ATTACHMENT 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

FEB 17 1983

MEMORANDUM FOR: Chairman Palladino
Commissioner Gilinsky
Commissioner Ahearne
Commissioner Roberts
Commissioner Asselstine

FROM: William J. Dircks
Executive Director for Operations

SUBJECT: REVIEW OF B&W-GPU TRIAL RECORD

During the staff's review of the trial record requested by your memorandum of December 29, 1982, potentially significant information has been identified. This information was discussed by Dr. Lahey and Dr. Wallis and concerns the technical adequacy of small break loss of coolant and natural circulation procedures proposed for use following authorization to restart TMI-1 and may be applicable to other B&W reactors. This information has been referred to NRR for evaluation of the technical aspects of this issue. The evaluation of this issue may put a new or different light upon an issue considered in the current restart proceeding and result in Board notifications in accordance with NRR Office Letter No. 19, Rev. 2.

William J. Dircks
Executive Director
for Operations

cc: OGC
OPE
SECY
H. Denton, NRR
V. Stello, Jr., DEDROGR

While the concerns expressed in References 117 and 118 were addressed to the B&W 205-FA plants and the CE System 80 design, respectively, most concerns have direct applicability to all PWR designs including the B&W 177-FA design.

By letter dated January 23, 1979,[96] B&W responded to the TVA concerns expressed in Reference 117. In the letter, B&W concluded that it had performed sufficient analyses to "ensure the ability of the B&W 205 plant's ECCS system to control small breaks in the RCS." These analyses were documented in BAW-10074A, Revision 1.[49] In April 1979, the staff met with B&W to discuss in detail the concerns expressed in Reference 117. As a result of these meetings, B&W submitted a comprehensive report[62] regarding the response of the 177-FA plant to small break LOCAs. The information contained in Appendix 5 of Reference 62 included information on the concerns expressed in Reference 117.

The staff has reviewed each of the TVA concerns presented in References 117 and 118. We have reviewed the B&W responses to the Reference 117 concerns and we have also examined available information in order to address the concerns presented in Reference 118. Where information was not available to the staff, it was requested from B&W or the B&W licensees. As pointed out later in this section, certain responses to the staff requests have not been received to date. This information is considered to remain outstanding.

A detailed discussion of each of the TVA concerns is provided below.

4.2.2 Intermittent Natural Circulation

4.2.2.1 Background and Analysis Results

This mode of decay heat removal was characterized by TVA as steam bubbles being generated in the core and accumulating at the top of the hot leg U-bend. If sufficient vapor accumulated to fill the U-bend, natural circulation would be lost. The loss of natural circulation and subsequent loss of the steam generator as a heat sink would cause the system to repressurize, provided the break could not remove all of the decay heat. Repressurization would then cause the steam bubble in the hot leg U-bend to condense and natural circulation would be reestablished. This, in turn, would lower the pressure and the steam bubble would form again.

According to TVA, a steam bubble would also accumulate in the upper part of the reactor vessel. This bubble would not completely condense during repressurization and would become larger during each natural circulation/repressurization cycle due to the net decrease in mass flow through the break. The ability to alternately stop and subsequently reestablish natural circulation as described by TVA was questioned as an unstable mode of operation. With regard to the growth of the bubble in the vessel head, B&W stated that "because of the internal vent valves, no extensive steam bubble will form within the reactor vessel while any significant liquid inventory remains in the loop."[96]

The staff agrees that liquid levels around the system would be in equilibrium with the vessel level before the vessel level would drop below the hot leg piping and into the active core region. The pressure in the vessel dome, necessary to sustain a significantly higher head of liquid in the steam generators, would be sufficient to open the vent valves and allow equalization.

B&W also stated in Reference 96 that intermittent natural circulation as described in the TVA report would not occur "due to the slow nature of the small break transient." Specifically, B&W stated that once natural circulation was lost, some repressurization would occur, but only until the liquid level on the primary side of the steam generators dropped below the liquid level of the secondary side. Once this occurred, decay heat removal through the steam generators would begin and the system would then depressurize. The basic question is whether the steam generator primary liquid level would drop fast enough from the discharge flow to establish decay heat removal by condensation heat transfer before repressurization condensed the steam bubble in the top of the hot legs and refilled the steam generators.

In Section 6.2.5 of Reference 62, B&W presented analyses of three small break events that showed repressurization. These were 0.01 ft^2 and 0 005 ft^2 breaks in a 177-FA lowered loop plant and a 0.01 ft^2 break in a 177-FA raised loop plant. These analyses were performed with the CRAFT2 code for simulations out to 3000 seconds.

The analyses for the lowered loop design showed that for the 0.01 ft^2 and the 0.005 ft^2 breaks, no cyclic repressurization occurred. Liquid natural circulation continued until enough mass was lost from the system through the break to cause the hot leg U-bend to start draining. Once the hot leg U-bend commenced draining, liquid natural circulation stopped. Eventually, enough mass was lost from the system to expose a condensing surface in the steam generators, causing decay heat removal to be reestablished via two-phase natural circulation. The analysis for the raised loop plant showed that for the 0.01 ft^2 break, cyclic repressurization did occur, as predicted by Michelson. However, the peak pressure reached was significantly less on each successive cycle and died out completely after three cycles. Once the cyclic repressurization phenomenon ceased, two-phase natural circulation commenced. For both the raised and lowered loop designs, the core remained covered throughout the entire period of these transients, thus assuring acceptable peak cladding temperatures.

A significant factor in the establishment of some mode of natural circulation (i.e., all liquid or two-phase) is that a steam-condensing surface must exist in the steam generators before the core could begin to uncover. For raised loop plants, this occurs from relative elevation differences. For lowered loop plants, this occurs because the AFW enters the steam generator from the top. For all B&W lowered loop plants, the small break emergency procedures require that the levels in the secondary side of the steam generators be raised to 95% on the operating range level indicators if the RCPs are not running. Auxiliary feedwater is automatically fed to the steam generators when the level reaches the low level limits (~30 inches on the startup range indication) if the RCPs are running. Analyses by B&W show that auxiliary feedwater will be initiated before the vessel water level drops below the top of the core.

4.2.2.2 Relationship of Concern to Events at TMI-2

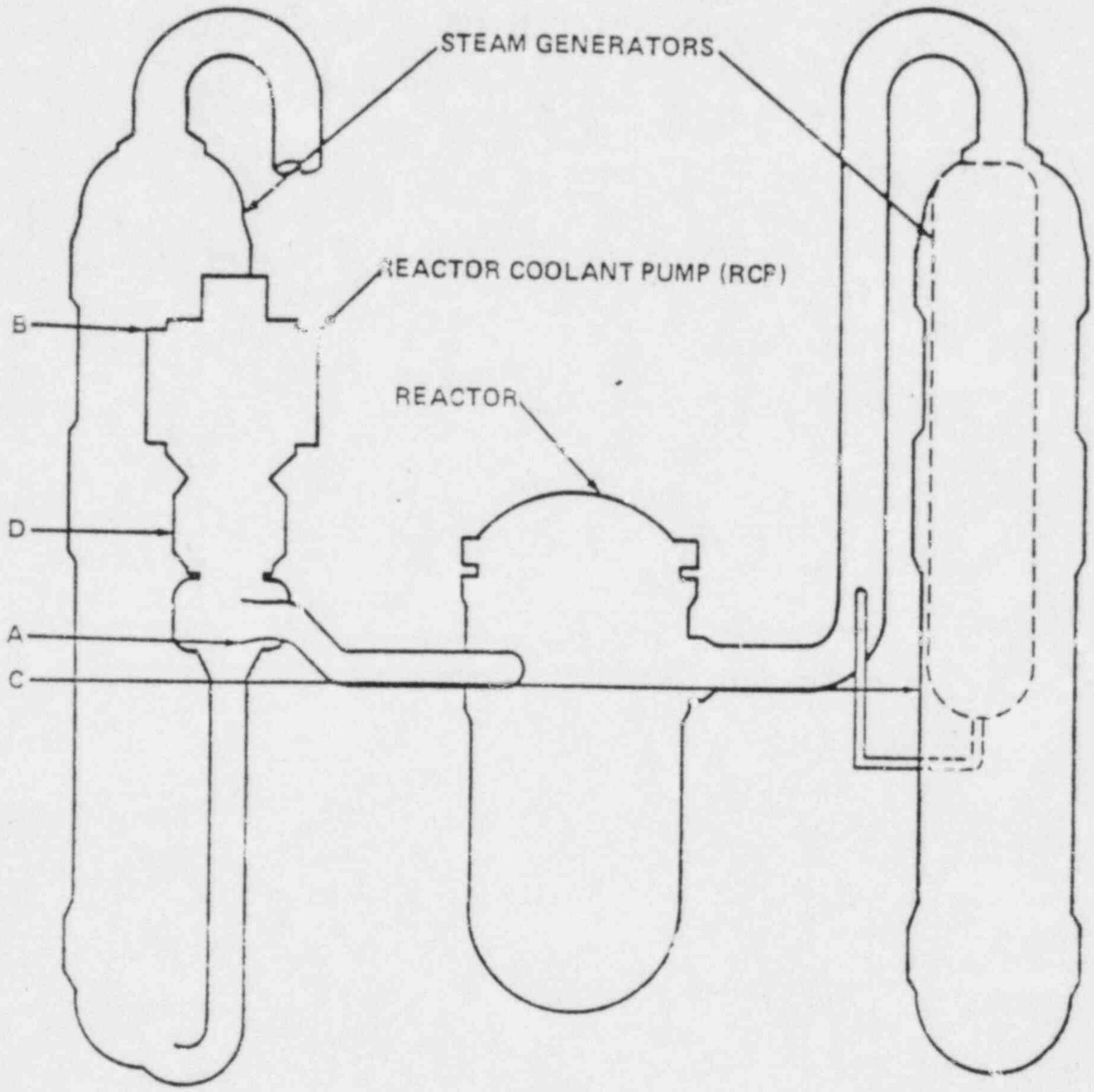
During the course of the accident at TMI-2, the operators tripped the last operating RCP 101 minutes into the accident. Immediately after the RCPs were stopped, reactor coolant temperatures in the hot leg piping were observed to rapidly increase. It was during this period that the majority of the damage to the reactor core was postulated to occur. Because of this occurrence, concern was raised as to why natural circulation was not established after the RCPs were tripped.

Based on examination of the component elevations in the plant, the steam generator secondary level setpoints, and the estimated primary system inventory, it is believed that the inability to achieve natural circulation flow can be qualitatively explained.

During the initial phase of the accident when the RCPs were operating, the primary system evolved to a high system void fraction due to the continuous loss of inventory through the stuck-open PORV and the limited make-up due to manual throttling of the HPI flow. Despite the high system voids, operation of the RCPs circulated the steam and water as a two-phase saturated mixture throughout the system and provided ample cooling of the fuel rods.

When the RCPs were tripped, the steam and liquid phases separated, with the liquid falling to the lower elevations of the primary system. For the TMI-2 plant, this is the bottom of the steam generators, the RCP suction piping, and the bottom of the reactor vessel, as can be seen on Figure 4-12. Also shown on Figure 4-12 is the elevation (elevation C) of the automatic feedwater control level setpoint, which was set to control level at 50 percent of the operating range when the RCPs were tripped. Since the TMI-2 accident, B&W has recommended that this level setpoint be increased to 95 percent of the operating range whenever the RCPs are tripped.

After the RCP trip, it is postulated that liquid existed in the bottom of the reactor vessel, the bottom of the steam generators and the RCP suction piping. Steam existed in the hot leg piping; upper portions of the core, the reactor vessel, and the steam generators, and also in the RCP and the RCP discharge piping. In order to initiate natural circulation, the liquid level in the RCP suction piping would have to increase such that liquid could flow through the RCP, into the discharge piping and into the reactor vessel downcomer. In order to raise the liquid level in the RCP suction piping, the liquid level in the steam generator tubes must be raised to an elevation above that of the bottom of the RCP discharge nozzle. This, in turn, can only be accomplished by establishing a condensing surface in the steam generators above this elevation



ELEVATION A – BOTTOM OF RCP DISCHARGE NOZZLE
ELEVATION B – APPROXIMATE ELEVATION OF AFW SPARGER
ELEVATION C – 50% OF OPERATING RANGE
ELEVATION D – 95% OF OPERATING RANGE

FIGURE 4-12 REACTOR COOLANT SYSTEM ARRANGEMENT FOR THREE MILE ISLAND UNIT 2 (SELECTED ELEVATIONS) (elevation A in Figure 4-12). Feedwater enters the steam generators through a sparger at elevation B (see Figure 4-12), and would normally produce a condensing surface well above that needed to force the water in the RCP suction piping up through the RCP and into the discharge piping; however, feedwater will only be supplied if it is replenishing liquid lost through boiling. Without the initial flow of liquid out of the steam generators and into the reactor vessel, the stagnant primary coolant in the lower portion of the steam generator tubes will eventually reach equilibrium with the secondary water which will be held at the 50 percent level on the operating range (elevation C in Figure 4-12). When the heat transfer stopped, so did the boiling of the secondary water. This, in turn, stopped the feedwater demand, and the condensing surface due to sparger spray above the RCP discharge nozzle was lost. The only condensing surface left was the secondary water level, and it was below the elevation necessary to allow water to flow through the RCP and into the reactor vessel. Thus, liquid could not flow from the steam generators to the vessel, and the steam produced in the core could not condense in the steam generators.

4.2.2.3 Corrective Action By The B&W Licensees

Subsequent to the accident at TMI-2, B&W has included in its operating guidelines for small breaks the requirement for the operators at the lowered loop plants to manually raise the steam generator secondary water level to 95 percent on the operating range in the event that the RCPs are tripped. This is shown as elevation D in Figure 4.12.

This level assures that a steam condensing surface will exist at elevations above the bottom of the RCP discharge nozzle. Therefore, a sufficient static head of water will be available to establish natural circulation flow.

This action alone, however, would not have prevented the fuel damage from occurring at TMI-2. Even though establishing two-phase natural circulation would have produced a heat removal path by steam flow in the core, this would have, in all likelihood, been insufficient to adequately cool the core, primarily because of inadequate liquid inventory in the reactor coolant system.

Due to the uniqueness of the B&W raised loop design, the inadequacies described in Section 4.2.2.2 and the corrective action discussed in the section are not applicable to the raised loop design.

4.2.2.4 Conclusions

The potential for disrupting natural circulation during a small break LOCA via the cyclic repressurization phenomenon described by Michelson has been analyzed and evaluated by B&W. For the raised loop design, this phenomenon was shown to exist temporarily but died out after three cycles. The disruption in natural circulation did not lead to uncovering of the core and peak cladding temperatures remained acceptable. For the lowered loop design, the cyclic repressurization phenomenon was not exibited.

4.2.2.5 Recommendations

a. The various modes of two-phase natural circulation, which are expected to play a significant role in plant response following a small break LOCA, should be demonstrated experimentally. In addition, the staff requires that the licensees provide verification of their analysis models to predict two-phase natural circulation by comparison of the analytical model results to appropriate integral systems tests.

b. Appropriate means, including additional instrumentation, if necessary, should be provided in the control room to facilitate checking whether natural circulation has been established.

4.2.3 Time Delay Associated with Transitioning Between Modes of Natural Circulation

4.2.3.1 Discussion

TVA expressed concern that once liquid natural circulation was lost, the time required for the primary side steam generator level to drop level the secondary side level (exposing a condensing surface and thus commencing two-phase natural circulation) might be of sufficient length to allow the reactor coolant system to repressurize (with a subsequent increase in flow rate through the break) to you understand, that if HPI was left on because they didn't have both pressurizer level and RCS pressure above the safety injection actuation set point, that you would have had the Michelson result, is that what you are telling me, and that that would have uncovered the core anyway?

MR. KLINGSBERG: No.

THE COURT: What are you telling me, then? I am not with you.

MR. KLINGSBERG: I am telling your Honor that B & W knew in February 1978 or at least Mr. Dunn knew and the people who got his memo and understood it knew and the people who got the Michelson report knew that there are very small breaks where under circumsta ces if you followed that rule you would have a disaster. That is why that rule is no good.

THE COURT: If you follow this rule.

MR. KLINGSBERG: That's right.

THE COURT: That's what I said to you just now.

MR. FISKE: No. Your Honor, I think I can be helpful here, very briefly. First of all, two different points --

MR. KLINGSBERG: I also think, your Honor --

MR. FISKE: It is important that we get this straightened out.

MR. KLINGSBERG: I think we ought to get this from the witness and that will clear it all up.

MR. FISKE: I think it is important before you listen to any other testimony that you understand what our position is, because I am perfectly willing to let Mr. Klingsberg explain this further if he wants to.

First of all, Mr. Klingsberg is mischaracterizing what the existing procedure says. This section which your Honor has in front of you, this caution section, says if you can't maintain level and pressure above their actuation points, then that means --

THE COURT: That means you suffered a major interruption.

(Continued on next page.)

MR. FISKE: Right.

Then you go to part B and part B says leave it on and leave it on until you get to the point where the low pressure injection comes on. So that there is no provision for terminating it at all in part B except to the point where you would have to make certain adjustments to keep the pumps from vibrating or running out or whatever. But the testimony, I think, is pretty well undisputed that once you are under part B, that says leave the HPI on until you get down to where low pressure comes on.

THE COURT: Mr. Fiske, if I have --

MR. FISKE: This is the second part of my point, your Honor. This is where I think your Honor is confused.

Everything they told you this morning about this so-called Michelson scenario, we believe, has no application to a break size the size of the pilot-operated relief valve, the so-called .007 break size that this concept of match-up or turn around or the idea that more water will go out the break than comes in from the HPI. That doesn't apply to a break size the size of the PORV and this idea that you get so much back pressure that somehow the high pressure injection system doesn't function, we don't believe that applies to a break size in the PORV.

That was the original point of my objection. It is a double, two-pronged objection.

First of all, that this whole discussion has nothing to do with a break size the size of a PORV. Michelson didn't make any calculations that showed that and, in fact, it doesn't apply.

Secondly, Mr. Klingsberg in putting the question as he did to Professor Lahey has mischaracterized what the B & W existing procedure was anyway. It doesn't say turn off HPI when the pressure gets above 1640. It says if with HPI on you can't keep the pressure above 1640 then you have got a major rupture and go to part B. Then once you are in part B, it says leave it on.

THE COURT: Well, I think the bottom line of what you are arguing to me is you are saying there is no foundation for showing that this is applicable to a break size of the PORV?

MR. FISKE: That's part of it.

MR. KLINGSBERG: It's got nothing to do with my question. This question goes to the Dunn memo. It is talking about the Davis-Besse accident.

If your Honor will hear my question, it was based on the Dunn memo which was talking about the Davis-Besse accident. So how can you say it has nothing to do with the stuck PORV.

THE COURT: I will take this testimony and I'll leave to you to strike it and when you move to strike it

I'll consider it at that point.

Let me ask the witness, you have heard all of this dialogue we uninitiates have been having here.

What about Mr. Fiske's position that this doesn't apply to a 007, a James Bond size hole?

THE WITNESS: I'm not sure why he feels that way. I would be more than happy to have him ask me questions about that on cross-examination.

THE COURT: I am asking you right now.

MR. FISKE: My point was with two trains of high pressure injection, which they had on the day of the accident.

THE WITNESS: Absolutely.

THE COURT: Tell me why?

THE WITNESS: Because in those kind of events where you have breaks of that size you do, in fact, depressurize for the initial period of time. You will lose your natural circulation. Once the pumps are off, you repressurize.

THE COURT: But in our case we had the pumps on. That's what Mr. Fiske was saying. We had the pumps on and we had both HPIs going and he is saying, why is this comparable in any way to the Michelson scenario. Isn't that your position?

MR. FISKE: Yes.

THE WITNESS: It did repressurize once the pumps were turned off after 100 minutes into the accident.

The only reason it didn't repressurize sooner was because the pumps were left on. If they turned the pumps off at any point in time once they had the high void fractions they were generating, the natural circulation would have been lost, you would have repressurized the system and, as I understand the point of the question that I was originally asked, had they followed their existing procedures, they would have seen high pressure, high level in the pressurizer and they would have certainly terminated the HPI.

MR. FISKE: I object to that, your Honor.

THE WITNESS: It indicates there is some inadequacy.

MR. FISKE: I don't believe Mr. Lahey is here to talk about the procedures and if we talk about them we will have to take up the heatup/cooldown curves which are the universal truths of the complete application.

THE WITNESS: I was talking about the perfect procedures.

THE COURT: This is in the nature of opinion evidence and I'll let you cross-examine on it.

MR. FISKE: One last point.

I don't understand that Professor Lahey is here as an expert witness on operating procedures. I thought he was here as an expert witness on the system design, none of which we have objected to, but nobody has qualified Professor Lahey and I never understood he was going to be qualified to testify as to what is proper operating procedures. That opens up a whole new area here which I thought --

THE COURT: I thought so too. I'll strike out any reference he has made so far as to operating procedures one way or another. That's stricken.

MR. KLINGSBERG: There are certain fundamental things which, without getting into details --

THE COURT: I am going to overrule the objection and take this testimony subject to a motion to strike.

Q. Dr. Lahey, do you have an opinion as an expert on nuclear reactor safety as to whether in light of Dunn's comments in paragraph one of Exhibit 78 a prescription for operation and management of the high pressure injection system based on pressure and pressurizer level would be adequate to deal with small break LOCAs from the point of view of nuclear safety and keeping the core covered?

A. No, it is obviously inadequate. Those two parameters alone wouldn't allow you to properly manage HPI or the HPI system. This was clear to Mr. Dunn and it was clear to Mr. Michelson. Other parameters --

MR. FISKE: Objection.

THE COURT: Strike it out after the first sentence. Put another question.

MR. FISKE: Mr. Lahey really isn't here to sum up the case.

THE COURT: I understand that part of it.

Q. Would you explain your conclusion from a technical point of view?

A. Well, we have scenarios that I have shown your Honor on the board in which the level can be high and the pressure can be high. I will show you other ones later on this afternoon. So there is obviously cases in which those two parameters are not sufficient.

The key parameter you are interested in for these small break LOCAs is the mass inventory in the system and if you have a direct measure of the amount of mass in the system, such as are commercially available today, then that's an obvious choice. If you have none, then another possibility would be to insure you never get into a situation where you have boiling in the system and therefore it could get into this kind of phenomena, such as a subcooling rule as Mr. Dunn has put forth.

Q. Would you refer, please, to your figure 5 which is Exhibit 3120.

A. Should I put it back up?

Q. Yes.

You have there pressure between 1600 and 2295 PSIG?

A. Yes. It is above the set point of the HPI SFAS actuation and you have your level high in the pressurizer.

Q. What is your view as to what would happen if high pressure injection at that point in that scenario was turned off altogether because the pressurizer level was high and the pressure was above the set point for HPI?

A. At this point in time the only in-flow you have going into the system is the high pressure injection. You have a discharge from the system through the break, whether it is here or in the pressurizer.

The consequences of terminating that high pressure injection is just the hastening of the uncovery of the core, because then all you would have is a discharge from the system in which case the level would drop and no compensating in-flow to the system.

Q. What conclusions, if any, do you draw from your review of the Michelson Report as to whether high pressure by itself or combined with high pressurizer level is an adequate indicator of a safe core condition?

A. I think it is inadequate for sure. Here is a clear example. There are others that you can call upon.

Q. Could you explain to the court, please, why this is a clear example?

A. Because in this situation I have shown here you have a high pressurizer level, you have a high pressure, you have a situation in which you are losing mass inventory from the system and the core is in the process of uncovering. So if you monitor these variables and make any decisions about HPI solely on those variables, you can get yourself in deep trouble.

Q. When you say deep trouble, you mean you can uncover the core?

A. You can uncover and damage the core.

Q. Now, I would like you to turn to page 26, Section 4.6 of the Michelson Report --

A. Page 26?

Q. Yes, sir, the little numbers up at the top.

A. Any particular section?

Q. Yes.

First of all, up at the top in the second paragraph it says: "Full pressurizer may convince the operator to trip the HPI pump and watch for subsequent loss of level."

Then later on, 4.6 as "Pressurizer level indication. The modes of decay heat removal discussed in Section 3.0 point out that pressurizer level is not a correct indicator of water level over the reactor core.

During the natural circulation phase water can be draining from the reactor vessel top plenum while pressurizer level is slowly increasing. If the break is at the top of the pressurizer steam space, a rapid pressurizer refilling can occur. During the transition to boiling and during the transition to pool boiling and while in pool boiling the level should stabilize even though the core may be uncovered. Therefore pressurizer level is not considered a reliable guide as to core cooling conditions. No other primary side level indication as provided there is a full range level indicator on the second side of each steam generator."

Now, could you please explain that paragraph to the court, please, from a technical point of view?

A. The second one that you read?

Q. Yes.

A. Well, this is for a break, a small break in the top of the pressurizer rather than the one I showed up there. The concern is very similar.

In this case the level will go up in the pressurizer and you can have a repressurization once you lose the natural circulation capability, once you have steam in the upper candy cane as shown in the diagram on the easel.

If Mr. Michelson is concerned that if the operators used pressurizer level as the indicator of how to manage HPI, that you can uncover your core, damage your core.

Q. How, if at all, does the concern expressed in this paragraph by Michelson relate to the concern expressed by Mr. Dunn in Exhibit 78?

THE COURT: Can I just -- you'll have to forgive me, professor, for asking these questions, but you are saying to me, as everybody I think has been saying to me all along, if the Dunn instructions had been known to the operators and followed, we would have had no core uncovery in this case, is that correct?

THE WITNESS: Yes, because you wouldn't have gotten into these situations that we are discussing now.

THE COURT: All right. I don't understand how these situations we are discussing now have any relevance to our case, because either the Dunn instructions were there and were followed and we had no problem or you are dealing with a situation where your pressure, until they closed the block valve, was always below the HPI actuation point and yet it was turned off.

THE WITNESS: In the real accident?

THE COURT: In the real accident.

THE WITNESS: Yes.

THE COURT: So what has this got to do with our case?

THE WITNESS: Well, we're going to show you a situation later on in my testimony in which if things were done differently, following the instructions precisely, that you would still get yourself in trouble.

THE COURT: Following Dunn?

THE WITNESS: No. Following the existing training and procedures.

The point of it is, the existing training and procedures, as I understand them, are inadequate for small break LOCAs. They were never formulated for small breaks. They were always formulated for big breaks.

THE COURT: I see, according to what you are telling me, where I went wrong. That is because you used the second half of the first paragraph of Exhibit 78 as a take off point for your answers and I assume, therefore, you were following from the Dunn situation and, as a matter of fact, you are not really following from the Dunn situation. You are just saying he recognized certain principles.

THE WITNESS: He recognized the same concern of this repressurization.

THE COURT: That's what you are telling me.

THE WITNESS: Yes, sir.

THE COURT: You are saying that given what the

LOCA procedure was at TMI-2 in March of 1979, that if that had been followed, you would have had the condition you have been describing in these exhibits that end up in the 3121 series, is that what you are saying? That's this group up there, right?

THE WITNESS: You could have had -- it would be lower steam generators for the 177 plant, but you could have had at least as bad, in fact, worse because of the characteristics of the lowered steam generators.

THE COURT: I am beginning to follow what you are telling me.

In any event, let's go ahead.

Q. Now, on the following page, page 27, Michelson goes on to say: "Similar problem with the pressurizer level indication is found in Section 4.5 relative to HPI pump trip. A full pressurizer may convince the operator to trip the HPI pump and watch for a subsequent loss of level. Although this response appears desirable, a full pressurizer level may not always be a good indication of high water level in the reactor coolant system."

Now, could you explain what your understanding is technically of that statement?

A. Well, my understanding is that he was concerned that -- this is a section that we have for pressurizer level indication. He was concerned that the high pressurizer level may convince the operators to take out the HPI pump, as he states, and the consequences of this are what I have discussed before, once you eliminate your in-flow of mass to the system and all you have is flow going out your break, then you are going to deplete the mass in the system and you risk uncovering the core and damaging the core.

Q. And Exhibit 5 is one example, is it, where you have the high pressurizer level?

A. That's one example, yes.

Q. Now, in your opinion, Dr. Lahey, does the Michelson Report provide any lessons concerning the role of the steam generators in mitigating small break loss of coolant accident?

A. Yes. As I have tried to --

THE COURT: Let me have the question read back, please.

(Reported read)

A. Yes. That was a very important lesson of this particular document. It clearly showed that the steam generators were extremely important for small breaks. In the large breaks there is a large amount of energy going out the break and it can accommodate the energy that's being input by the core from decay heat. Therefore, the system will not pressurize.

In the small break, there is not as much -- not nearly as much energy flowing out with the fluid in the break and if you do not have a significant amount of energy being extracted from the steam generators, you may well repressurize the system and get into the case where you can no longer put as much HPI flow in as is going out the break. So for these very small breaks, smaller than had been analyzed and reported at this point in time by B & W, you can get yourself into this problem with more flow going out than you are putting in by HPI because of the higher pressure.

Q. Now, Dr. Lahey, the question has been raised and I will ask you specifically as to whether the lessons which you've discussed from the Michelson Report in the context of the 205 plant are applicable to a 177 FA lowered loop plant such as Three Mile Island Number 2 and I would like you, if you will, to dig out one of your diagrams on the sequence of events in the Three Mile Island accident and describe for the court, if you will, whether there is any difference in what you have been discussing when you talk about it in the context of a 177 plant?

MR. FISKE: Your Honor, I don't want Professor Lahey to lose the question and I'm not really objecting to what Mr. Klingsberg is asking, but other -- other than I have already objected and your Honor has overruled me --

but I do object to the characterization in the Michelson Report as "lessons".

Mr. Lahey said, and I think it is clear, that Michelson was asking questions about potential problems and B & W responded with their views as to those problems. So I don't have any objection to the question, but I don't think -- I think it is overstating it when he uses the word "lessons".

THE COURT: Is there some way to keep the question and delete the word "lessons"?

Q. I will be happy to say potential problems.

THE COURT: Let's avoid that hereafter.

MR. KLINGSBERG: Mr. Fiske wasn't objecting and I think it is fair.

THE COURT: He was objecting in a roundabout way. He says he's objecting to the form of the question and I am sustaining his objection on the form.

Q. Dr. Lahey, can you answer me?

A. You want me to explain essentially the transition period and the role of the steam generators during and after that transition period?

THE COURT: Didn't you tell me that a little earlier?

THE WITNESS: I want to show you how it is now related to the 177. It is different in the 177. In fact, it is worse. I can explain, I believe, why.

THE COURT: Very well. Go ahead.

A. You remember when you have steam collecting in the upper U-bend of the hot leg that natural circulation ceases and it continues to have no flow until the level on the primary side drains down to below the level on the secondary side and in this picture I show here, this picture 5 of GPU 3120, you see the level is below the secondary side and now you have some heat transfer potential where the steam can come around here and then condense on the inside of the tubes, boil the secondary fluid on the outside of the tubes and thereby transfer heet and start to reduce the pressure in the primary side.

In contrast to the 177 plants, because of their lowered loop configuration, the transition period which is the time it takes the liquid to drain down to the level of the secondary fluid, that's what Michelson calls that time period, this transition period is forever. You never get to the point where you get below the secondary side, because, now as I have shown here, as the liquid on the primary side drains down, it can only drain to this point. Such that we have a manometer balance with the cold leg and from then on any liquid, any condensate which forms just from heat loss to the containment will dribble over into the bottom of the core.

The reason that's true is that the existing procedures required the auxiliary feedwater to be controlled to this level, 50 percent, which turns out to be coincident with a bottom of these cold leg penetrations.

So in this case you will not cease repressurization because you are unable to get the liquid level below there. So you have a condensation surface such that you can boil the water on the secondary side as you do here and extract the energy.

So in a 177 lowered loop plant this whole concern of repressurization and thereby a mismatch between the break flow out and the HPI flow in is much more exaggerated.

(Continued on next page)

Q. What does that mean in terms of what happens at what time is that?
A. This is 6:05 a. m.
Q. If you lose natural circulation.
A. Well, in this particular view, we have not lost natural circulation earlier in time. It just means that the system pressure will go higher, it's on its way up now, and in the other views that I showed you, it continues to go up, and therefore, the HPI flow, if it were on at this point, would see a continually higher and higher back pressure that it would have to push against.
Q. Now, do you have an opinion, Dr. Lahey, as to what would have been the result at Three Mile Island on March 28, 1979, if Babcock & Wilcox had notified Metropolitan Edison that the steam generator water level control should be set at 95 percent following a reactor coolant pump trip rather than at 50 percent as B&W had recommended?
A. Yes, I do.
Q. What is that opinion?
A. In my opinion, had it been set at 95 percent, which was the original design level of those steam generators, the core would have suffered very little damage; it would have been adequately cooled.
Do you wish me to demonstrate that with the --

Q. Yes. Do you have some diagrams on that?

A. Yes.

What I am going to do, your Honor, is now show you some things which I would characterize as what-if; you know, what if this had been different; and I believe in this case there are good reasons for why that might have been different.

What I have drawn here is a picture at 6:30, so what I think I should do is put the same diagram for TMI on at 6:30, so that if I could have one of the assistants get the 6:30 a. m. diagram, we will see the difference.

In this view here, at 6:30 a.m., which is the point in time that fuel failure was clearly indicated by all the sensors in the plant, had you had your level at 95 percent rather than 50 percent, as was actually the case, now the water which can only fall on the primary side to this level, would have a condensing surface, would see a surface over which the steam in the primary side could condense, thereby extract energy from the system. All right.

There would have a number of features. One of the things it would do is it would depressurize the system, and the other thing it would do is form another natural circulation path such that the liquid now which is able to condense, as it condenses on this side will run over into the core, come up and -- into the core region you would have a steam flow up into the steam generators, and condensing into the steam generators, so there would be a path by which you would produce energy and you would extract energy, which would be in a balance.

The other thing it would do is it would allow the pressurizer to drain because the pressurizer has electrical heaters in it, and all during the accident they were on at full level in an attempt to pull a bubble and lower that level.

Well, they would now see a system which was no longer continually going up at high pressure, but rather was holding pressure or slightly depressurizing, and they -- you would be able then to build up pressure in the pressurizer and push the water out.

It turns out, if you go through the scenario, the drain rate of the pressurizer, because of those electrical heaters, would then be enough to displace this water, which was held up in the pressurizer, and the amount of water, the volume of water in the pressurizer would be sufficient to cover the core.

From that point on, you would have a natural circulation cooling and it's my assumption that you would -- the operators would turn on HPI.

However, the conditions would be stable even if they did not turn on HPI. You would have a situation in which you had natural circulation in the sense you boil water in the core, you form steam, the steam goes through the steam generators, condenses in this region here, which is not the full length but certainly is sufficient length, and the liquid would then come down, pour over the We are here, this raised region into the downcomer, up through the core, repeat the cycle, so it would be a stable configuration; but I think clearly when the operators would see this situation they would have gone to HPI.

At least, that has been their testimony, they went to HPI with lower levels.

Q. As I understand, you have two points:

One, if the pressurizer level coming down under these circumstances induced the actuation of HPI, you say the core would have remained covered, is that correct?

A. One point is, as I contrast these two, you see this case which is the actual case, the block valve is closed. I made all the same assumptions at Three Mile Island, block valve was closed at 6:19 a. m., we are now looking at it 6:30 in both cases. The only difference is I have allowed the secondary side level to go high. As a consequence of this, you are no longer pressurizing the primary system.

In this case, you can -- all the energy that is put into the primary system by the core cannot be extracted by the steam generator. In fact none of it can be extracted from the steam generator. Nothing is going out the break. So the only thing that happens is you build up the pressure.

Because you are building up pressure in this system, the heaters which are on in the pressurizer will not allow -- will not -- there is not enough power in those heaters to build up steam fast enough in this pressurizer to push the water out.

That is because of this loop seal configuration. Its that you are unable to have the water flow out until you have a pressure differential between here and here. The higher pressure has to be here. In this case here you are not pressurizing the system because the steam generators are removing heat.

As a consequence, you can build up enough pressure in the pressurizer to push the water out, break down the loop seal, and it will go directly into the core.

As you see, this water here, which I show flowing backwards, would be in a loop like this, so that if the water came in here it would drain directly into the core, just from the back region.

Q. Just to come back again, you are saying that if the drop in pressurizer level caused an HPI actuation, that

that would have saved the core at that point?

A. Without -- with or without. The conditions would be stable in this configuration even if HPI were not put on.

Q. I am going to take them one at a time. If HPI were put on because of the level drop?

A. It would clearly refill the system.

Q. Even if HPI wasn't put on, you would have induced natural circulation and that could keep the core covered?

A. Right. You would have induced the mode of heat transfer that Michelson calls full boiling which is really a form of natural circulation.

Q. In actuality, the actual Exhibit, what is that?

A. 3108.

Q. 3108 on March 28, 1979, between 6 and 6:30, had natural circulation been lost?

A. Oh, yes.

Q. Was that attributable to any extent to the fact that the steam generator levels were set at 50 percent rather than 95 percent?

A. Right. As I mentioned before, because the level is at 50 percent, and the minimum level that you can get on the primary side is above that, you cannot establish that mode of cooling in the steam generator. You can not have that type of natural circulation.

Q. Is it your testimony that if the levels had been set at 95 percent by B&W and that had been done on the day of the accident, that there would not have been core uncovery?

A. Yes, it's my testimony that -- well, I don't believe I said there wouldn't have been core uncovery. There may have been some core uncovery. But my testimony is that the re-covery, because of -- when you close the block valve the repressurization in the pressurizer would drain the pressurizer at a rate sufficient to reflood the core to prevent any significant core damage.

Q. And you wouldn't have had the fuel damage that you had on the day of the accident?

A. That's my testimony, yes.

Q. I would like to direct your attention to a document marked as GPU Exhibit 612. Do you have a copy of that?

A. I am still looking. 612?

Q. Yes.

A. Yes, I do.

Q. I direct your attention to this document which is a memorandum from Mr. Jones of B&W to Mr. Engel dated March 14, 1977 relating to auxiliary feed water steam generator overfill problem.

I direct your attention particularly to the second page of the document as well as the first The second page says in handwriting, " Aftersteam line break ESFASinitiates auxiliary feedwater flow by starting the AFW pumps and opening the AFW isolation and control valves. Operator action is required to terminate AFW flow or the steam generator will overfill in about 11 minutes. Operator action within 11 minutes is not allowed by the NRC."

On the first page there is also a discussion which you can read, particularly with reference to the portion which states, "The present NRC accepted small leak analysis for the 205 FA plants is given in BAW-10074A Revision 1 and uses a 40-foot level in the steam generator for auxiliary feedwater control. For small breaks, continued operation of the auxiliary feedwater system helps depressurize the primary system. Therefore, no analysis presently exists for the 205 FA plants which supports the conclusion that a 6-foot level is acceptable for mitigating small breaks. However, there is presently some concern as to whether the steam generator model in the CRAFT code, which calculates the blowdown during the accident, is that correct."

Then skipping a sentence, "At the completion of that program it will be determined whether a 6-foot level is acceptable."

Can you explain to the court your understanding of the discussion of the steam generator overfill problem in this document?

MR. FISKE: Your Honor, number one, this document, I don't believe, has been offered in evidence, and I think with respect to many of the documents we haven't objected because they were discussed in the depositions and there was the author of the document who explained what the purpose of the document was, what the discussion was about.

There is no such discussion that I know of with respect to this document. It's just surfaced, and was marked at a deposition, and now they have apparently just want to offer it in evidence and have Prof. Lahey look at this document and presumably start testifying about I don't know what; but I don't know that we have the whole story here, whether there is just one isolated document that relates to the 205 plants, not the 177 plants.

I really am not sure I know where all this is going. Maybe this will all turn out to be innocuous, but I have an uneasy feeling it won't be.

THE COURT: Probably in terms of the evidentiary aspects of this, no question of the document's authenticity?

MR. FISKE: No, we don't dispute that.

THE COURT: On that basis I will permit it to be use used, and we will see where we go from there.

Q. Could you explain the problem discussed in this document from a technical point of view, Dr. Lahey?

A. The problem has to do with the effect of steam generator water level on -- for small break accidents. B&W had a procedure in effect in which when the auxiliary feed water came on, it would control to a high level. In that case it was 40 feet.

In fact, if your Honor wishes, I could put on that 205 diagram again.

You have it there.

And the problem was it wouldn't turn off when it got to 40 feet. It had to be manually turned off by the operators, and the concern was that if the operators only had a limited amount of time when you had both aux. feed water pumps injecting water, and if you didn't turn it off at 40 feet, you could overfill the system and the water would get carried out the steam lines into the turbine and presumably damage the turbine.

So the concern of this was, one, over the fact that the water level was -- had to go very high as it was presently configured, and No. 2, that had to do with the -- this requirement for that 40-foot level had to do with small break LOCA mitigation, and at least as I understand it the authors were concerned as to which was the worse problem, having the high level and thereby being able to mitigate the small break LOCA. For all the reasons I discussed here, the higher the level, the sooner you get to the condensation phase, and thereby start to depressurize the system, vs. the problem of having the level go so high that it may carry over and do mechanical damage to the turbine.

So that is my understanding of the first page.

The second page basically recommends a change to automatically control the level to hold it down at 6 foot rather than going to 40 foot, so that in this change notice, the recommendation was to never go to the high levels, which is -- which were the levels that Michelson assumed in his analysis.

And as a footnote, I might say that even with those high levels, Michelson had concern, and with these low levels, it's much more aggravated. The transition time is much longer.

Q. I would like to show you GPU [illegible] 323, which is the copy of the Michelson report that we got from the Babcock & Wilcox files, which was reviewed by Mr. Jones, according to his testimony in deposition, and marked up in the margin, and I'd like to direct your attention in particular to page 6 where Jones, who was the author of

Exhibit 612, where they talk about reducing the level from 40 foot to 6 foot, writes in the margin in handwriting, "Problem, they are assuming 40-foot levels."

Do you see that?

A. Yes, I do.

Q. Is it a problem that Michelson was assuming 40-foot levels while B&W had reduced the level to 6 feet?

THE COURT: Where are we?

THE WITNESS: Page 6, your Honor.

MR. FISKE: I object to the form of the question. I don't know what the problem is that Mr. Klingsberg is talking about.

THE COURT: Why don't you rephrase that.

Q. Mr. Jones says that there is a problem, they are assuming 6-foot levels. Is there any concern, Dr. Lahey, that Michelson was -- there was any cause for concern from a technical point of view, based on your understanding, that Michelson in his report was assuming a 40-foot level while B&W will reduced the level to 6 feet?

MR. FISKE: Your Honor, I object that question. If you look at Mr. Jones's memo, the one that is Exhibit 412, right at the very first part of the second paragraph, it talks about because of the seriousness of the overfill problem. ECCS, that is Mr. Jones gives tentative approval to the fix, which is I guess the 6 foot level that Mr.

Klingsberg has been talking about, so obviously they are balancing or debating in the Jones 612 memo two different problems. One is the problem of overfill as I believe Prof. Lahey described it, and the other is the 6-foot level, and apparently with the concurrence of ECCS they came out with the 6-foot level.

I don't see how Mr. Michelson was involved in -- no indication that the Michelson report that he was involved in that kind of a consideration. So I don't see how you really relate these two.

THE COURT: Can I have the question back, please?

(Record read)

THE COURT: I am going to ask to you get the question a little bit firmer. I will sustain that objection.

MR. KLINGSBERG: Surely, your Honor. I will reframe it.

Q. Dr. Lahey, you have just explained Exhibit 612 where there is the discussion of the reduction of the steam generator level from 40 foot to 6 foot. You have also testified that Michelson report assumes a 40-foot, and you have seen Jones writes in the margin in his handwriting, "Problem, they are assuming 40-foot levels."

My question to you is very simple: Is there any more or less cause for concern by a reduction of the level to 6 foot as compared with the 40-foot that Michelson assumed in his scenario?

MR. FISKE: That is exactly my problem, your Honor. Cause for concern about what?

MR. KLINGSBERG: We are going to find out from the witness. It will take him two sentences to explain.

THE COURT: I think frankly you have already answered that question in another form, but I will let you do it again.

THE WITNESS: OK. I think I have.

THE COURT: I think you have.

A. Let me show you the picture one more time here of the 205 plant, which is what Mr. Michelson was concerned about.

The steam -- as you may recall, once you break down natural circulation and you continue draining off the liquid, the point at which you stop pressurizing the system, it stops going up in pressure, is when you then drop the level on the primary side below that on the secondary side, and then condensation occurs and you remove energy and you start to depressurize; and this allows to you get down where HPI can then do some good for you.

If your level is down here at 6 foot, the time period that it takes for your level on the primary side to drop down there is much longer than it takes it to cross over when it's trying to go up to 40 feet.

So the length of time over which the pressure is high, in this figure 3124, the length of time over which you have a high pressure, and therefore cannot inject HPI at the same rate as which you are discharging it out the break, is longer. And because of that it makes everything worse in terms of core uncovery. You have a longer period of time in which you are reducing the level in the reactor system.

THE COURT: You also have a smaller area of heat transfer possibility, isn't that right?

THE WITNESS: Absolutely, absolutely, so when you finally get to a configuration when you are below, you have less possibility for this natural circulation mode for the steam condensation.

So from both points of view, for a small break LOCA, it's much better to have a high secondary level than a low one.

Q. Just so the record is clear, because you point to the chart, when you say 6-foot level and 40-foot level you are referring to the level in the steam generator on the secondary side?

A. That's correct, in 3120, GPU 3120.

THE COURT: Is this a new subject?

MR. KLINGSBERG: If I could just ask two more questions on that.

THE COURT: You tell me when you want to break.

MR. KLINGSBERG: Thank you, your Honor.

Q. I show you now Exhibit 3517 for identification, and Exhibit 2208 for identification

Exhibit 3517 is a memo from B&W's files from Karrasch to Pittman, Natural Circulation Mode of Operation, discusses analysis of natural circulation data acquired to date at a /KOEPB slows the level set point can be reduced from 95 percent on the operation range to 50 percent, and Exhibit 2208 is a memorandum from Rogers to Herbein, Rogers of B&W to Herbein of Metro Edison, dated July 31, 1974, referring to a 50 percent high level set.

You have already testified, Dr. Lahey, that the level control on the steam generator based on your understanding was reduced from 95 percent to 50 percent for a 177 plant such as TMI.

Did you rely on these documents for those conclusions?

A. Yes, I did.

MR. KLINGSBERG: This is an appropriate time, your Honor.

THE COURT: We will take a ten-minute recess.

(Recess)

BY MR. KLINCSBERG:

Q. I'd now like to show you GPU Exhibit 613, which is a memo from Mr. Shah of ECCS Analysis to Dr. Roy, the manager of the plant design section. I direct your attention particularly to the portion under the heading "introduction" which says "we have, at present, an NRC approved small break LOCA analyses for the 205 plants. The approved analyses were done using an AFW level control of 40 feet. Subsequent to the analysis, the level control has undergone a design change where the FOCG system now controls the auxiliary FW at a 4 foot level in the secondary side of a steam generator. The old level, 40 foot, control is non-safety grade whereas the new one is safety grade thus protecting the steam lines from the steam generator 'overfill' condition. A new LOCA analysis is now necessary to verify that the new level control will mitigate the consequences of a small break in the RC primary piping wholly in compliance with the requirements of 10 CFR 50, Appendix K."

Can you help us, Dr. Lahey, by explaining the reference in this memo which I have read?

A. The question is will I explain the reference?

Q. Yes, the portion that I have reviewed.

A. It is what I talked about before the break, that they have switched from the original design level on the secondary side of the steam generator of 40 feet to a much lower level because of concern about overfilling the generator, and they realized that there are some implications in terms of loss of coolant accident analysis, and this is a report on such an analysis.

Q. Would you explain to the Court -- briefly summarize and explain the nature of the small break analysis which is discussed in this memorandum, particularly insofar as it relates to the matters which you have previously been talking about in your testimony.

A. B & W defines small breaks, at least at this point in time, as a break of size .5 foot square or less, and they are now doing an analysis of the smaller breaks, and they are looking -- if you look under "characteristic importance of a small break LOCA," in the second paragraph, your Honor, you will see the line that says:

"The four important phases of a small break LOCA can be described as follows: (1) forced circulation coastdown," this is the period in which you have the natural circulation of the single and then two-phased mixture. Number 2, "quiescence period blowdown," that's what Mr. Michelson calls the transition period when you are draining down until you get to the level -- the primary level gets to the same elevation as the secondary side level. Number 3, "boiling pot period." this is the situation in which you now have the core operating in more or less a pool boiling type mode with steam going around and condensing. Then finally "long term cooling" in which there is a clear balance between the energy produced by the core and extracted by the various means.

So they are certainly aware of all these phenomena for small break LOCA, and this report does an analysis on various break sizes at various locations.

Q. What's the purpose of that analysis, as you understand it in relation to the 40-foot level which is indicated as approved by the NRC and the 6-foot level to which they went as indicated in the prior exhibit?

A. To try to determine whether the lowering of the secondary level and the consequent lengthening of the transition period, that is the period of time over which the system pressure is high, has some adverse consequences on the core, namely uncovery of the core.

Q. I now show you Exhibit 616, which is a Babcock & Wilcox preliminary report of safety concerns from N. H. Shah of ECCS Analysis, the same man who wrote the previous memo. It is signed on the bottom "Bert Dunn" on 4/4/78. Can you explain to the Court the concern, preliminary safety concern, in Exhibit 616?

A. The concern is when they did the analysis -- or the motivating factor for doing the analysis is what we just described, that it only has a 6-foot level, and the fact is when they did the analysis, as the figures show at the back of the previous document, the core does in fact uncover for a .05 square foot break. This is a report which was filed by Mr. Shah once he calculated that result with their craft code, that in fact a .05 square foot break at the pump discharge causes the core to uncover for the 6-foot level control in the steam generator, and the statement is that the design change to a 6-foot level control does not provide a safe acceptable result. That's a quote from this.

Q. What does it say after that?

A. It says "for a safe plant operation the system design needs to be modified to avoid the unacceptable consequences of a 6-foot auxiliary feedwater level control." This can be done in a number of ways, but he is saying that something needs to be done.

Q. Now I show you Exhibit 2202, which is the December activities report from Bert Dunn, manager of ECCS Analysis, to Dr. Womack, the manager of plant design. Please turn to paragraph B entitled "20S auxiliary feedwater level control."

You mentioned in your last answer that several changes could be made to deal with the problem that you discussed. Please explain the two changes that are discussed here and how they relate to resolving the steam generator level concern.

A. Well, the two changes suggested by Mr. Dunn in this activities report are, one, you could increase the steam generator level to a higher level such as 20 feet or somewhere in the range 20 to 40 feet or increase the HPI inflow, and that would mean either getting a large or higher head pump or making some other mechanical change in order to get more flow into the system by HPI.

Q. I now show you Exhibit 2201, which is a memorandum produced to us from the B & W files. I direct your attention to page 1, paragraph 1, section 3, the second paragraph at the bottom. I ask you to explain what that means?

A. It starts out, "The importance of"?

Q. Yes.

A. "The importance of once through steam generator level on LOCA analysis will be readily apparent for both proposed fixes." That's the two fixes that we talked about, HPI and level. "The dual level set point change," that is going to a high level for LOCA mitigation, "is expected to raise the obvious question as to why high steam generator level is required, and this could provoke an NRC review of the once through steam generator level effects on small breaks. B & W has never admitted that once through steam generator performance is a key factor to small break LOCA mitigation. If the present once through steam generator or secondary model in craft is found to be nonconservative by the NRC," and then in parenthesis it says "it is nonconservative," "a small break reanalysis may be required. The dual set point change is thus viewed to have the largest potential impact in the long run in both analysis and equipment change areas."

Q. Can you explain that?

A. The author of this document, it is not identified,. is concerned that because they have not identified -- because they have not told the NRC how important steam generator heat transfer and level is for small break LOCA, that if they go to that fix, if they go to the higher level and highlight it to the NRC, that there may be some repercussions to B & W.

MR. FISKE: Your Honor, I am going to object to Professor Lahey in effect being called upon to make characterizations.

THE COURT: Yes, I will strike that.

MR. FISKE: There is no technical expertise here.

THE COURT: It is stricken.

Q. Let me ask you a technical question. Is it a fact that the once through steam generator level performance is a key factor to small LOCA mitigation?

MR. FISKE: Is that in the context of the 205 plants, that question? I think it is important, your Honor, in fairness, that all of this -- these memos that we have been looking at dealing with this problem relate to the 205 plants, none of which were operating at the time. They were still under construction. So this 40-foot versus 6-foot level wasn't something that related directly to the 177's. If they want to try to tie it in later, that's fine.

MR. KLINGSBERG: We are going to tie it in in a minute, your Honor, later in this document.

THE COURT: I understand Mr. Fiske's point and yours as well. Go ahead.

Q. Isn't it a fact that the once through steam generator level performance is a key factor in small break LOCA mitigation?

A. Yes. As I have already testified, it is extremely important for small break LOCA mitigation. It is also, if anything, even more important for the 177 plants than the 205, and I believe I have demonstrated that with diagrams previously.

Q. Do you know what the craft code is?

A. It is a proprietary computer code that is used by B & W for analysis, safety analysis.

Q. Does it apply to 177 as well as 205 plants?

A. Yes. It is a general code. It is a nodal type code.

Q. In other words, it shows more cooling than actually occurs?

A. Yes. During this transition phase, it would overestimate that.

Q. Now, would you please explain the note?

A. Would you like me to read it?

Q. I'll read it and ask some technical questions.

THE COURT: Don't read it. Let the witness read it.

Q. Would you read the note and then I'll ask you a question on it, please.

A. You want me to read it out loud?

THE COURT: No, please don't. I can read it, too, all right.

(Pause.)

Q. Now, Dr. Lahey, there is reference to IEOTSG's. What is that?

A. That's an alphabet soup for Integral Economizer Once Through Steam Generator. It is a design that was used in the 205 plants.

Q. Now, the note says: "Regardless of the final fix which is chosen for the 205 FA Plants, B & W must avoid additional small break exposure on the operating plants. Our 177 FA customers have just recently paid for a small break reanalysis. It is highly important that ECCS establish their position of SG modeling techniques; evaluation model changes, if required, should be presented as appropriate only for the B & W plant types which employ the IEOTSG's."

So you are saying the plant types that supply the IEOTSG's are only the 205 plants?

A. That's correct.

Q. Now, in point of fact or in your opinion, were the proposed changes in steam generator model techniques also necessary for 177 FA plants?

MR. FISKE: I will object to that.

THE COURT. With that foundation, I am going to sustain that.

Q. Is it important for nuclear safety to have a level dependent model for 177 plants?

MR. FISKE: Your Honor, I am going to object to this. I don't think Professor Lahey is in any position to comment on this document. This is something that requires technical explanation in the way that perhaps some of the other documents have. This document is plain on its face.

MR. KLINGSBERG: This is my concluding two questions which I have been building up to for the last three-quarters of an hour and I think that it is extremely important.

MR. FISKE: Well, I mean, your Honor, I'm not sure that the admissibility of evidence depends on how long you have been building up to get there.

MR. KLINGSBERG: These documents, your Honor -- these are very complicated technical documents.

THE COURT: Let me hear the question without getting an answer.

MR. KLINGSBERG: I will reframe it.

THE COURT: Read it back.

(Record read)

MR. FISKE: My objection to this is you would have to know what the background is to know whether it is necessary to make the changes for 177s. This author says I think we have to make them for 205s but I don't think we have to make them for 177s.

How can Professor Lahey comment one way or another without knowing all the facts? This is just one document.

MR. KLINGSBERG: That's not what the document says. It says they must avoid exposure on the operating plants which are the 177 plants and he says the customers have just paid for a small break reanalysis.

MR. FISKE: They don't want --

MR. KLINGSBERG: What the witness is going to testify about is the extent to which we just showed -- I don't know if your Honor wants me to anticipate it or not, but I will explain it, if you want me to rather than the witness.

MR. FISKE: I have sort of a continuing objection to this whole procedure of putting isolated memos out of the B & W files before Professor Lahey who wasn't there, wasn't part of the discussion doesn't know perhaps what other memos there are, what conversations there are about all of these things and they put one piece of paper in front of him, and take one paragraph and say, what do you think that means, Professor Lahey? And then he goes off with his answer. I just think this is a totally inappropriate procedure to begin with. It certainly is inappropriate in cases where there isn't some technical phrase or something which your Honor needs assistance in interpreting.

I have no objection when he wants to tell you what an IEOTSG is. I was glad to hear that myself. But with respect to these other things as to who is concerned about what and what do you think the problem is here, Professor Lahey, I just think is totally inappropriate.

MR. KLINGSBERG: I think I might be able to obviate by jumping to my conclusory question.

THE COURT: Let's do that.

Q. Dr. Lahey, what, in your opinion, would a level dependent loss of coolant analysis have shown as to the adequacy of the 50 percent level which we have shown was established for the B & W 177 FA lowered loop plants?

A. As I have shown your Honor with diagrams, the 50 percent level is completely inadequate because it gives you an infinite transition time. You never get the level of the -- you can never get the level of the primary fluid below that of the secondary fluid. So it would have clearly shown that it was inadequate.

Q. Now, in light of that answer, can you tell the court whether a level dependent analysis was required for the 177 plant as well as for the 205 plant?

MR. FISKE: I object to that, your Honor.

THE COURT: I'll sustain it.

MR. KLINGSBERG: I think we have it, your Honor.

MR. FISKE: I think your Honor ought to know since there is no date on this document. To the best we have been able to determine, this document was produced or written some time in late February or early March of 1979.

Q. The document states -- strike that.

Do you have an opinion, Dr. Lahey, as to what the consequences would be by B & W avoiding further analysis or reanalysis of the 177 FA plant 50 percent level?

MR. FISKE: I object to that. There is no evidence that they avoided it, your Honor.

THE COURT: I'll sustain it.

MR. KLINGSBERG: I think your Honor has the conclusion and we'll stand on that.

THE COURT: All right.

Q. Now, turning to another subject.

MR. KLINGSBERG: The essence of this, your Honor, which I was trying to establish with the other questions on the 205 plants they analyzed the drop from the 40 to the six foot. They decided that based on a similar analysis to what Michelson did they found the six foot analysis was inadequate and they went back to the 40 and they never did it on the 177 and that's how they ended up with the 50.

MR. FISKE: Quite the contrary. I think this analysis was still going on in February of 1979.

THE COURT: Can I treat this all as counsel argument and disregard it?

Q. Dr. Lahey, do you have an opinion as to what would have been the result at Three Mile Island on March 28, 1979, if the surge line on the pressurizer had been vertical instead of having a loop seal configuration?

A. Yes.

MR. FISKE: I just object to that on the grounds that I never understood that there was any claim in this case that there was any defect in the design.

THE COURT: Is that so?