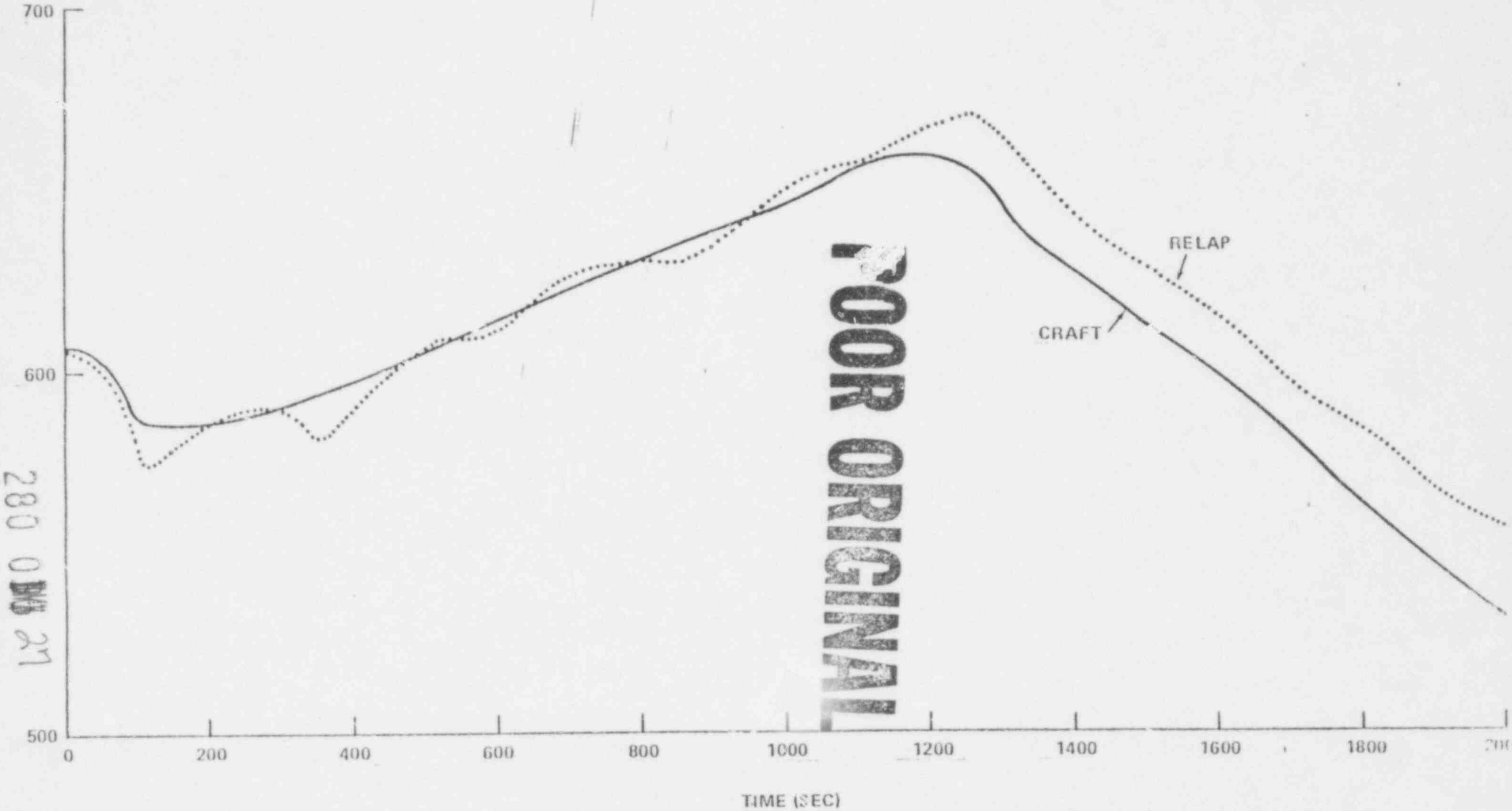
Break Flow Rate Versus Time – 0.01 ft^2 Break at Pump Discharge – Auxiliary Feedwater After 20 minutes.

POOR ORIGINAL

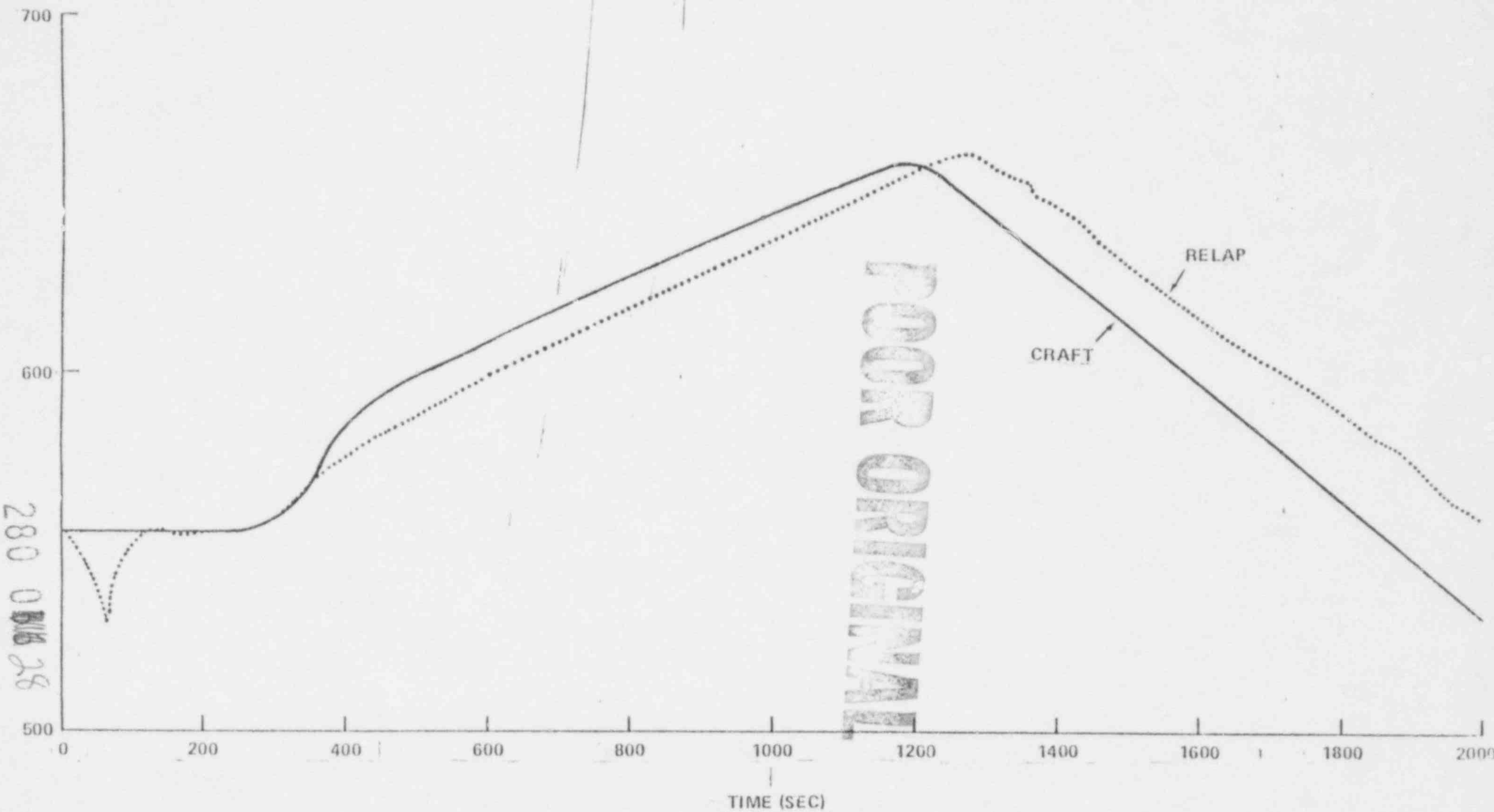
280 025



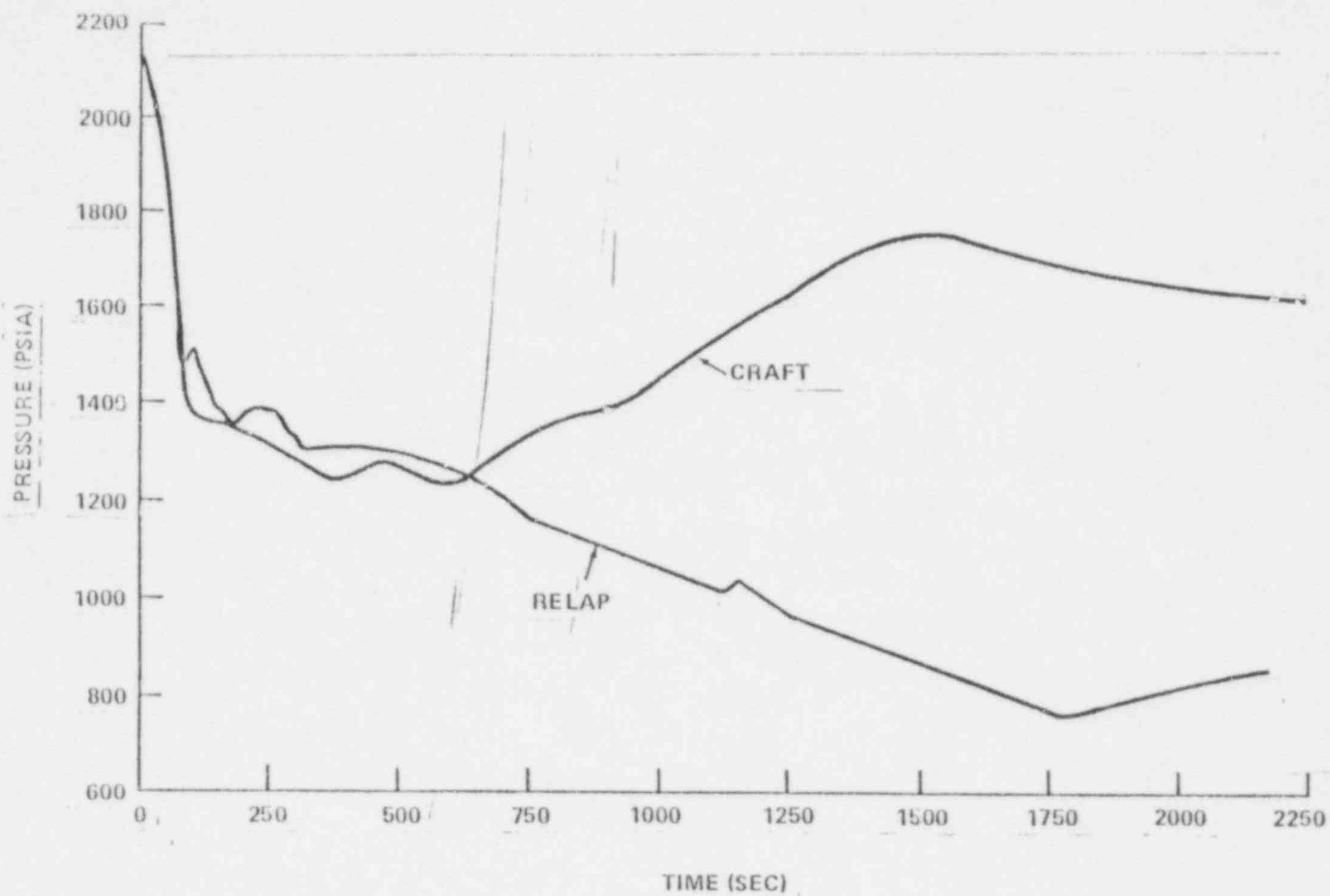
Mixture Height Versus Time — 0.01 ft^2 Break at Pump Discharge — Auxiliary Feedwater After 20 minutes.



Hot Leg Temperature Versus Time – 0.01 ft^2 Break at Pump Discharge – Auxiliary Feedwater After 20 minutes.

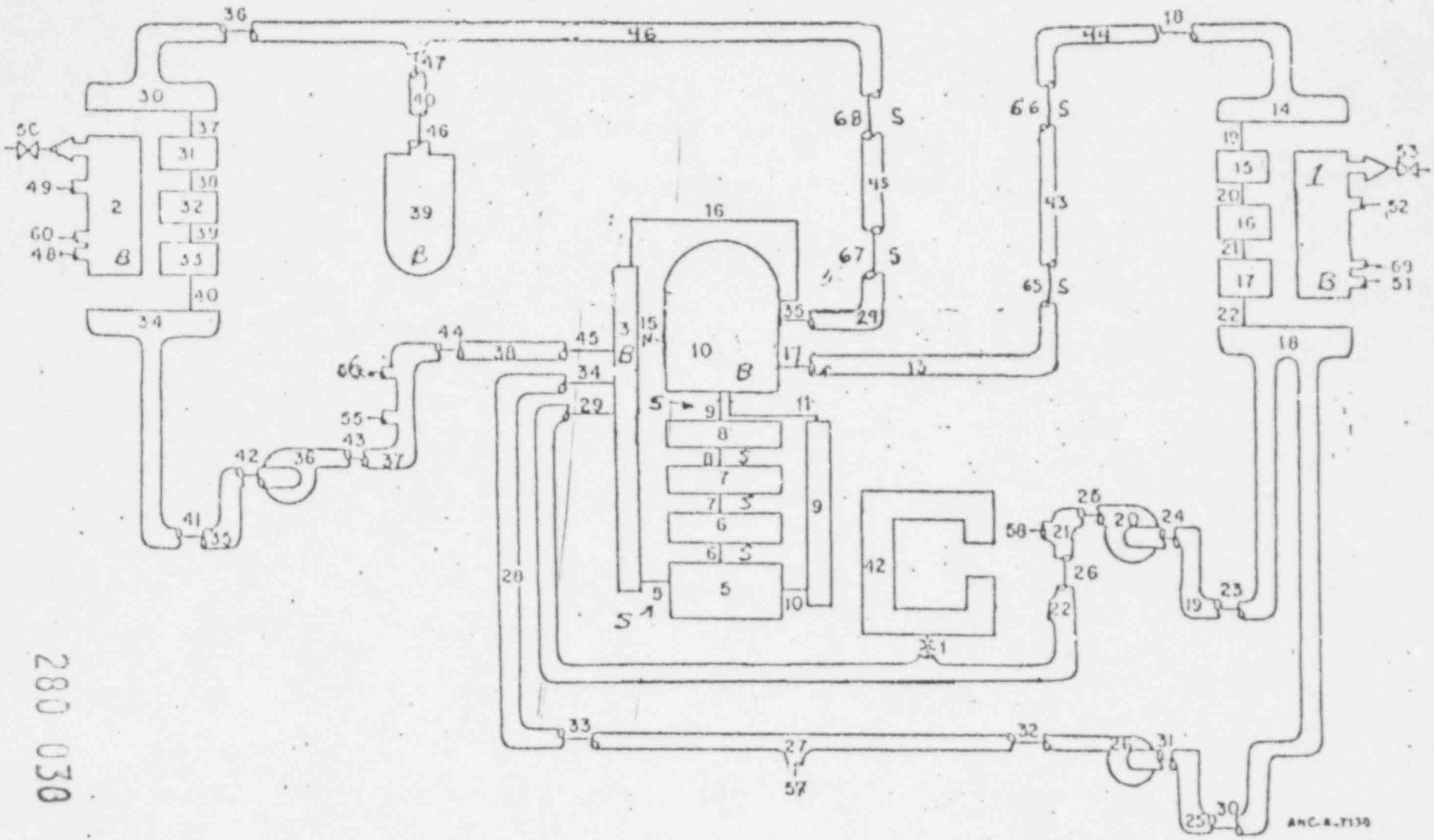


Cold Leg Temperature Versus Time – 0.01 ft^2 Break at Pump Discharge – Auxiliary Feedwater After 20 minutes.



Hot Leg Pressure (Inact Loop) —
0.01 ft^2 Break - No Auxiliary Feedwater Delay.

280 027

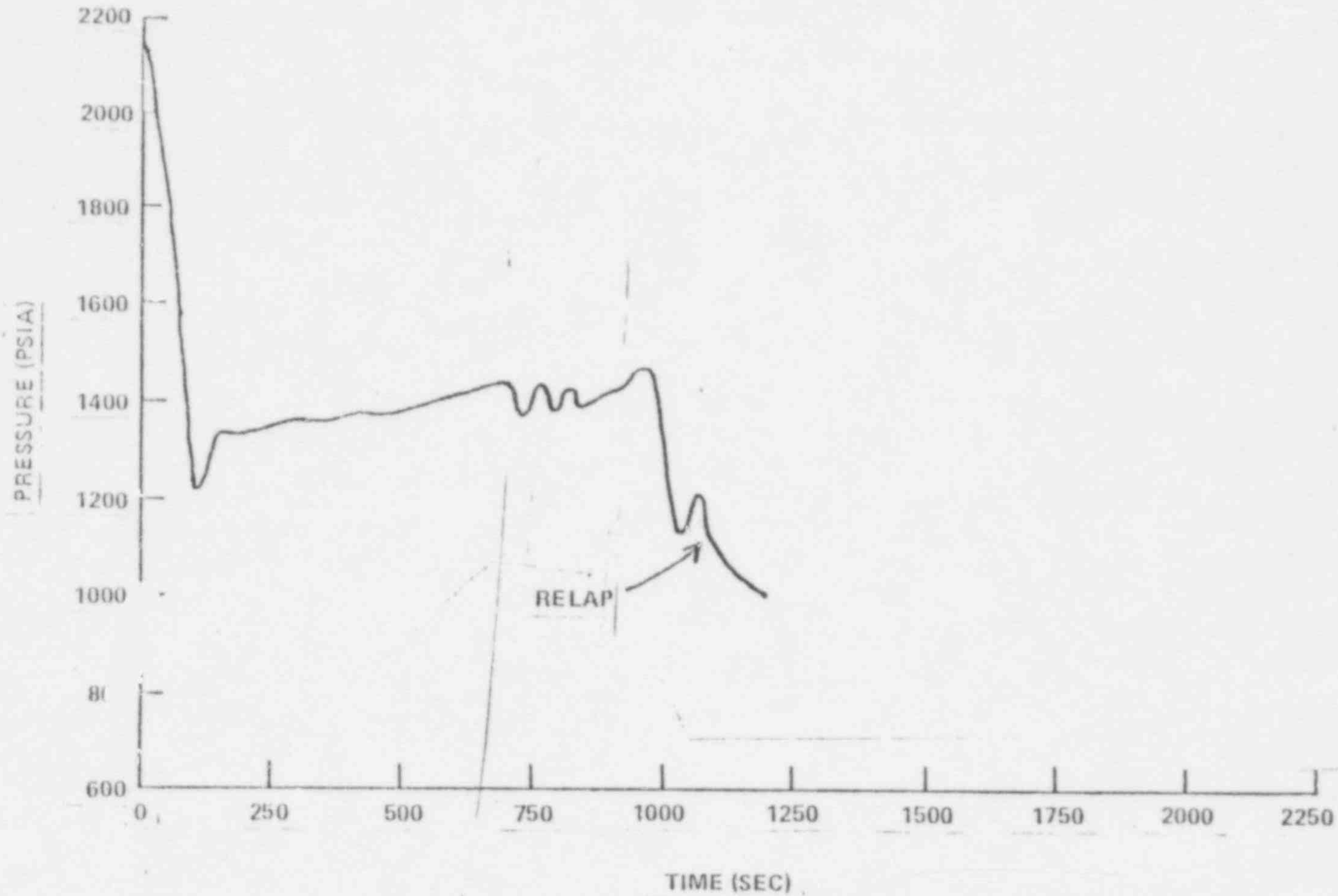


Revised Nodalization diagram for the B&W Oconee reactor.

POOR ORIGINAL

280 030

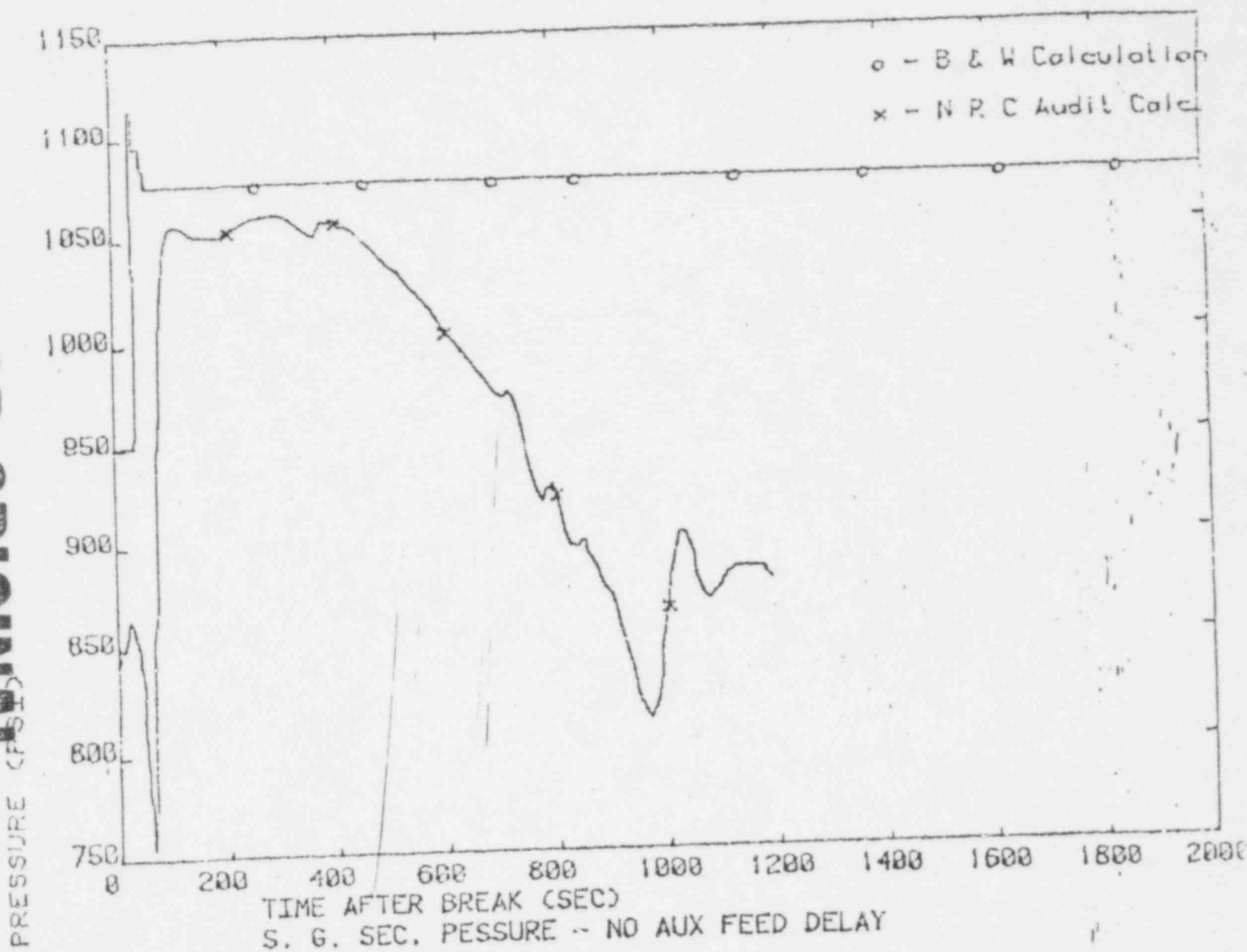
79



Hot Leg Pressure (Inact Loop) —
0.01 ft^2 Break - No Auxiliary Feedwater Delay.

280 031

80



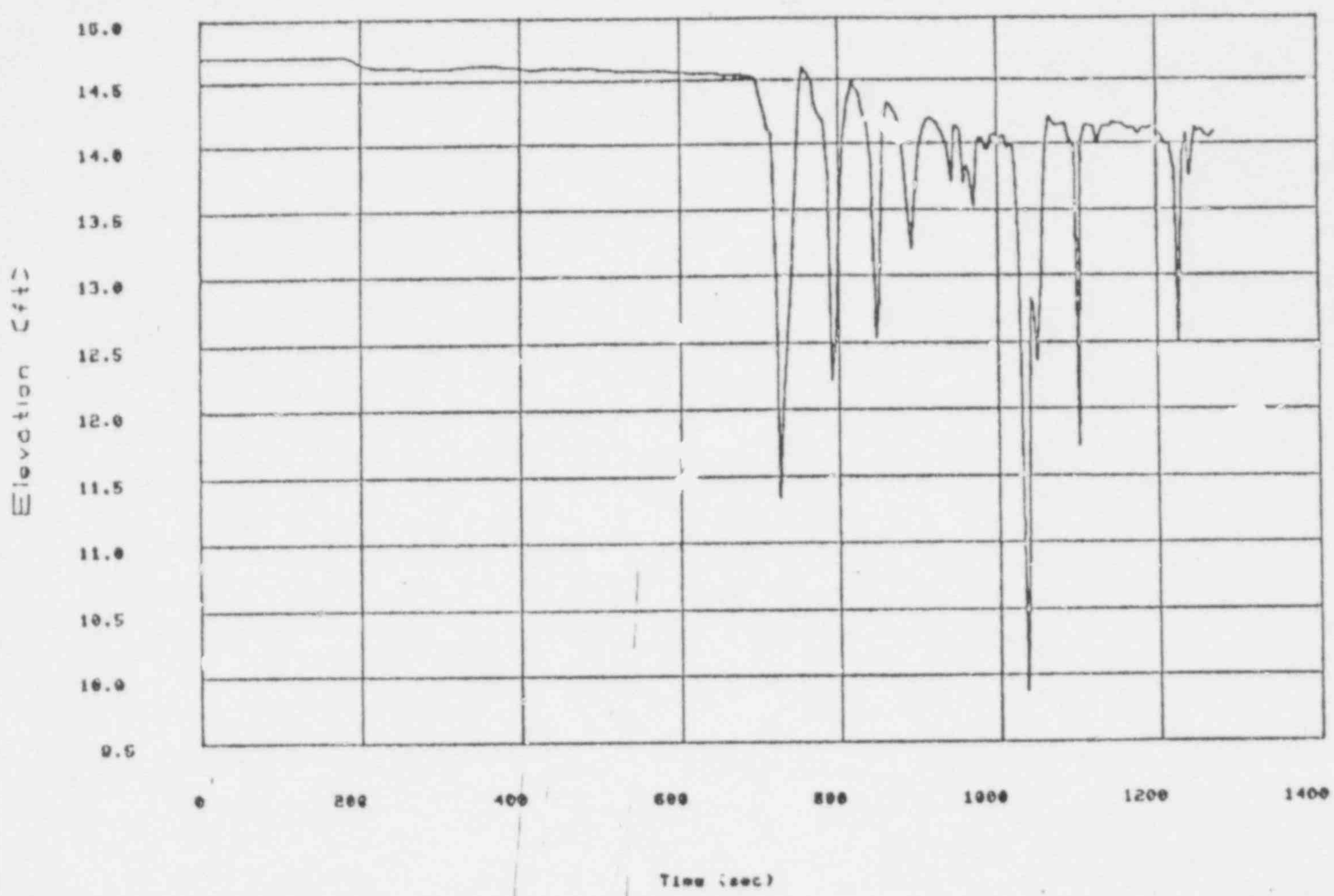
Steam generator secondary side pressure - no auxiliary feedwater delay.

280 032

81.

1 ML44

MIXTURE LEVEL IN B CANDY CANE (VESSEL SIDE)



OCONEE SMALL BREAK

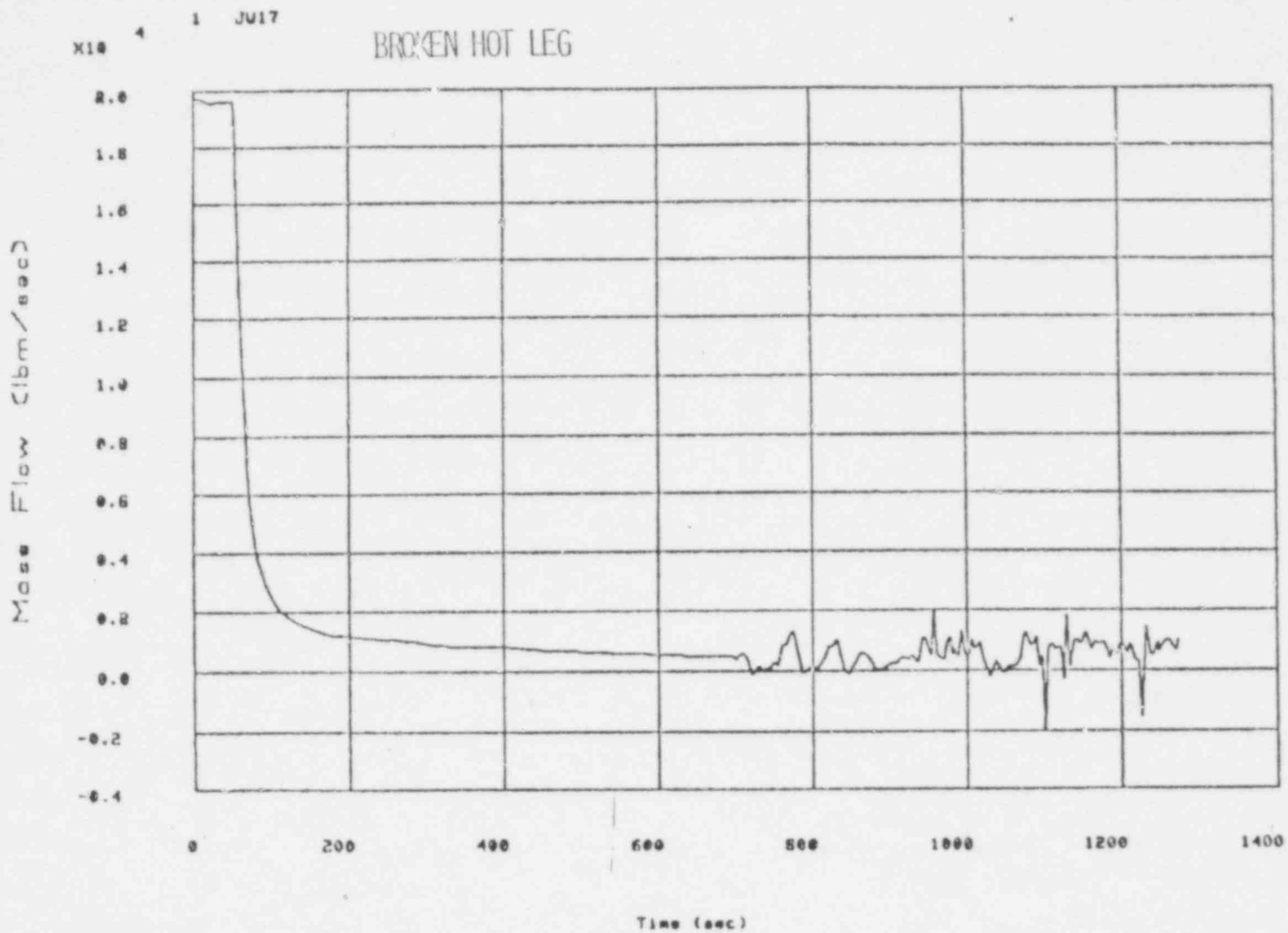
RUN 0, NEW MODALIZATION

NO AUX FEED DELAY

POOR ORIGINAL

280 0[illegible] 33

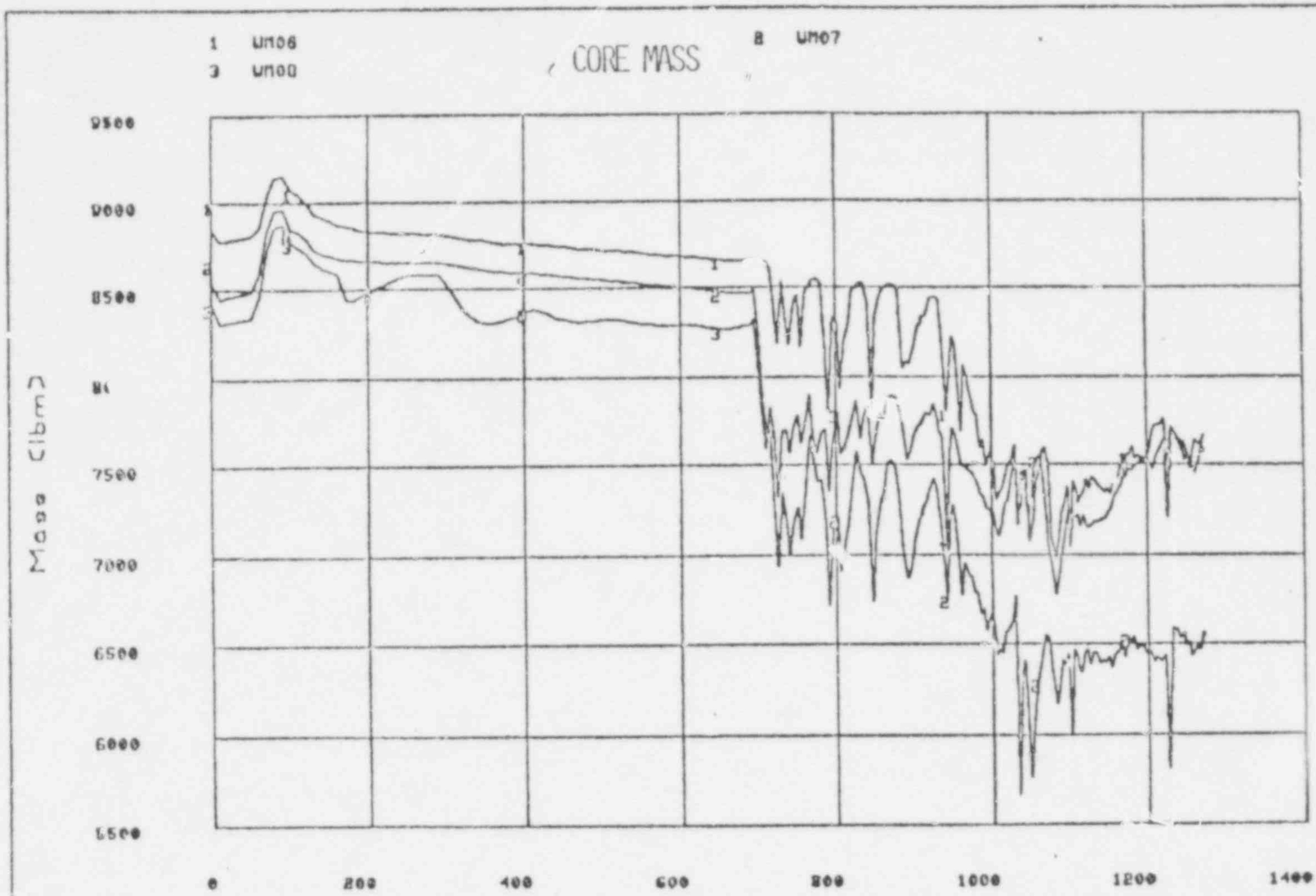
82



OCONEE SMALL BREAK

RUN 0, NEW NODALIZATION

NO AUX FEED DELAY



Time (sec)

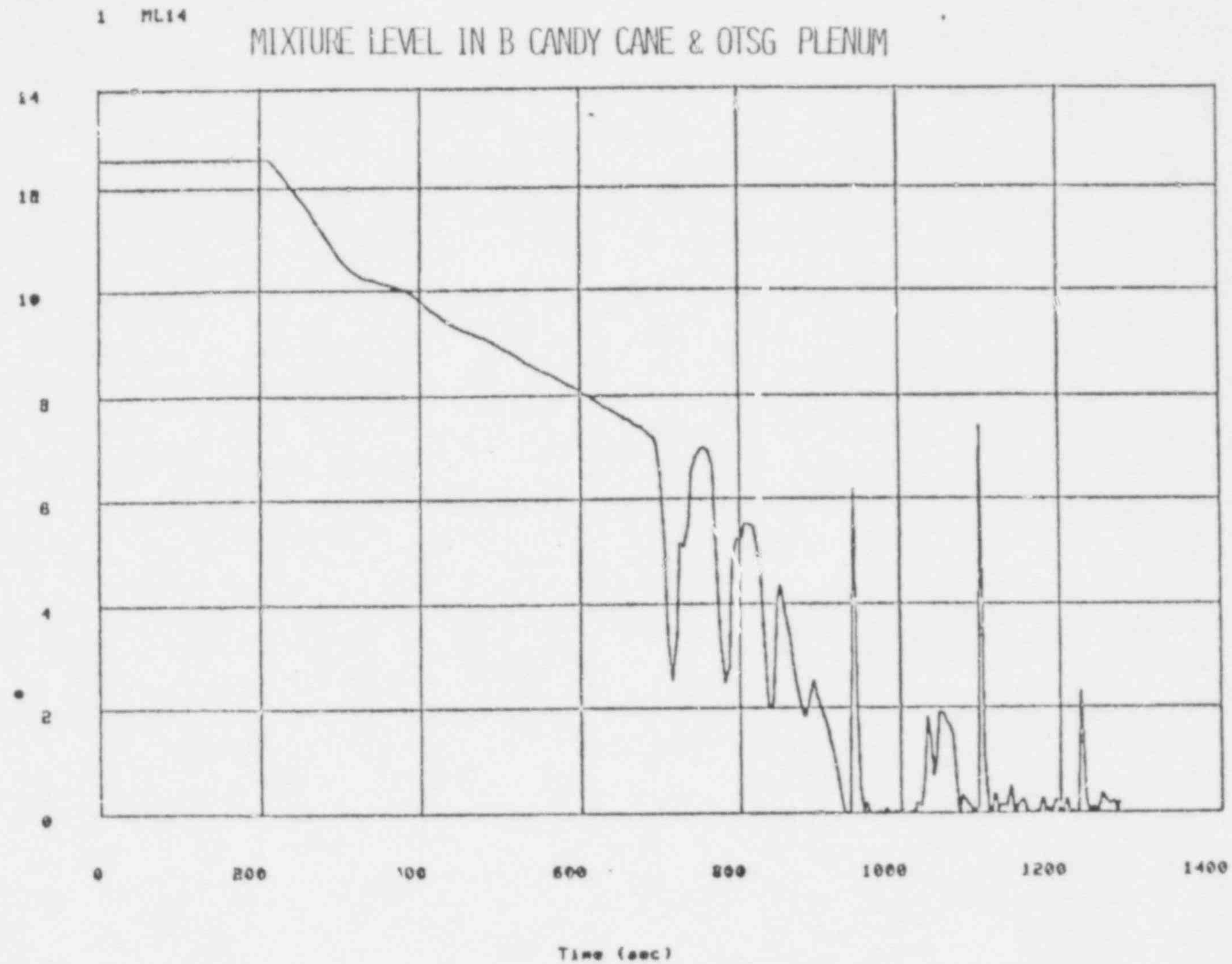
OCONEE SMALL BREAK

RUN 0, NEW NODALIZATION

NO AUX FEED DELAY

POOR ORIGINAL

280 0435



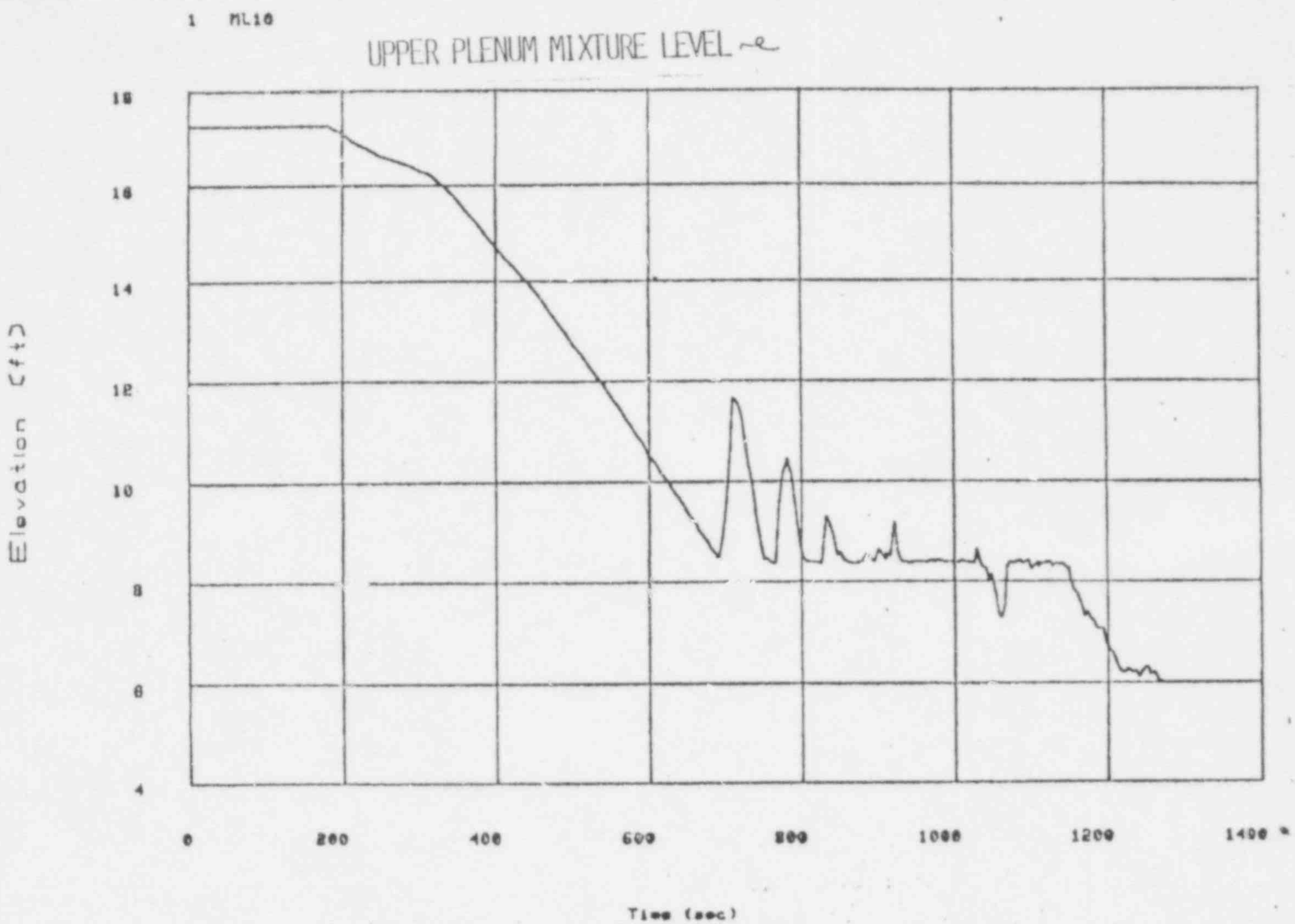
OCONEE SMALL BREAK

RUN 0, NEW NODALIZATION

NO AUX FEED DELAY

280 036

85



OCOMEE SMALL BREAK

RUN 0, NEW NODALIZATION

NO AUX FEED DELAY

280 0?? 371

86

CONCLUSIONS

RELAP4/MOD7 CALCULATION WITH 20 MINUTE AUX. FEED DELAY COMPARED VERY WELL WHEN STANDARD METHODS WERE USED.

NO CORE UNCOVERY WAS SHOWN

280 0[illegible]

38

87

CONCLUSIONS

(NO AUX. FEED DELAY)

RELAP AND CRAFT IN KEY VARIABLES WHEN ANALYSING THIS CASE.

DIFFERENCES MAY BE DUE TO DIFFERENCES IN AUX. FEED CONTROL.

NO CORE UNCOVERY INDICATED.

CASE SHOULD BE STUDIED FURTHER.