NUCLEAR REGULATORY COMMISSION

ORIGINAL

In the Matter of:

HOUSTON LIGHTING & POWER COMPANY	)
	)
(Allens Creek Nuclear Generating	) DOCKET NO. 50-466 CP
Station, Unit 1)	)

DATE: October 5, 1981 PAGES: 17574 thru 17799

AT: Houston, Texas

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UNITED STATES OF AMERICA

BEFORE THE

NUCLEAR REGULATORY COMMISSION

In the Matter of:	)	
	)	
HOUSTON LIGHTING & POWER COMPANY	)	
	)	Docket No. 50-466 CP
Allens Creek Nuclear Generating Station, Unit 1	)	
	)	

Sun Belt Room
Eleventh Floor
Ramada Inn
7787 Katy Freeway
Houston, Texas

Monday,
October 5, 1981

PURSUANT TO ADJOURNMENT, the above-entitled matter came on for further hearing at 9:00 a.m.

APPEARANCES:

<u>Board Members:</u>

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I N D E X

P R O C E E D I N G S

9:20 a.m.

JUDGE WOLFE: All right.

The hearing is resumed in the construction permit application for Allens Creek Nuclear Generating Station, Unit 1.

Would the counsel for the parties and/or representatives please identify themselves, beginning to my left.

MR. COPELAND: Greg Copeland and Bob Culp for Applicant, Houston Lighting & Power Company.

MR. DOHERTY: John Doherty representing himself as an Intervenor.

MR. SCOTT: Jim Scott representing Texas Public Interest Research Group.

MR. SOHINKI: Good morning, Mr. Chairman and Members of the Board, my name is Stephen Sohinki of the Office of the Executive Legal Director, Nuclear Regulatory Commission. With me today is Mr. Lee Dewey. Together we represent the Commission's Technical Staff in this proceeding.

JUDGE WOLFE: All right. Are there any preliminary matters to bring to the attention of the Board?

MR. SOHINKI: Yes, sir. As I mentioned off the record to the Board, the testimony of Dr. Huang with

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regard to reactor water level indicators. That's Doherty Contention 41 and TexPirg Additional Contention 54 was originally filed with the Board on July 27, 1981.

As the Board knows, Mr. Hodges will be joining Dr. Huang with regard to this contention. And in discussion last week, both Dr. Huang and Mr. Hodges felt that certain changes to the prefiled testimony were necessary in order that the testimony be a little more precise than it is at the present time.

Therefore, we have placed on the table -- at the Board's table, and have distributed to the parties copies of Dr. Huang's testimony with these changes typed in; in other words, clean copies of the testimony.

We would propose simply to substitute the copies that we have provided today for the testimony that was prefiled on July 27, 1981.

And if the Board wishes, I can explain where the changes in the testimony are at this time.

JUDGE WOLFE: All right.

MR. SOHINKI: They start on Page 3 of the original prefiled testimony in the second answer on that page, on the fourth line. The line begins, "placed inside the reactor vessel." That was in the original testimony.

Instead of "inside the reactor vessel," it will now read, "on the reactor vessel."

JUDGE WOLFE: I don't see that, Mr. Sohinki. I'm looking at the original 7-27 proposed testimony.

MR. SOHINKI: Right. And in the second answer on Page 3, in the fourth line down, the line begins, "placed inside the reactor vessel."

It should read "placed on the reactor vessel."

JUDGE WOLFE: All right.

MR. SOHINKI: On the second line from the bottom of that same page, the line that begins, "water level." Strike everything after the word, "between," and the balance of that sentence, so that it would now read, "approximately between the bottom of the steam dryer skirt and five feet above that point," instead of "between the bottom of the steam dryer and the bottom of the steam separator."

Going to the top of Page 4, strike the second line on that page from the original prefiled testimony. That line originally read, "the bottom of the steam dryer and the top of the core."

And it will now read, "one foot above the top of the active fuel and five feet above the top of the steam dryer skirt."

MR. SCOTT: Check that reading.

MR. SOHINKI: "... the bottom of the steam

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dryer skirt," excuse me.

All right. On Page 5, in the first -- well, it's the only answer on that page, in the eighth line, which begins, "between the annulus ard core region," the original testimony read, "when the recirculation pumps are not running," the substituted piece of testimony will read, "when all five recirculation loops are isolated."

And then at the beginning of the next sentence which originally read, "Since the pump is not running," will now read, "With all loops isolated."

Then three lines below that, there is a sentence that begins, "The water level indication system" -- Does everyone see that? All right.

Instead of "The water level indication system," that will be changed -- those five words will be changed and substituted will be "Operating procedures at Oyster Creek have since been modified to eliminate this problem."

In the fourth line up from the bottom of Page 5, the first word of the line is "could;" we will strike the word, "could" from the originally prefiled testimony and substitute the word, "did."

MR. SCOTT: What is before and after that?

MR. SOHINKI: The sentence reads, "Therefore,

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the reactor water level instruments for Oyster Creek did provide a discrepant vessel level indication."

And on the final page, in subparagraph 1 of the concluding answer, in the original testimony it read, "It is based on pressure taps in the reactor itself." Instead of the word, "in," it would be "on the reactor itself," to conform with the previous change.

And in subparagraph 2, it originally read, "It is employed in a reactor design, which eliminates the possibility of discrepant level indication," and so on.

In between the words, "which eliminates," we will add the word, "virtually," so it now reads, 'It is employed in a reactor design, which virtually eliminates the possibility of discrepant level indication."

And that completes the changes.

JUDGE WOLFE: Any other matters?

MR. COPELAND: Yes, sir, I have one preliminary matter.

Tomorrow, Your Honor, we are scheduled to try Doherty Contention 38B, which is on cold shutdown in 24 hours.

And that contention, Your Honor, reads that "Contrary to NUREG-0578, the reactor cannot be brought to cold shutdown in 24 hours."

It has recently come to my attention that NUREG-0578 has never been adopted as a requirement as being applicable to the Allens Creek plant. This was one of the early NUREG's that was developed in the wake of the TMI incident.

And as I understand it now, the requirements that apply to a plant at this stage of the licensing process are set forth in NUREG-0718.

NUREG-0718 has no requirement that the plant be brought to cold shutdown in 24 hours. And, therefore, it seems to me that we no longer have any basis for this contention.

And because it is scheduled for tomorrow and because we do have a witness who will be coming and leaving San Jose, California this afternoon to come here, I'd like to just get this matter cleared up as to whether we're going to go ahead and proceed on this contention.

JUDGE WOLFE: Wasn't this brought to our attention in your motion for reconsideration?

MR. COPELAND: Yes, sir, it was. I felt like it was a separate matter that really needed to be discussed here this morning.

JUDGE WOLFE: Well, let me ask while we're on this subject, Applicant's motion for reconsideration was filed September 18th.

We received Mr. Doherty's opposing response. Have the other parties filed any submission reply to Applicant's motion for reconsideration of September 18th?

MR. SOHINKI: Yes, sir. I believe -- I have spoken to Mr. Black, and that answer has been filed. It was not filed in time for me to bring it down here on Friday.

But, I believe it was filed this morning; and it will be physically in the room here tomorrow morning.

I can tell the Board that we have, in that response supported the Applicant's motion in each instance in which they asked for reconsideration.

JUDGE WOLFE: All right. Yes, we would like copies of that response as soon as you get it.

MR. SOHINKI: Yes, sir.

JUDGE WOLFE: No other replies have been filed then, other than Staff's? All right.

Now, getting back to you, Mr. Copeland, I take it what you want is for sometime today that we make a ruling on that matter. How are you presenting that to the Board at this time? It was obviously set forth in your motion for reconsideration, and now you're bringing it to our attention, and what are you asking the Board to do specifically?

MR. COPELAND: I don't know what the technical term is for it. So I'm struggling --

JUDGE WOLFE: I don't either --

MR. COPELAND: I presume what I'm really saying is that it seems to me that the Board ought to find at this point that there's no longer a basis for the contention because there is no regulatory requirement and dismiss the contention.

JUDGE LINENBERGER: A question on this point, Mr. Copeland: Should we consider that Applicant's comment with respect to these NUREG documents in the motion for reconsideration constitutes in any sense an amendment to your original motion for summary disposition?

MR. COPELAND: Yes, sir, I think so. And, obviously at the time my original motion was filed, there was no way to tell what was ultimately going to happen with respect to that rule, because 0718 did not become a final determination yet, and certainly the Commission hadn't passed judgment on whether that would be the standard.

JUDGE WOLFE: 0718 was issued in November of '80; is that correct -- or thereabouts?

MR. COPELAND: I'm sorry, I can't remember,

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Your Honor.

MR. SOHINKI: I have 0718 with me.

(Pause.)

MR. SOHINKI: I have Revision 1 with me, and that's dated June '81.

JUDGE WOLFE: June '81. What was the first issuance?

March 1981, I have -- NUREG-0718 was issued March of 1981. Revision 1 in June of '81.

MR. SOHINKI: That sounds correct.

JUDGE WOLFE: All right.

Yes.

MR. SCOTT: Mr. Chairman, I'm having troubles with procedurally what's happening here. First of all, I didn't respond to Applicant's motion because I couldn't find anywhere in the rules that there was any allowance for a motion for reconsideration of anything other than, quotes, a final decision. And this is obviously not a final decision.

So it seemed to me like there was no procedural or legal grounds for the motion --

JUDGE WOLFE: Did you bring that to the attention of the Board before today?

MR. SCOTT: No.

JUDGE WOLFE: All right.

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MR. SCOTT: I mean, I'm sure the Board would see that anyway.

JUDGE WOLFE: Well, you are going to have to address it --

MR. SCOTT: Well, I want everyone else to know my position --

JUDGE WOLFE: Why didn't you timely bring this to the attention of the Board? You had ten days from the time the motion was filed.

MR. SCOTT: Well, I think it's timely. And also, this application here was some 18 days, which is at least eight days past even the ten days allowed under the rules to allow a motion for reconsideration of a final decision.

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JUDGE WOLFE: Once again, did you bring this to the attention of the Board in a timely manner?

MR. SCOTT: No --

JUDGE WOLFE: All right.

MR. SCOTT: Well, I think it's timely. It's timely to do it now.

JUDGE WOLFE: In writing?

MR. SCOTT: No.

MR. DOHERTY: Mr. Chairman, to interrupt a minute, I did bring it to the attention of the Board.

JUDGE WOLFE: Yes.

MR. SCOTT: And I thought I just heard the Applicant say that he wanted this to be considered not as a motion for reconsideration, but as an amendment to a motion for summary judgment.

And I've understood that summary judgments had to be made some specified length of time prior to the hearing starting. And that, obviously, hasn't happened.

(Bench conference.)

MR. COPELAND: Just to set the record straight, Your Honor, that was not what I said. I didn't -- Judge Linenberger asked me if this was, in effect, amending something we had said in our motion for summary judgment. And I said yes, that was true, because we didn't

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make this point at that time because it was not clear at that time what the regulatory requirements were going to be.

JUDGE WOLFE: I see somewhat of a departure from the wording that was employed in your motion for reconsideration, what you advised us this morning, Mr. Copeland.

MR. DOHERTY: Mr. Chairman --

JUDGE WOLFE: This morning you advised us that 0718 does not apply to Allens Creek, and that makes it a specific argument addressed to this plant. In your motion for reconsideration, you said that 0718 -- inasmuch as NUREG-0578 was not incorporated does not apply to the construction permit applications across the board.

Was there some distinction here --

MR. COPELAND: Not in my mind, Your Honor. That was ...

JUDGE WOLFE: Yes, Mr. Doherty.

MR. DOHERTY: On the issue of Doherty Contention 38B, I think we've uncovered that NUREG-0718 came out in March of '81 had no mention of the 24-hour shutdown, which had been mentioned as an earlier requirement in NUREG-0578.

I think that that should have put the Applicant to work bringing this to the Board's attention at

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that time and not bringing it up the day before a hearing is scheduled on the actual issue. I feel prejudiced by this delay, and that's why I feel that, you know, it shouldn't be heard at this point.

I think the Applicant is lached (I guess) on that particular point.

JUDGE WOLFE: Howsoever, what would we be trying then, something that is material to our case here, or just getting into matters that because of a procedural objection there's really no point to getting into the merits of it because it's really not a matter -- should not really be a matter in contention anyway?

MR. DOHERTY: The Commission's requirements have a more general word for a requirement to get to cold shutdown still, and that's just a broader term -- reasonable.

You know, I think that in that instance we might consider the contention.

JUDGE WOLFE: I'm sorry, but would you explain that a bit more?

MR. DOHERTY: It's my understanding that what could remain, even though there's no limit of 24 hours is can the Applicant reach cold shutdown in a reasonable time, because the requirement is in that broader term, reasonable.

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JUDGE WOLFE: All right. With respect to Applicant's counsel's request, the request is denied. It was not timely submitted after the issuance of 0718. We will -- We take official notice that 24-hour shutdown is not a requirement of NUREG-0718.

However, as Mr. Doherty indicates, we should suggest -- or we should have something on the record to show that the -- a cold shutdown may be effected -- may or may not be effected within a reasonable time, so we will hear evidence on that point.

Anything else?

MR. SOHINKI: Mr. Chairman, are we to assume then that Mr. Doherty has now amended his contention and the Board has accepted that amendment?

JUDGE WOLFE: I take it that was your suggestion, Mr. Doherty.

MR. DOHERTY: I think it has to be looked at that way.

JUDGE WOLFE: Yes.

MR. SOHINKI: Well, I'm having trouble then because I don't understand what Mr. Doherty means by a "reasonable time."

MR. COPELAND: I don't either, Your Honor, and that leaves you with the question as to what is the legal standard against which we're comparing that reasonable time.

As a lawyer, I don't know how I would brief that issue. I don't know what a "reasonable time" is. I don't know that there is a requirement for a reasonable time.

And as to the timeliness of the matter, I think that we have to consider the fact that the Commission is the one that decided that 0718 was going to be the rule that the Commission would follow; and that was just done very recently.

So I just don't understand legally where we are with that being the contention, Your Honor. I'm not objecting to going forward at all, I just --

JUDGE WOLFE: Yes, we understand that. Can you make that more specific, Mr. Doherty, when you say -- using the word, "reasonable," what you mean by that term?

MR. DOHERTY: Well, it -- I'm kind of caught here ... reading the rule and readin g of 10 CFR. I'm trying to find exactly what I want here.

MR. COPELAND: Well, maybe we can --

MR. DOHERTY: Okay. Now, the -- just relying on memory now because I didn't come prepared to deal with 38 today, there -- all I can do is represent to you that there is a Commission ruling that used the term "reasonable."

The term "reasonable" was not invented by me on the spur of the moment.

I don't have it with me, and that's because this was not scheduled today --

JUDGE WOLFE: Are you saying the word is defined in any particular reg --

MR. DOHERTY: Not to my knowledge is it actually defined in any regulation. It just says "reasonable."

JUDGE WOLFE: Well, now, wait a moment.

MR. DOHERTY: Okay.

JUDGE WOLFE: First of all, is the word, "reasonable," at any time used in a regulation which relates or refers to cold shutdown?

MR. DOHERTY: All right. Where I'm having problems is the word is used. Now, is it a regulation? All I can get in my memory is it's either a standard review plan or branch technical position or some document of that authority.

I'm just not certain where it is. In examining 10 CFR 50, I don't see it.

So, I mean, that's where I'm at on that word. I know there is -- I know that much and no more.

MR. COPELAND: Maybe Mr. Doherty could work on this further during the next break, and maybe we can make some progress that would --

MR. DOHERTY: Counsel, I don't think there's anything I can do here.

MR. SOHINKI: Mr. Chairman, I might be able to help out somewhat. The word "reasonable" appears in the Standard Review Plan. As far as I'm aware, it does not appear in the regulations.

MR. SCOTT: Mr. Chairman, let me make sure we're all understanding this. As I understand it, there is a 24-hour -- I'm not sure if it's a regulation or a suggestion, or a requirement, or a NUREG what, but there's some sort of 24-hour -- I'm going to call it "requirement" in the general term ... general sense -- that this cold shutdown be achieved for all the new plants, quotes.

As I understand it, there's some sort of exception for six applicants or six plants that are in this new-term licensing procedure.

And if you read the Commission's history on this, you're led to believe that some sort of expediency requires that maybe they're too far along to meet this new requirement, so we'll, quotes, let them off.

And that includes those licensing people who have had -- I'll say -- a construction permit for a number of years, and they don't yet have an operating permit, and that sort of thing.

I don't think it even addresses the issue of someone like Allens Creek that's in the middle of hearings and there has not been an ounce of concrete poured.

So, you know, I think you can just almost take judicial notice of -- 24 hours is reasonable for Allens Creek, if it was reasonable for all of the other units.

And, you know, I don't know if there is any explicit statement that this will not be a requirement, or if it .as just left out. Who knows if that was an accid or intentional? I don't know.

(Bench conference.)

JUDGE LINENBERGER: Mr. Copeland, to get your staff's reaction to something here, and again, in the vein of Mr. Sohinki, trying to get us on dead center, might it not be reasonable to consider that a "reasonable time" is one that is not long, compared with 24 hours?

In other words, 24 hours -- forgive me -- is a day. If it's going to take three, four, five or six days to achieve a cold shutdown, I think there would be some possible cause for concern.

If it can be achieved in 24 hours or less, recognizing that 0718 no longer contains the 24-hour requirement, I think the technical history of the matter might give some guidance as to what is reasonable time.

How does this --

MR. COPELAND: Well, I guess we can go forward with that. I can tell you my understanding as to how this is actually done now; and that is, that the operating plants are tech spec'ed to be required to shut down within about 36 hours is my understanding.

That has not been changed. There is no special rule that requires any plant to shut down in 24 hours, contrary to what Mr. Scott said.

The NUREG-0578 just never was adopted. It was a tentative recommendation that never came about. And so ... you've seen our testimony, you know what our witnesses are going to say. They're going to say they can shut it down in substantially less than 24 hours anyway. I'm not worried about the facts here.

The point is just that there is -- or we're proceeding in little bit of a fog as to what the legal standard is. And I just -- if everybody understands that, let's go on and let's get it out of the way. We're spending more time arguing about it now than it's worth the effort.

And I just wanted the Board to be aware of where we were, and I think that has been done; and I suggest we proceed on. If there's some legal requirement that imposes -- that Mr. Doherty can come up with, that applies here, so be it. I guess he can do it on his brief.

MR. DOHERTY: I --

MR. SOHINKI: Well, first of all, I'd like to agree with Mr. Copeland that certainly a 24-hour requirement has not been applied to any plant, Allens Creek or any other plant.

It was a tentative recommendation. It was, I might add, a conditional recommendation, depending upon a series of events at a given plant. It was never adopted.

The Staff has approved times up to 72 hours, so in terms of saying that "reasonable" is something close to 24 hours, I don't think I could accept that.

The point is: It really doesn't make any sense to us to argue about it, since 24 hours is not a requirement, and especially since the testimony in any case would show that it was far, far less than 24 hours for this plant's shutdown.

MR. DOHERTY: Your Honor, Regulatory Guide 1.139, "Guidance for Residual Heat Removal," states that the system should be capable of bringing the reactor to a cold shutdown condition within 36 hours following shutdown with only off-site power or on-site power available, assuming the most limiting single failure.

That document came out before TMI. And to me that would be the closest thing -- the closest improvement we have over the word, "reasonable." That does seem to back Mr. Copeland's recollection somewhat.

So we have something a little more solid than a recollection, and something closer than 72 hours. So that --

JUDGE WOLFE: I'm looking around for a solution. Why don't we just -- insofar as your Doherty Contention 38B is concerned, which reads, "Contrary to NUREG-0578, the reactor cannot be brought to cold shutdown in 24 hours" -- why don't we just amend your contention, if agreeable, and strike the word, "Contrary to NUREG-0578," and have it read, "The reactor cannot be brought to cold shutdown in 24 hours."

You can have testimony on that particular contention as modified and brief it; we don't get into the question of reasonableness or unreasonableness or 36 hours or whatever, just -- we'll have testimony on the record as to the positions of the parties and you will brief them on that point.

Yes.

MR. SOHINKI: I hate to throw a chink into that proposal, but suppose the Board were to find, after

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hearing the evidence, that the reactor could not be shut down in 24 hours? What could you do?

JUDGE WOLFE: You could bring it to our attention, for example, that, yes, the contention was admitted -- hinged upon 24 hours, but that a regulation provides 36 hours, and that this appears in whatever regulation is involved.

So it's not a -- while, factually, the contention is correct, based upon what was shown in the testimony, as a matter of law 36 hours is reasonable or is actually the time --

MR. SOHINKI: If I might just note for the record, the Reg Guide that Mr. Doherty is reading from, I believe is out for comment.

JUDGE WOLFE: Yes.

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MR. SCHINKI: It has not been adopted by the Staff as a final regulatory guide.

MR. SCOTT: Even though it was submitted prior to Three Mile Island? It has been out for comment that long?

JUDGE WOLFE: Well, in any event, is this agreeable?

MR. COPELAND: Yes, sir.

JUDGE WOLFE: Is that agreeable, Mr. Doherty? It's your contention.

MR. DOHERTY: Yes, sir.

JUDGE WOLFE: All right. It's so done.

MR. SCOTT: Mr. Chairman --

JUDGE WOLFE: Doherty Contention 38B is so amended at this time.

All right, Mr. Scott.

MR. SCOTT: I guess it won't have any legal impact, but I just wanted to point out -- it boggles my mind at least to be discussing whether or not the 24 or 36 hours, quotes, is reasonable, when it seems that there's a technology available, based on Applicant's own words, to direct them to do it in a third or a fourth of that time, based on other NRC regulations of having emissions as low as reasonably achievable and things like that.

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I think there may be an issue of reasonableness inherent in all of this.

JUDGE WOLFE: Well, we're not getting to the merits now. Certainly, the sponsor of the contention is agreeable; and we'll proceed on the basis that we ...

(Bench conference.)

MR. SCOTT: Mr. Chairman --

JUDGE WOLFE: Yes.

MR. SCOTT: -- I've got another issue here. Once again, I'm not totally clear on how to approach it, but I think it needs to be aired.

The Board may or may not be aware of the fact that there has been public announcements recently that Houston Lighting & Power is replacing Brown & Root with Bechtel Corporation for their -- to do their engineering work on this Allens -- scratch that, that's not true.

They have withdrawn Brown & Root as their engineering consultant on the South Texas plant. So the only way that impacts us in Allens Creek is in terms of financial qualifications for the Applicant and technical qualifications of the Applicant, and when they're going to be able to finish the South Texas plant and a few issues like that.

As to those issues, I think we're going to need some testimony as to what effect, if any, that is

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going to have on those issues. I want to know if the Applicant plans on filing any additional testimony in that regard.

MR. COPELAND: The answer to that is no, I don't think it affects any of those issues.

MR. SCOTT: Well, you've just announced that you're stretching out the completion date of South Texas another 2 1/2 years. And that definitely affects on whether or not a construction force is going to be at South Texas during the time of construction of Allens Creek. That's one of the issues on the alternative sites analysis, the socioeconomic impact.

MR. COPELAND: Mr. Scott, I don't think that announcement has been made. I'm sorry to disagree with you.

JUDGE WOLFE: Well, in any event --

MR. SCOTT: It has been on the radio, television, newspapers, Mr. Doherty has had a press conference about it.

JUDGE WOLFE: Well, in any event, if Applicant is not going to do anything about it, Applicant is not going to do anything about it. We'll just have to --

MR. SCOTT: We'll make our own motions for additional testimony on that, and to reopen those issues.

JUDGE WOLFE: All right.

MR. COPELAND: Your Honor, he is correct in saying that Brown & Root has been replaced by Bechtel as the engineer on South Texas.

I would assume any questions about that could be asked of our witnesses this week on technical qualifications. I don't believe that that announcement affects any of the rest of our case, however.

JUDGE WOLFE: Well, what I'm saying, Mr. Scott, is that we don't have anything before us, other than your statement and Applicant counsel's statement that they plan to supplement what is in the record, or might be in the record in the way of written testimony.

If you have something concrete to argue and present as to why additional -- or new testimony should be adduced, bring that to our attention and we'll rule on it.

All right.

I understand now that we are proceeding with -- One moment.

JUDGE LINENBERGER: One loose end here that we don't need an answer on right now, I would just note that on August 27th, there was a discussion involving hydrogen and -- inerting -- and during examination, following the prefiled testimony presentation, it was elicited that given a significant interaction of zirconium with steam, followed by injection of CO_2 to inert containment, that the system containment would experience a pressure on the order of 45 pounds per square inch gauge, which was, as near as I could tell, to be compared with the design pressure of 15 pounds per square inch gauge.

And I think I raised the question that the Board was concerned about the compatibility of those two figures, or the compatibility of the containment design and would like some additional discussion of that at some time.

I only bring it up now to say that we haven't forgotten our interest in that matter.

MR. COPELAND: Well, I believe, Your Honor, that from our perspective, that Mr. Lugo, who is now to appear on the 27th of October, will address that issue for us.

He testified -- As I recall, that was Staff's witness Mel Fields who said that the combined forces -- You started asking him about inadvertent operation of the CO_2, and he said it was something like 25 psig.

You said, "Is that a problem?"

And he said, "Well, no, we can take both the inadvertent, plus the hydrogen generation, which gets up to 42 psig, which is below the service level C stress limit."

And I believe the question then was, "Why is it that you can take the service level C stress limit when the design pressure is 50 psig?"

And that's what Mr. Lugo is going to testify about.

JUDGE LINENBERGER: Thank you, sir.

MR. COPELAND: Yes, sir.

JUDGE WOLFE: All right. I understand that Staff is calling Mr. Hodges and will resume cross-examination; is that correct?

MR. SOHINKI: That's correct.

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JUDGE WOLFE: Mr. Hodges, you are still under oath.

Whereupon,

MARVIN W. HODGES

was recalled as a witness and having been previously sworn to testify the truth, the whole truth and nothing but the truth, was examined and testified further as follows:

MR. SOHINKI: I believe when we left off with Mr. Hodges, Mr. Chairman, we were in the middle of a discussion of TexPirg's Additional Contention 41, and Mr. Hodges' written direct testimony on that issue appears at page 12 of his prefiled testimony.

JUDGE WOLFE: All right.

MR. SOHINKI: I believe Mr. Doherty had completed approximately an hour of cross-examination on that issue before we adjourned.

JUDGE WOLFE: Mr. Doherty.

MR.SCOTT: Did I cross-examine on that?

MR. SOHINKI: I don't believe you were here at that time.

MR. SCOTT: I believe I was. This is the day that Mr. Hodges and Mr. Sohinki raised the issue of not testifying on Doherty Contention 8.

MR. SOHINKI: That's not correct, Mr. Chairman.

MR. COPELAND: It shows clearly in the record --

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MR. DOHERTY: Mr. Chairman, may we have the record of that last date. I think it would be of value.

MR. COPELAND: This is it.

(Document handed to Mr. Doherty.)

MR. DOHERTY: Thank you, Counsel.

MR. SOHINKI: I think if you will check the appearances for that date, you will find you were not present, Mr. Scott.

MR. SCOTT: The date that ATWS was to be discussed?

MR. SOHINKI: No, the date that we left off with your Contention 41.

MR. SCOTT: How about the date we started on 41, though?

MR. SOHINKI: It was the same day. We started and adjourned on Contention 41 the last day of Mr. Hodges' presence at the hearing.

MR. SCOTT: I'm sure I was here on the day he started testifying.

JUDGE WOLFE: What does it say in the transcript you have?

MR. SCOTT: It would take me hours to find it. I would just remember, you know, because I had said I was going to have to do extensive cross-examination on ATWS, and after a break, which was in the morningtime, we came

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back and agreed to not discuss ATWS until he came back later with some additional witnesses.

Then we started in on some other contention, and I can't remember which one it was, and that's as far as my memory carries me.

JUDGE LINENBERGER: The Board's notes here, for whatever it's worth, indicate that on the 21st of August, TexPirg Additional Contention 41 was taken up for the first time.

Mr. Scott was not present. Mr. Doherty began cross-examination, and at 11:45 on the 21st of August, Mr. Hodges was excused in order to catch a plane.

The notes indicate that we are not finished with Mr. Doherty's cross-examination. The notes also indicate that Mr. Scott was not present.

I cannot --

JUDGE CHEATUM: I confirm this with my notes.

MR. SCOTT: Mr. Chairman, let me get one thing clear. If that's the same day that he was discussing ATWS, I can say your notes are wrong.

That's what I want to know, if it was the same day or not?

MR. COPELAND: No, it was not. ATWS was discussed on the 20th.

MR. SCOTT: The day before?

MR. COPELAND: Yes.

MR. SCOTT: Okay, that may be correct.

JUDGE CHEATUM: It is correct.

(Bench conference.)

JUDGE CHEATUM: I also indicate Mr. Doherty had not completed his cross-examination.

MR. SCOTT: Okay.

JUDGE WOLFE: All right, Mr. Doherty. You may proceed where you left off.

CROSS-EXAMINATION (Continued)

BY MR. DOHERTY:

Q. Mr. Hodges, do you have the SER with you, the Supplement No. 2? You don't seem to have much baggage with you.

A. I have Supplement No. 2, yes.

Q. Did you by any chance write any of the Section 5.2.2.?

A. No, I did not.

Q. Can you look at page 5-3 for me?

A. Okay.

Q. Now, in the section marked Part 2, there is a discussion of high flux signal scram and the high pressure signal for scram.

At the moment, as the pressure increases in the vessel, which of these signals should activate first?

MR. COPELAND: Asked and answered in the testimony, Your Honor.

MR. DOHERTY: Your Honor, in view of the fact it was almost two months ago, I would request that it be answered.

It's very hard for me to come back to this, and it's almost as if foundationally I'm trying to get started again.

JUDGE WOLFE: All right. Objection overruled.

Go ahead.

THE WITNESS: The question is which reactor scram activates first, the pressure or the flux?

BY MR. DOHERTY:

Q. That's right.

A. The flux scram would activate first for most transients -- for a number of transients.

Q. Do you see there it states, the last sentence in the indented part on page 5-3, "Since the analysis value of 1,045 psig is conservative for flux scram, this variation is acceptable."

When it says "is conservative for the flux scram," how do you interpret that? How did you interpret that or how has that been interpreted, to your knowledge?

A. Let me read the full paragraph for a second, please.

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Q. Sure.

A. I don't know quite how to interpret that sentence.

Q. Well, is a high flux scram at this point calculated to occur before 1,045 per square inch gauge?

A. Is a flux scram -- If I understand the paragraph correctly, that 1,045 is initial operating pressure that you assume in the analysis.

This is not the trip pressure for the scram. So I have a little bit of trouble deciphering exactly what was meant by that paragraph, but the 1045 is initial operating pressure.

Q. The normal expectancy is that the flux scram will precede -- that is, go before -- the high pressure signal as a scram signal?

MR. COPELAND: Asked and answered twice. That's in his direct testimony and that was the first question that he asked him.

THE WITNESS: Should I answer again?

BY MR. DOHERTY:

Q. Now, looking up at that sentence, it says at that same section, "The Applicant has not confirmed that the initial operating pressure of 1,045 pounds per square inch gauge anticipated to be the highest allowable results in the highest transient pressure if reactor scram is initiated by the high pressure signal."

Where they state it would be appropriate to use the high flux signal rather than the high pressure signal, are they relying on a calculation in making that appropriateness?

MR. SOHINKI: Is who relying on a calculation?

MR. DOHERTY: Is the reviewer here who authored the SER, would you assume that he or she was relying on a calculation?

THE WITNESS: I can speculate on what he was saying. I know how we review that today, and I would probably phrase it a little differently.

I can only speculate to what exactly he has in mind.

BY MR. DOHERTY:

Q. Well, how would you review it today?

A. For the most recent plans we have looked at, and, of course, that was operating stage, we have also accepted the analyses with the high flux scram, as opposed to having to wait until you get the high pressure scram.

The reason being that you already have taken the failure of a safety grade scram, which is the one on the closure of the MSIV's, and there are other high quality scrams that are being ignored, which the primary reason that they are being ignored is that they are not seismically qualified, and for most MSIV closure events you would not expect them to be precipitated by a seismic event. There are a number of those that occur every year without a seismic event.

So we have accepted the analyses using the flux trip as opposed to high pressure trip. And if you wait for the high pressure trip, you get a slightly higher pressure; and in most of the plants we've looked at you could still stay within 110 percent of the design pressure.

But we have been accepting -- and in fact, the Standard Review Plan is being revised so that we won't have to continue quoting an exception to that.

We have been accepting it, and it will reflect standard practice.

Q. Is this exception, has it occurred so frequently that -- well, first of all, the exception you mentioned, is that the exception mentioned in this Paragraph 2?

A. The exception mentioned there is the exception to the fact that the variation is waiting until the high pressure trip.

The Standard Review Plan has stated that you take the high pressure trip or the second -- yeah, the high pressure trip or the second safety grade trip, whichever comes later.

The high pressure trip would come later, and so with strict compliance with the Standard Review Plan, you would wait and give credit only for the high pressure trip and not for the flux trip.

But that exception has been taken in the last several years on every boiling water reactor that has come through the licensing process; and we are now revising the Standard Review Plan

Q. You said the second --

A. Safety grade trip.

Q. Second safety grade trip. Would that include MSIV?

A. The MSIV. The reactor trip on MSIV closure is a safety grade trip. So you assume that fails.

Q. Does that typically fail prior to these other two, or does that typically occur -- Is it designed to occur prior to these two or is it designed to occur in the middle or where?

A. For an event which is the limiting pressure events, like a main steam isolation valve closure event, that is the event. That's how it starts, with the closure of the main steam isolation valve.

If you gave credit for a reactor trip on a ten percent closure of that valve, which is the trip set point, then the event would be a much milder event. The pressure would not be nearly as high.

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We have traditionally not given credit for that reactor trip, although it is a safety grade trip.

Now, it again becomes a question of whether you take the second safety grade trip or do you wait for another one, the third safety grade trip, which for that event would be a high pressure trip; and we have been giving credit on a number of plants, and we have done the same with Allens Creek, to give credit for reactor trip on high flux as opposed to high pressure.

Q. So there's actually three trips?

MR. COPELAND: Asked and answered four times now.

BY MR. DOHERTY:

Q. Now, you have the discussion drift of set point on page 13 of your testimony.

A. Yes, sir.

Q. And that drift is with regard to power range instruments, which were made part of the contention with regard to flux trips.

A. Correct.

Q. Now, of those three different sensoring, is the performance with regard to set point trip worse for flux trips or for which of those three?

A. I don't understand your question.

Q. Well, there seems to be the three ways in which a reactor would get a signal to scram on overpressure, and I, in the contention, raise the possibility that the flux trip wasn't -- had had some problems from -- I forgot where, but anyway, I put some figures down.

I'm wondering about the other two trips. Are they susceptible to set point drift, or are they constructed in such a way that they are not.

MR. COPELAND: I object to that question, Your Honor.

Based on Mr. Doherty's own explanation, it's outside his own contention.

He's talking about set point drift on the high flux signal.

MR. SOHINKI: We object on the same grounds.

MR. SCOTT: Mr. Chairman, I don't see how you can claim that that's not relevant and material to the contention.

Just because the contention may have not mentioned that in the contention is no reason not to discuss it, cross-examine on it, as long as it affects the health and safety on that issue.

JUDGE WOLFE: Mr. Doherty?

MR. DOHERTY: No, I don't have any comment. I think that is about what I would say.

JUDGE WOLFE: That which Mr. Scott has said?

MR. DOHERTY: Yes, sir, I'm sorry.

(Bench conference.)

JUDGE WOLFE: Objection overruled. It would appear that the testimony of the witness has opened the door for this line of cross-examination.

THE WITNESS: Okay. If I'm understanding your question correctly, you are asking if the high pressure trip and the main steam isolation valve set point trip or closure trip are subject to drift.

Is that your question?

BY MR. DOHERTY:

Q. Yes.

A. Yes, they are.

- - -

Q. In your experience, are these --

A. Well, let me expand a little bit.

The main steam isolation valve closure uses a set of reed switches, and so it's a position of a read switch. It is not a drift like you would think of in terms of something like a flux trip. It's an actual position on the valve.

Q. Well --

A. On the valve stem. Excuse me.

Q. But what about the pressure?

A. Yes, it's subject to drift.

Q. It's subject to drift.

Is the drift on a pressure sensor used for a scram about the same amount as the flux, about the same amount of drift?

A. It has been a few years since I looked at those numbers, but if I recall correctly, it's about a half of a percent. It's not real large. It's a half to one percent.

Q. Now, you mentioned a reed switch a minute ago. That makes me think of some kind of wood, but I'm sure that's not it.

Is that a mechanical touching sort of thing that prompts the signal?

A. It's a set of magnets basically. You get an electrical signal from a series of magnets. If you want to get at the design of that, you are outside the scope of my expertise.

I just know it involves the relative placement of magnets, and an electrical engineer could tell you a lot more about that than I can.

Q. Does it involve movement?

A. It does involve the mechanical movement of the stem and the physical placement of magnets on the stem that trigger a switch when the magnets move in relative proximity, but much more explanation than that and you are outside my area.

Q. Now, in your testimony on page 13 you spoke about allowable drift and gave some figures. Measurement of uncertainty, one percent; range instrument drift is two percent.

Is it fair to add those numbers together and get a -- if you add them together, would you get a possible inaccuracy, or would that be just not possible? Would they always run contrary to each other; the two percent would be in one direction and the one percent in another direction or something like that?

A. They are independent quantities, and so to add them together is a conservative approach. In the analyses that are typically done by the vendor, they are added together, as far as accounting for the uncertainties, but ostensibly the two are independent. That is for conservatism.

Q. And that three percent, then, is used --

A. Sometimes it's three percent; sometimes it's four percent. It may well be that in Allens Creek they used a total of four percent.

It varies slightly from plant to plant. Those are typical numbers I was quoting. I'm not aware of the exact numbers that were used in Allens Creek.

Q. Okay. Now, going on on page 13, you talk about, "Overpressurization events, such as MSIV closure, the flux spike will peak at approximately 300 percent of nominal full power flux."

What's the source of that, that 300 percent?

A. Okay. Those are some numbers that were taken from Safety Analysis Reports and I quoted it at 300 percent to show that the numbers are extremely large relative to the actual drift.

The numbers are slightly different for each plant and for each event, whether it's a main steam isolation valve closure or a turbine trip. It may well exceed 300 percent, but the intent there was to show it's a very large number.

Q. Well, I'm not sure I see. So is that to make us -- well, is it to say that we certainly will exceed a set point drift? Is that the reason?

In all these problems the pressure is going to be so high that we're going to get scram, because we are just --

A. I believe I'm talking about the flux spike goes up so rapidly, not the pressure.

Q. All right. So --

A. And I'm talking about the increase in pressure is many-fold times the drifts that are allowed; and, therefore, I think -- I believe the contention refers to a series of LER's as indicating unreliability of these trips; and since a large percentage of these LER's are due to drifts in the set points, the point I was trying to make is the actual signal you get is many times the actual drift that would be observed. So a few percent of drift is insignificant relative to the flux spike that you would see for a transient of this nature.

Q. I see. Now, does the ASME Boiler and Pressure Code call 1,375 pounds per square inch gauge, that's the design -- that's the safety limit?

A. What the Code says, it allows 110 percent of the design pressure, whatever the design pressure is. The design pressure for Allens Creek is 1250. A hundred and ten percent of that would be 1375.

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Q. Well, how much additional -- how high would the flux go if we had these unfortunate conditions of allowable drift at maximum and uncertainty of measurement in the same direction? Do you have any idea?

A. You mean if you were taking the uncertainty and the drift both at their full allowable values both in the same direction?

Q. Yes.

A. I don't know. I can't quote you an exact number, but it would have to be very small, because the flux spike that you get is extremely steep. The rise in the flux is very, very quickly, and it would be hard to distinguish on such a flux curve exactly where the difference of three to four percent occurred.

The flux spike is almost a vertical line on a time trace.

Q. Well, does the pressure tend to take a similar, almost vertical route, or not?

A. They build up rapidly, but not as rapidly. It also does not increase as many-fold on the pressure spike.

Q. All right. So -- okay.

Now, on page 14, you added quite a bit to your testimony at that point, I believe, at just the very end.

The main steam isolation valve scram, is that inside the containment building, the actual sensors of

2-18

reed switches? Are those inside the containment building?

A. You have a main steam isolation valve both one inside and one outside of the containment.

Q. Yes. Is the reed switch?

A. It would be on either valve. When you get a valve starting to close, you would get the scram. So, yes.

Q. So it would scram on either closure, inside or outside containment; is that right?

A. Yes, I believe that's correct.

Q. Now, what building are those located in, the ones on the main steam line, but outside the containment? What building are they in, if they are not in the containment building?

A. They are in a steam tunnel that runs from the containment building over to the reactor building.

Q. Well, is that the --

A. That would be the turbine building. I'm sorry.

Q. Is that in the auxiliary building, the steam tunnel you are speaking of? Where is that?

A. I'm not certain for Allens Creek. I just haven't looked at the drawings of where that would be located.

On the ones I've seen it's been like a separate tunnel. It's not in that building proper.

I can't say 100 percent that's not the case for

2-19

Allens Creek. I haven't seen the drawings, but typically, it's not in that building itself.

It's like in an underground tunnel or definitely a separate chamber.

Q. Is it Seismic Category I?

A. To the best of my knowledge, yes. It has to be.

Q. Is it your testimony that the only one of these trips that is not Seismic Category I is the turbine stop valves?

A. Also, there's the turbine stop valves, and there's also a trip, I think, on the turbine control valves. Both are located in the turbine building itself, which is not seismically qualified. That's correct.

This would not be located in the turbine building itself. It's in the steam tunnel between the reactor building and the turbine building -- or the containment and the turbine building.

Q. Well, do you know by any chance if auxiliary buildings are typically Seismic Category I?

A. They are not typically, to my knowledge, no.

Q. Do you know about Allens Creek auxiliary building where these are located, if they are?

A. No, I don't.

Q. Okay.

MR. DOHERTY: I have no further questions, Your Honor.

JUDGE WOLFE: Redirect, Mr. Sohinki?

MR. SOHINKI: No, sir.

JUDGE WOLFE: Board questions?

JUDGE CHEATUM: I have no questions.

BOARD EXAMINATION

BY JUDGE LINENBERGER:

Q. Sir, I think there's really only one question I have here.

You mentioned the flux spike peak at approximately 300 percent of nominal full power flux in a context relating to set point drifts, but I'm just curious how the Staff looks at this in the following context.

This, to me -- and, again, I'll put it in the worst possible light, says that momentarily the system is up at three times its nameplate rate power, or the reactor is up three times its design power.

That just somehow sounds uncomfortable to me. I would like for you to comment on why it is that that kind of, I'll call it, excursion, represents an acceptable situation, if you would, please.

A. Okay. For a transient of moderate frequency, such as a main steam isolation valve closure or a turbine trip, which we expect to occur several times during the life of the plant, basically we try to prevent the overpressurization of the vessel and we try to prevent excessive failure of the fuel cladding so that we have the first protective barrier that remains intact.

So that for the transient you don't exceed the pressure limits. You've satisfied those requirements, the vessel, the piping, all of the associated systems should be intact and there would be no safety problems from that aspect.

To determine whether or not you have violated the cladding integrity, we look at the critical power ratio, the critical power bein- the power at which you go into boiling transition for boiling water reactors from nuclide to film boiling, basically.

So we look at the ratio of that critical power to the actual power that you have on the rod. If you look in terms of heat flux, which is what determines whether or not you have this boiling transition, even though the nuclear flux goes up several hundred percent, the actual heat flux will only increase a few percent, maybe five to seven percent, the reason being that there is considerable heat capacity in the fuel pellets themselves.

They will start to heat up, and if you can think in terms of a lumped parameter system where you think of a time constant for the fuel pin itself, if you get a step disturbance, how long does it take to get one equal, change,

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and the heat flux at the surface there. The time constant is about six seconds for this fuel.

Those things can have a very rapid spike, a fraction of a second. The actual heat flux at set point goes up a few percent, and so you don't challenge the integrity of the cladding.

Neither do the fuel pellets themselves heat up to the point where you would get incipient melting of the pellets.

So the pellets remain intact, the cladding remains intact. You don't exceed your pressure limits and there's no reason to expect there to be anything wrong with the event.

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3-1 bm

BY JUDGE LINENBERGER:

Q In essence then, it seems to me you're saying there's a sort of thermal inertia to the system that resists a significant change in efflux from a short duration neutron flux spike; is that --

A. That's one way of putting it, yes, sir.

Q All right, sir. Now, this -- I understand your words, I just need to know what causes you to believe that's true.

A. I've done the calculations myself, among other things.

Q All right. Fair enough, I just wanted to be sure it wasn't hearsay on somebody's part.

But you have calculated this yourself --

A. I have done calculations with spikes and the neutron heat flux in looking at the actual changes in the fuel temperature and in the heat flux themselves, yes.

Q All right, fine, thank you, sir.

JUDGE LINENBERGER: I think I have nothing else.

JUDGE WOLFE: Cross on Board questions? Mr. Culp?

MR. CULP: No, sir.

JUDGE WOLFE: Mr. Doherty?

RECROSS-EXAMINATION

BY MR. DOHERTY:

Q Are you saying here on Page 13 that in a normal overpressurization event, there will be 300 percent full power flux for some very small duration?

MR. COPELAND: Asked and answered, Your Honor.

JUDGE WOLFE: Sustained.

MR. DOHERTY: Okay.

BY MR. DOHERTY:

Q How often has this happened?

MR. COPELAND: I object, Your Honor; that's outside the scope of the Board's questions.

MR. DOHERTY: Well, Your Honor, the Board inquired as to how he knew this could happen -- the Board member inquired as to how he knew this could happen, and he stated calculations. And I think I can go one step further and ask him the events that actually occurred, which would go along with that.

I think it's relevant to that type of inquiry.

JUDGE LINENBERGER: I believe the witness did characterize this kind of occurrence as something that might be expected to happen several times in the useful operating lifetime of the system. Now, Mr. Doherty, are

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you trying to refine that several times answer or --

MR. DOHERTY: Yes, sir.

JUDGE WOLFE: Objection overruled.

THE WITNESS: For any one particular plant you might expect this to occur half a dozen times a year at most, I would think.

BY MR. DOHERTY:

Q. Has it ever happened to a BWR-6 plant?

A. There's no BWR-6 plants operating.

Q. Is the 280 percent that you mention with the Peach Bottom plant the highest that the flux spike [illegible] has ever been observed in an operating plant?

A. Well, let me modify the statement I said a little bit. First of all, the Peach Bottom is not an MSIV-closure event. It's a turbine-trip event. It's -- You get a slightly lower peak, and that's why it's less than the 300.

Also, at the Peach Bottom, in order to get that severe an event, they had to disable the MSIV closure trip. Normally, that would trip you much earlier, and you would not get those types of pressures.

When I say the event occurs a half a dozen times a year, I'm talking about an MSIV closure event, and you would get a very high flux spike. It may not be up to 300 percent, because the MSIV closure trip would occur

3-4

and would prevent it.

But it is still a very large flux spike. It may be 250 percent or something on that order. But the actual event, with the failure of that trip, it wouldn't be anywhere near on the order of half a dozen times a year.

And the only reason you got as high as 280 at Peach Bottom by disabling that trip --

Q. May we expect perhaps half a dozen moments when the flux spike will reach 300 percent at Allens Creek?

A. If you were to disable that trip.

Q. This is for a main steam line isolation valve closure?

A. Yes. If you were to disable that trip so that it didn't work, then you would expect to get to that order of magnitude about half a dozen times a years.

But since you're not intentionally disabling that trip ... and then it is redundant and ... you know --

Q. Which trip is that?

A. That is the main steam isolation valve trip.

Q. Okay. We're not understanding each other.

A. What I was asking is may we expect half a dozen -- Excuse me.

May we expect at Allens Creek the flux spike to reach 300 percent on the order of half a dozen times a year because of main steam isolation valve closures --

A. What I'm saying is if you disable that trip, yes. But if you don't disable that trip, it would keep it under that, I would think.

Q. Okay. By how much would you expect to keep under?

A. I haven't seen an analysis, and in the FSAR and the PSAR both, we require that they disable the trip and we've never seen the analysis with the trip in place.

Q. I see. Thank you very much.

MR. DOHERTY: No further questions, Your Honor.

JUDGE WOLFE: Redirect, Mr. Sohinki?

MR. SOHINKI: No, sir.

MR. SCOTT: Mr. Chairman, I would like to ask the Board a question.

JUDGE WOLFE: You would like to ask the Board a question?

MR. SCOTT: Well, cross-examine him on the Board questions that ya'll have asked.

(Bench conference.)

JUDGE WOLFE: Any objection?

MR. COPELAND: I'd like to know in advance what the question is, Your Honor, and what the relevance is of it, because I don't ... you know --

JUDGE WOLFE: I was just talking about the right of an Intervenor, or any party, not having been here during the initial examination to proceed then to cross-examine upon Board questions.

MR. COPELAND: I don't think he's entitled to, under your rule that you've established. I think he has waived his right of cross-examination. He wasn't here to defend his own contention when it was taken up.

But I'm willing to have him explain what the question is and what the relevance is, and why it needs to be asked before --

JUDGE WOLFE: You can object to it --

MR. COPELAND: Well, I guess that's true. But you asked me my position and I'm just telling you --

JUDGE WOLFE: I was more interested in your position on our initial ruling with regard to an absent party not being permitted to cross-examine.

MR. SOHINKI: Well, I would object, Mr. Chairman. I think if the Board is going to stick with its original ruling, then Mr. Scott should not be permitted to cross-examine.

(Bench conference.)

JUDGE WOLFE: The Board has conferred. Oft times Board questions are derivative -- are derived from the cross-examination. Our rule then must -- that we had made earlier must also extend to the right to cross-examine upon Board questions.

If the party is not here at the time -- well, particularly as to Intervenors, if an Intervenor is not here at the beginning of the cross-examination of a witness, our ruling to date has been that that intervening party not present may not take the witness on cross-examination.

And an extension of that ruling, because oft times the Board questions are derivative from questions on cross-examination, we will not permit cross-examination on Board questions where the intervening party or any party has not been here for the cross-examination by other parties.

Any redirect, Mr. Sohinki?

MR. SOHINKI: No, sir.

JUDGE WOLFE: All right. We'll now proceed then to TexPirg Additional Contention 53; is that correct, Mr. Sohinki?

MR. SOHINKI: Yes, sir.

JUDGE WOLFE: All right. We'll take a recess until five after 11:00.

(A short recess was taken.)

JUDGE WOLFE: All right.

Mr. Sohinki?

MR. SOHINKI: Yes, sir, Your Honor. Witness Hodges is now ready to testify -- or submit to cross-examination with respect to TexPirg Contention 53 on noncondensable gas explosion.

JUDGE WOLFE: All right. Is there cross-examination, Mr. Copeland?

MR. COPELAND: No, sir.

JUDGE WOLFE: Mr. Scott?

MR. SCOTT: I wanted to do some voir dire on this particular contention before we got to cross.

JUDGE WOLFE: All right.

VOIR DIRE

BY MR. SCOTT:

Q. Mr. Hodges, do you have a degree in chemistry?

A. I have a degree in mechanical engineering.

Q. Okay. Have you had any experience in the instrumentation that's used in chemical analysis?

A. Only limited.

Q. Limited to what?

A. In some course work in school where we would determine the oxygen contents of -- for example, determine the content of various gases and products of combustion, for example.

But that has been a while.

Q Did that use instruments, or was that done by some sort of chemical analysis weight method?

A No, it's -- obviously there are instruments, but it's an analysis.

Q I couldn't understand you.

A I said obviously there are instruments involved in taking the measurements, but an analysis goes with it, yes.

Q Well, I was asking you specifically about instruments that there may be some sort of chemical analysis -- some reactions going on inside of them, or whatever, to cause a needle to read, or a readout to change.

But I was asking about that kind of instrument as opposed to, say, a scale where you weigh grams of potassium permanganate or something on it.

A This was measured on the various gases.

Q In other words, were you using an instrument to measure the percentage of these various gases?

MR. SOHINKI: Your Honor, I object to this line of voir dire. These questions are not relevant to Mr. Hodges' testimony concerning this contention and why the problem with respect to non- and condensable gases has been resolved.

He's talking about -- Mr. Hodges' testimony concerned the fact that the gases will be vented out of the reactor. And, therefore, there's no problem. And thus it's unnecessary to get into the gas -- to the gauges or this type of thing that Mr. Scott is referring to.

MR. COPELAND: I would support that motion, Your Honor, because Mr. Hodges has not testified about the accuracy of measuring chemicals with any kind of of gauges or whatever, so I don't understand how that could possibly be relevant to his qualifications to testify as to the things that he said in his testimony.

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MR. SCOTT: Mr. Chairman, you can't get by by just saying gases disappear. I mean, how does he know that?

He's going to have to have some sort of gauge to measure that, or maybe the gas is still there. And that seems to me like a very intimately reasonable thing.

We've got a very touchy situation here about whether or not we've got five percent or three percent of a gas, specifically hydrogen.

And we -- I'm trying to find out why this man is here testifying on this subject, as opposed to possibly someone else.

MR. DOHERTY: Your Honor, I would oppose the Staff's motion in that the Staff said that the testimony talked about the gases and said that they were insignificant.

However, the testimony hasn't been accepted as part of the record, so it can't be used as factual at this point.

MR. SCOTT: Well, also, part of his testimony that has already been submitted has to do with the SER; and it does mention such percentages as being relevant to the --

MR. DEWEY: Your Honor, may I say something on

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this? First of all, the testimony has already been admitted into the record.

Secondly, Mr. Hodges does have the expertise in his mechanical engineering background to be able to testify that the gases, whatever the amount, would be vented in the various ways that he discusses. It's very clear in his testimony.

So, I don't understand what Mr. Scott's reference to the fact that he'd have to gauge the gases to know how much are there.

Mr. Hodges is saying that these gases would be vented through -- in these various methods.

MR. SCOTT: Mr. Chairman, he doesn't say that. He just says most of it would be vented. We don't know how much is left, or whether or not that amount that's still left is dangerous or not. You have to measure it.

(Bench conference.)

MR. DEWEY: Also, you have the reactor level indicators whereby the hydrogen would not be -- would be shown -- or would be reflected early on.

MR. SCOTT: I didn't understand that.

MR. DEWEY: I'll refer you to the testimony at Page 15, the first answer, "ACNGS unambiguous water level instrumentation for the vessel."

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MR. SCOTT: Who's talking about water level?

MR. DEWEY: The water level will indicate the hydrogen level.

MR. SCOTT: That certainly has a lot of built-in assumptions. Other things can affect water level --

JUDGE WOLFE: All right. The Board sustains the objection. The testimony of the witness does not at all go to how he determines the existence, or the percentage of these noncondensable gases, but to what the system does with these gases.

Objection sustained. All right. Next question.

BY MR. SCOTT:

Q. Mr. Hodges, how extensive is your knowledge in the solubility of various gases in water?

MR. DEWEY: Your Honor, I think this is getting to the same line of voir dire that you just sustained our objection to.

MR. SCOTT: I don't understand that.

He pointed to a particular statement in the testimony to say that we don't need instruments. So I'm following up on that very last statement made by Staff counsel.

He has got a built-in assumption here that only

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hydrogen is going to affect the water level of the pressurizer, or in the Allens Creek vessel it's obvious that there are other things that can affect the water level.

MR. DEWEY: He does not get into the solubility question here.

MR. SCOTT: "Unambiguous water level instrumentation" is ambiguous.

(Bench conference.)

JUDGE WOLFE: That's a difficult question. Where there's that doubt in the Board's mind, where we have doubts because we don't know how this question ties up with the witness' testimony -- however, where we have some doubt, we'll overrule the objection.

THE WITNESS: I don't have extensive knowledge of the solubility of oxygen . the various situations for water, but I do know that a standard method for removing gases -- and one of which would be oxygen -- a dissolved oxygen from the water would be to boil it.

And we are talking about a boiling water reactor. So under normal conditions, I know that the amount that would be dissolved would be extremely small, but I don't know the exact amounts.

MR. SCOTT: Okay.

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3-15

BY MR. SCOTT:

Q. Have you had any previous experience with Allens Creek proposed unambiguous water level instrumentation?

A. I'm not sure I understand what you're asking.

Q. Well, on Page 15 --

A. Yes.

Q. About one, two, three, four, five -- seven lines down from the top of the page --

A. Uh-huh. I'm familiar with the water level instrumentation for Allens Creek, if that's what you're asking me, yes.

Q. Okay. I was asking you, are you familiar with -- have you used -- do you understand the design of the unambiguous water level instrumentation that's going to be used for Allens Creek?

A. Yes, I do. I understand the design, I have not used it. But I do understand the design.

Q. Have you seen a comparable instrument before?

A. I have seen the comparable design on other plants. I have not gone out and physically examined the instrument on the other plants.

Q. Have you seen any test data to indicate how it works, what its uncertainty of measurement is?

A. Yes, I have --

MR. COPELAND: Objection, Your Honor. This line of questions is cross-examination.

MR. SCOTT: No, Your Honor, it's to see if this witness has any expertise in the subject matter on which he is presenting testimony.

Of course, it's already answered anyway.

JUDGE WOLFE: Objection overruled.

All right, next question.

BY MR. SCOTT:

Q How -- I think you are, are you not, familiar with the concept of water/metal reactions?

A. Yes.

Q Have you ever done any experiments utilizing water/metal reactions?

A. Not intentionally.

Q You've never dropped any sodium in the water in the lab intentionally?

MR. DEWEY: Your Honor, I think this is going beyond the scope once again of the witness' testimony. The -- His testimony is that the gases will be vented through the opening.

And his testimony also includes the fact that there are unambiguous water level instrumentations which will show when the core isn't covered and, therefore, whether the hydrogen will, in fact, be released.

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I don't quite understand why this reaction question is really relevant at this point.

MR. SCOTT: Well, the witness states fuel rods must be uncovered for a long period of time without core coolant to oxidize a large fraction of that fuel cladding.

And I'm wanting to know how does this guy know that.

JUDGE WOLFE: This witness?

MR. SCOTT: This witness.

MR. COPELAND: Can I ask for a clarification here, Your Honor? Does Mr. Scott dispute that statement?

MR. SCOTT: That's for cross-examination --

MR. COPELAND: Well, if --

MR. SCOTT: -- to dispute. He has made the statement, I'm just trying to find out if he has got the expertise to be believable in such a statement.

MR. COPELAND: Well, the point is obvious, Your Honor. If Mr. Scott doesn't dispute that statement, why is he bothering to cross-examine to try to get that statement thrown out of the testimony, which is the whole purpose of voir dire, I presume -- is that he thinks that the witness is incompetent to say that.

If he doesn't disagree with that statement, what is the point?

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MR. SCOTT: We're just here to find out what his competence is. I'm not making any position yet as to what his competence is.

MR. COPELAND: Well, then he's wasting time, Your Honor.

MR. SCOTT: No, I'm not.

The whole purpose of voir dire is to learn. If we already knew, I'd just give you a speech.

(Bench conference.)

JUDGE WOLFE: It's a good question -- a valid question on voir dire. Objection overruled.

THE WITNESS: Could you restate your question, please?

BY MR. SCOTT:

Q. The best I can remember, I was asking you what your experience has been in water/metal reactions. And I gave as an example throwing sodium in water. That wasn't really the gist of it. I was wanting to know what experience you have had.

A. Okay. The extent of my knowledge on the water/metal reaction is in the application of data that has been correlated through the Baker/Just equations to try to talk about the reaction rates and such. I have not done the measurements themselves, but I am familiar with at least some of the technology and how you apply that in calculations.

Q. By technology, do you mean computer program models?

A. This is the model that's used in a computer program, yes.

Q. Have you run that program before?

A. There are a number of programs that have it in it. I have not run them, but I am familiar with them and what are in those programs, yes.

Q. You say you're familiar with what's in the programs. I assume you don't mean you have written the programs; is that correct?

A. That is correct.

Q. Okay. To what extent then are you familiar with what's in them?

A. Part of the responsibility I've had while being with the NRC was to evaluate the calculational models that are used with these various subcomponents of these computer programs. And that I've done in some detail, and compared the models with data and -- requesting that the calculations be done by Applicant or the vendor, and then comparing that with data.

And then I have -- As I say, I'm familiar with how the equations are programmed in there, but I have not physically run the program myself.

Q Okay. Do you send this off to some other department, and you give them directions on input that you want the program to have in it, and ask them to run it and you get the results back and you work with it that way?

A. Within the group that I have worked -- and there are several individuals who do the calculations, and we -- I have requested that calculations be done on occasion and they have done them for me. It's not another department.

And we've also relied upon calculations by the vendors.

Q Okay. I remember earlier that you had done, or you were involved with some various calculations, but I hadn't remembered, and I'm still not clear on whether or not one of these calculations is calculting the amount of hydrogen that would be generated in the water/metal reaction for a facility either at Allens Creek or one very comparable to it?

A. You asked me if I had done the calculations myself personally, and the answer is: No, I have not. I have requested such calculations be done by other individuals working within the same organization in which I work, and I have evaluated the results.

I am familiar with the codes that they use for that, but I did not personally do the calculations myself.

Q. Okay. Now, when you say that you evaluate their work, are you the head of a group of people who are doing this work? Are you their supervisor?

A. Yes, I am.

Q. Okay. What I'm not clear about yet is -- you know, you can evaluate in many ways. It's somewhat a difference in management style, but some managers are not happy unless they've done it themselves.

Others say, "I've got an expert, I'll take his word." And there's also the gradations in between there. Where do you stand in that regard in respect to water/metal reactions?

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A. Okay. Under normal -- Let me make two statements.

First off, the experience that I've had with that was prior to becoming a supervisor, so I don't think it has a lot in relationship to my present supervisory duties. But as long as I have competent individuals to do the work for me, and I know that they're competent, and I know the tools that they are using, I see no reason for me to duplicate their efforts.

Q. Yes. But the issue comes down to how do you know that they're competent?

A. (No response.)

Q. I mean, we -- as an example, hopefully this doesn't happen with your group.

But there are doctors practicing in hospitals for a number of years that they discover never went to med schools. And they were even in some cases thought to be pretty competent.

MR. DEWEY: Your Honor --

MR. SCOTT: That's a far-out example. That's why --

MR. DEWEY: -- I think this is getting a little bit beyond the realm of reality. He testified that he knows that the people who are working under him are competent. He's a man with -- who is clearly qualified in his area. I can't see why this knitpicking is going to accomplish anything.

JUDGE WOLFE: Objection overruled. Answer the question: How do you know they're competent?

THE WITNESS: Okay. Well, actually there's two aspects of that.

When someone is running -- doing the calculation, it is not necessary for him to be competent in metal/water reactions to do the calculations. It is necessary that the individual who did the correlation of the data and put it into the code and checked the code out, that that or those individuals be competent to do that part of it.

It is necessary then that the individual who is running the code is competent in getting the input in and interpreting the data. And that's where, as far as I'm concerned, the competency of the people working for me comes from. They have not necessarily had experience in correlating the data on metal/water reactions, they are familiar with the literature and through discussions with the individuals ... you can determine to the extent of their background their facility with use of these codes, and that's how their competency is determined.

But it's their competency in doing the overall analysis, not necessarily that one individual subcomponent.

BY MR. SCOTT:

Q Well, it seems what you're saying is you have not done the chemical experiments on water/metal reactions. None of the people that's working for you have done those, but that the people that work for you have taken models developed by other people and run computer programs.

I'm still left, how in the world that you can have any degree of confidence that the models given you were correct, if you don't have any working relationship with the people who developed those models?

A. The models for the metal/water reaction were actually evaluated by another group within NRC as to acceptable or nonacceptable. We do have people with chemical backgrounds, metallurgical backgrounds who look into those particular subcomponents of the models.

The people in the group that I'm in do an analysis. They don't have to go back and evaluate each time they do an analysis the acceptability of that model.

We rely upon the expertise in these other branches of the NRC. And, in fact, this particular model -- the Baker/Just equation has considerable exposure at the ECCS hearings back in '73-'74 and has been commented on very widely by the nuclear industry in general, and is generally acknowledged by the nuclear industry to be an extremely conservative model.

I see no reason each time to go back and do the calculations to redetermine that.

Q On the other hand, you can't personally know whether it's correct or not, can you?

MR. COPELAND: Your Honor, he's just arguing with the witness now.

JUDGE WOLFE: Sustained.

BY MR. SCOTT:

Q Which group developed this model -- equation that you've made reference to, that calculates the amount of hydrogen generated on a water/metal reaction?

MR. COPELAND: I object to that question. He hasn't testified as to the amount of hydrogen that would be generated during a metal/water reaction.

MR. SCOTT: I didn't ask him that question.

MR. COPELAND: Well, then it's beyond the scope of his testimony, Mr. Scott.

MR. SCOTT: He has repeatedly answered that -- brought up this issue, and I'm asking him -- he says he's familiar with the people that did it. I'm asking who they are.

He just got through stating -- don't look at your paper here to see what his testimony is -- his

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testimony ... he just stated he was familiar with the people that had made the calculations, and he didn't feel that he had to go recheck them. So I wanted to know who did it.

MR. COPELAND: I don't see how that's relevant to his testimony, Your Honor.

(Bench conference.)

JUDGE WOLFE: Objection overruled. You may answer the question.

THE WITNESS: Okay. I'd like to know which question I'm answering, because every time he rephrases it and it seems like a different question.

MR. SCOTT: Okay.

BY MR. SCOTT:

Q. And if you don't know names of individuals, what's the name of the group at least, that developed the model that incorporates the equation -- I couldn't get the name of it -- I think you called it Baker/Just equation, that calculates the amount of hydrogen that will be generated in the water/metal reaction.

A. The Baker/Just equation -- the name refers to the people who did the experimental work, who made the correlation -- this was approved in the Core Performance Branch of the NRC during the days of the review of the ECCS model.

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The evaluation models were approved back in 1974. And this particular model had been accepted as being acceptable in the Appendix K, so it has been accepted by the Commissioners as being acceptable.

Q. Okay. That's the equation.

A. Yes.

Q. How about the model?

A. Okay. The actual model that uses the equation has been developed under contract work for the NRC in Idaho. And I don't know -- Idaho Nuclear Engineering Lab, I think it is -- INEL ... it used to be EG&G. It has undergone a management change several years ago.

Q. Okay. Did either you or people in your group actually look at a printout of that program -- the program that has that model?

A. Well, actually one of the individuals in our group helped develop the models.

Q. Who was that?

A. Dr. Lauben.

Q. Dr. who?

A. Lauben.

Q. How do you spell that?

A. L-a-u-b-e-n.

Q. Do you think he knows more about that than you do?

A. Yes, I do.

Q. Okay. What discussions did you have with Dr. Lauben in preparing this -- little over one page of testimony?

A. I did not discuss it with him.

Q. Have you had any discussions with him concerning the degrees of uncertainty in the model -- degrees of uncertainty in relation to the amount of hydrogen generated?

MR. DEWEY: Your Honor, I object. It hasn't been established that this witness needed to discuss anything with the individual in question.

MR. COPELAND: I support that objection as to the relevance of this witness' testimony.

MR. SCOTT: Mr. Chairman, he --

MR. COPELAND: He has not testified as to the amount of hydrogen that would be generated.

MR. SCOTT: Mr. Chairman, he has said that he has had discussions with people that work for him. We now know the name of a person that works for him, who was actually involved in developing the program.

Surely, that's one of them that he discussed this issue with. I'm trying to tie that down.

He has already said that he discussed it with people who worked for him.

(Bench conference.)

JUDGE WOLFE: Objection overruled.

THE WITNESS: All right. First off, I want to clear up a misimpression by Mr. Scott. Mr. Lauben does not work with me -- I mean for me -- he works with me.

So he would not work directly for me. The discussions I had with him on the subject occurred prior to the time I was promoted, so we were working on the same level at the time.

But I've had several discussions with him, not so much on the uncertainty in the correlations, but on the fact that the correlations are extremely conservative.

So there was no discussion of the actual uncertainty, when you're talking about the fact that the correlations are extremely conservative.

He was familiar with that fact.

BY MR. SCOTT:

Q. Did he give you any numbers as to how conservative?

A. No.

Q. So you just talked in general terms --

A. Yes.

Q. -- extremely conservative.

A. Yes.

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Q Now, in some of your testimony it seems to say Allens Creek is not going to attempt to measure hydrogen or any other non-combustible gas concentrations in the reactor vessel, and the NRC says, "That's okay, there's no need to measure it."

Is that an appropriate summary of your testimony?

MR. COPELAND: That's cross-examination.

JUDGE WOLFE: Sustained.

MR. SCOTT: Okay. I don't have any further questions on voir dire.

JUDGE WOLFE: All right. We are now ready for cross. Mr. Scott.

MR. SCOTT: Yes.

CROSS-EXAMINATION

BY MR. SCOTT:

Q Mr. Hodges, first of all, did you consider any non-combustibles other than hydrogen and oxygen in relation to this contention?

A. You mean non-condensible?

Q Yes. What did I say?

A. Non-combustible.

MR. COPELAND: Well, I would object to that question, Your Honor. As pointed out in our testimony, I believe, through Mr. Elliott, we took Mr. Johnson's

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deposition and Mr. Johnson explained two things about this contention in his deposition, which is cited in Mr. Elliott's testimony.

First, Mr. Johnson explained that the term non-condensible gas in the contention meant hydrogen, and he also explained that the phrase "during an ECCS" meant during a loss of coolant accident.

So I would object to any questions along this line by Mr. Scott after his own director of TexPirg has already said what the term "non-condensible gas" means to TexPirg.

MR. SCOTT: The best I can remember, there was some discussion that said roughly what he's talking about, but I don't remember Mr. Johnson specifically limiting that to hydrogen and oxygen.

I think he used that more as an example of the sort of things. If Counsel can read the transcript that shows that he was limited to that, he's made a good point as to himself.

I don't see that that has any relevance to a witness that's not even his witness. There's no indication that this witness has even seen that transcript.

MR. COPELAND: My point, Your Honor, is that TexPirg has put that limitation on its own contention. It's not relevant what the witness has done here.

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JUDGE WOLFE: We don't have that before us. We can't rule in a vacuum. There seems to be disagreement between two parties, so we'll overrule the objection.

THE WITNESS: Okay. There would be, I would suppose, other non-condensibles, such as some nitrogen present; but from my understanding of the contention, what you were asking, you were concerned about an explosion, and for that you were going to need some oxygen and you were going to need some hydrogen, and those are what I concentrated on.

I think the others are probably insignificant, but the venting that I referred to in my testimony is going to cover all of the gases, all of the non-condensible gases. They will all be vented.

BY MR. SCOTT:

Q Okay. I'm not clear on your answer. Is the answer that you only considered hydrogen and oxygen?

A In preparing the testimony I only considered hydrogen and oxygen, yes.

Q Wouldn't methane be a non-condensible gas in the sense of this contention?

A I presume methane would be a non-condensible gas, but I wouldn't presume there would be a large amount of methane present in the vessel. I'm not aware of a source of methane in the vessel.

Q. Okay. Isn't methane made from a combination of carbon and hydrogen?

A. Yes.

Q. Isn't there both carbon and hydrogen in the reactor vessel?

A. Yes.

Q. So what do you know that would prevent there being the manufacture of methane inside the reaction vessel?

A. I am not familiar with the process for the manufacture of methane.

Q. So, then, are you stating that to your knowledge, it could exist in there?

A. I'm stating that when I have discussed with people who are familiar with what gases would be present, people in our Chemical Engineering Branch, they tell me that the ones that should be considered are the hydrogen and the oxygen; and I think, again, because of the fact that the same vents that are going to relieve the hydrogen and oxygen would also relieve any methane that's in there, so I don't see any significance.

Q. Well, if you are going to take the position that whatever is in there is going to be released, why consider even hydrogen and oxygen?

A. I'm saying that even hydrogen and oxygen are not a problem because they will be vented, but those are

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the ones that people worry about most.

Q So why, though, have people spent considerable effort on the issue that's not in this contention, if you are now taking the position that it's not a problem?

MR. COPELAND: That's argument --

MR. DEWEY: Your Honor, I think he's arguing with the witness on this. The witness has answered him, I think, two times about what he's trying to say here.

JUDGE WOLFE: Sustained.

BY MR. SCOTT:

Q Do you happen to know what the explosive limits are for methane?

MR. COPELAND: Your Honor, I'm going to object to that question. At this time, I would like to offer an admission by Mr. Johnson from his deposition.

JUDGE WOLFE: What is the date of the deposition?

MR. COPELAND: February 27, 1980.

JUDGE WOLFE: Okay.

MR. COPELAND: And I'm sorry, I don't have a correct page number. I believe this is at page 112, but the Xerox copy is a little unclear, but I will doublecheck that. Line 21 -- Line 24, excuse me. The question was asked, "The only non-condensible gas of interest is hydrogen?"

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Answer, "Yes."

Question, "In the reactor vessel?"

Answer, "Yes."

MR. SCOTT: If I understood him right, that ''d seem from Mr. Johnson's viewpoint, who has, as far as I know, never claimed to be an expert in this particular matter. So I don't think that should be -- that statement as to Mr. Johnson's knowledge of the contention should be held against TexPirg in this matter, seeing that Mr. Johnson is no chemist or nuclear engineer, either.

He was never offered as an expert on this issue.

JUDGE WOLFE: How come he was deposed then, Mr. Scott? There must have been some inkling by you or by someone that Mr. Johnson was your expert on these matters.

MR. SCOTT: They wanted someone to depose and we didn't have anybody else.

MR. COPELAND: He was designated, Your Honor, as the person at TexPirg who could explain the meaning of TexPirg's contentions, and I'm sure I don't have to remind you of the history of how we got to that point.

(Bench conference.)

JUDGE WOLFE: In light of the deposition and the clear delineation by TexPirg's representative, sustain

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the objection.

BY MR. SCOTT:

Q. Mr. Hodges, what -- let's back up.

You state on your first answer that, "Hydrogen and oxygen are the non-condensibles which have the potential for combining explosively inside the reactor vessel."

In the second sentence you state, "The normal concentration of free hydrogen and oxygen is very small."

I want to know what is the relevance of normal concentrations in this contention?

A. Basically, we start out by saying there's not a lot of hydrogen and oxygen in there in the first place. So in order to get sufficient hydrogen or oxygen to reach either a flammability or a detonation limit, you have to do something.

Then secondly, we're talking about the likelihood that that will come about if you were to build up the concentrations.

We are saying that because you are venting off any gases that are formed, the likelihood of getting that concentration is very small. So that's why.

Q. Very small in normal operating conditions?

A. Well, that has to be the starting point.

Q. Okay, let's say that it's the starting point.

Is it also the ending point?

A. There are two sources of the hydrogen and oxygen. The first is whatever is there during normal operation and the second is that that is generated during the accident. I'm trying to address both parts of it.

I'm saying that that is there during the normal operation is extremely small. It does not come anywhere close to approaching dangerous limits.

I proceeded to say that during an accident itself, those that could be generated to uncover the fuel would be vented through the various methods that I have described in my testimony.

Q. Okay. What is this very small normal concentration of hydrogen and oxygen, of free hydrogen and free oxygen?

A. For oxygen, there are no tech spec limits on a General Electric plant; however, there are guidelines that are provided by General Electric, which says that the uncombined oxygen basically in the feedwater should be in the range of 20 to 200 parts per billion. That's billion, not million.

Actually, in the vessel itself the oxygen is in the range of .5 to .7 parts per million, ppm.

I'm not aware of what the actual hydrogen concentrations are, but they are small. The amount of

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oxygen that's available, I have numbers on that; I don't have the absolute numbers on the hydrogen.

Q. Now, is 200 parts per billion the same as .2 parts per million?

A. I don't want to try to do the arithmetic in my head, but you've got six places to shift your decimal point.

Q. Well, take 200 and scoot it over three more. Would that be .2?

A. Okay, that's .2. Right.

Q. Okay. If the feedwater has .2 parts per million oxygen and the reactor vessel .7 in normal conditions, where did it come from?

A. One source of it is the normal radiolytic decomposition of the water.

Q. Okay. Would that radiolytic decomposition be a function of time that the reactor vessel had operated?

A. You would reach equilibrium levels after, I would expect, some fairly short period of time. These are the normal range after a plant has been operated for an extended period of time, the .5 to .7.

So I would expect those numbers to be the equilibrium values.

Q. Would you expect that the concentration of oxygen inside the vessel would depend upon the neutron

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flux density inside the reactor?

MR. DEWEY: Your Honor, I think I'm going to have to object to this line of questioning.

TexPirg Contention 53 really speaks about the problem during a LOCA, and we're not talking about normal hydrogen generation. So I really don't know where this is getting us, and it's beyond the scope of the contention.

MR. SCOTT: Where do you see our contention is limited to a LOCA?

MR. DEWEY: I'm quoting your third line, "To assist in estimating the possible explosion hazard in the vessel during an ECCS," which Johnson said means a LOCA.

MR. SCOTT: I think there's lots of situation where the emergency core cooling system is used other than a LOCA.

I don't feel constrained to limit the questions to LOCA's.

MR. DEWEY: Well, it was my understanding that that was the definition in the testimony.

JUDGE WOLFE: Overrule the objection.

MR. SCOTT: I didn't understand what your ruling was.

JUDGE WOLFE: I said I overrule the objection.

THE WITNESS: I suspect it would be somewhat a function of the flux level because of the decomposition, but I don't know how strong.

BY MR. SCOTT:

Q During, quotes, normal operations, what kind of variation in the flux level can you get in a reactor like Allens Creek?

MR. COPELAND: I object to the relevance of that question, Your Honor. The contention clearly is not talking about normal operation. It's talking about accident conditions.

MR. SCOTT: Well, part of your concentration of your gas during an accident is what was already there before the accident started. The witness has clarified that at the very beginning.

JUDGE WOLFE: Why are you asking the question then?

MR. SCOTT: He just pointed out the relationship of the sources of hydrogen coming from what was there before the accident started, plus what was generated in the accident.

I asked a different question.

JUDGE WOLFE: You asked him what hydrogen was there during the operation of the plant, normal operation. It's my understanding that the witness has already answered that.

MR. SCOTT: I didn't remember that as being the question I asked. I guess I'd like the reporter to read back my last question.

(Record read.)

JUDGE LINENBERGER: Mr. Scott, let's try to focus on what you are trying to get at.

The witness has established what is recommended for oxygen and hydrogen concentrations in feedwater during normal operation after sufficient length of time of operation at full power that these concentrations should have reached equilibrium.

Now your question went to, if I remember it correctly, variations in these levels because of fluctuations, I guess, in power level. Is that correct?

MR. SCOTT: I used the word "flux" to mean a consequence of power.

JUDGE LINENBERGER: Now, you need to tie this in here, because as soon as you get to an off-normal situation you have a variation in flux, and so you either need to establish that normal operation can significantly swing these values that the witness has already testified to; or if it can't, then you need to tie in some relevance between the fluctuation of these values to normal operation and what you might get if you have a loss of coolant accident.

So you have to set some perspective here.

Otherwise, we are having trouble with the relevance of the question.

MR. SCOTT: Well, I think your explanations or questions -- I'm not sure which they were -- explains it.

I am not taking the position, I am not trying to prove what the conditions are. I'm asking the witness to explain what they are, and by your questions you can see the relevance of them.

JUDGE LINENBERGER: That's my problem. I can't and --

MR. SCOTT: Well, let me try then. He has stated, as I understood it, for oxygen alone (not hydrogen and oxygen) what the normal feedwater and normal vessel concentrations were.

We have very little, if any, explanation of what, quotes, normal is. Does, for example, normal consider the three -- the six or so yearly transients where the flux can increase 300 percent that was discussed earlier in the previous contention? Is that considered normal?

It's not clear whether or not that was considered normal in calculating these values. That's what I'm trying to get at.

That's just an example. There's a lot of other variations that go on inside the reactor that might very well have not been accounted for in these figures.

MR. COPELAND: Well, Your Honor, if that's where he's going, then I would object. That goes beyond the regulations.

If you look at Appendix K, Section I, Paragraph 5, the Commission has determined exactly how you calculate the rate of energy released from a metal/water reaction rate; and if we are relitigating that issue, I would object.

It seems to me that's exactly where he's going. I think that ties in with what you're saying, Judge Linenberger, that you have a jumping off point here.

MR. SCOTT: I am not challenging any rules or regulations that the Commission has. I am trying to find out within those rules and regulations how much variation can there be.

JUDGE LINENBERGER: I won't speak for the witness, Mr. Scott, but if the answer that he might give is that the variations in the ambient level that occur as a result of routine reactor operations are small compared with the value that might be generated in the event of a LOCA, would that kind of answer satisfy you?

MR. SCOTT: No, for the reason, as I understand, during the LOCA you have to assume a 100 percent reaction between the water and the metal, which would generate a huge amount of hydrogen.

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JUDGE LINENBERGER: Precisely, so if the ambient level above which that huge amount comes into play is small compared with that huge amount, then I have to again ask you what's the relevance of your spending so much time on what is that normal ambient level?

MR. SCOTT: Okay, let me explain that.

As opposed to 80, 90, essentially 100 percent concentration of hydrogen, say, in the reactor and the generation of huge amounts of hydrogen which would increase the pressure considerably and would, in fact, unless somebody overrides something, cause the valves to open and release at least some of that hydrogen, you could instead have a situation where concentrations may be increased to where you had three or four or five or six percent hydrogen.

It didn't increase the pressure inside the reactor vessel significantly at all. It wouldn't cause any valves to open, and yet you could have an explosion which would rip open the reactor vessel.

MR. COPELAND: Your Honor, the witness' testimony says that scenario can't happen because he's saying that you have to have the fuel rods uncovered for a long period of time before you can generate that kind of hydrogen.

MR. SCOTT: He says that. That's why we're talking about it. Him saying it don't make it true.

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In fact, I think we have already uncovered the clinks in that assumption.

(Bench conference.)

JUDGE WOLFE: The objection is overruled, but in the next two or three questions you had better show us some relevancy behind this line of questioning or we'll stop this line of questioning.

All right, Mr. Scott.

BY MR. SCOTT:

Q. Have you answered the last question?

A. I'm not even sure I know what the last question is now.

Q. I know I don't.

MR. COPELAND: It was how much hydrogen was there during normal operation. That's where this whole thing started.

MR. SCOTT: No, that wasn't it, because as you say, he's answered that.

I think that the question was what kind of variations of flux might you get in the reactor. Well, I don't know if that was considered as part of your normal operations to have the 300 percent variation in flux or not, because that only happens six times a year, as an example, as opposed to every 15 minutes.

THE WITNESS: Let me say that the numbers that

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I quoted for the .5 to .7 parts per million were numbers that have been attained on operating plants. So that took into account whatever flux variations might occur; and since what we're talking about for these normal compositions, I'm sure, are somewhat rate dependent, a temporary flux level of 300 percent for a fraction of a second should not affect the equilibrium concentration significantly.

We're talking about, basically, equilibrium types of concentrations of oxygen in the water. If you get much above that, because you are at saturation, because you are boiling, you are going to liberate those gases, and they are going to go down the steam line with the steam.

BY MR. SCOTT:

Q. Why didn't they at Three-Mile Island?

A. Several things happened at Three-Mile Island that we're not talking about happening in a boiling water reactor.

For one thing, there is not a direct connection between the reactor vessel and the steam lines. You have to go through a steam generator, and so you've got a secondary process.

You uncovered the fuel at Three-Mile Island for a considerable length of time, a couple of hours, a couple or three hours, and that was the source of the -- the hydrogen that was generated was uncovering this fuel for

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an extended period of time, and it happened because of a confusion on the part of the operators, which we are saying should not happen on the boiling water reactors because the operator at Three-Mile Island terminated his high pressure injection flow. He thought he was getting the system too full of water. He was measuring it on something other than the vessel itself.

On a boiling water reactor, you measure the water level on the vessel itself and the operator is going to be taking actions to keep the core covered. So under those circumstances you are not going to be generating all that hydrogen.

Q. Well, in remembrance of that accident, they eliminated the hydrogen built up by essentially running the reactor. Didn't hydrogen escape through -- I guess in the main steam line?

A. After the fuel damage that occurred and they had closed the safety valves, they turned the high pressure injection systems back on and filled the vessel with water.

Then you had still in there a large concentration of these non-condensible gases. They relieved primarily through the pressurizer where there was a level -- after they had re-established a water level in the vessel and in the pressurizer. You maintain pressure there by keeping a level of steam and water in that pressurizer itself, and part of the process of maintaining the pressure is a spray valve that sprays water from one of the reactor coolant loops into the pressurizer itself; and the spraying of this reactor water through that nozzle allowed the non-condensible gases to collect in the pressurizer steam space, and then by opening the vent valves -- or the power operator relief valves on the pressurizer, they could then vent these non-condensibles.

That's quite a bit different from the way the boiling water reactor operates.

Q. Okay, but if I'm understanding you right, you are saying the normal operating conditions of a PWR like Three-Mile Island, you would have, essentially, a reactor vessel filled up with water, not steam; is that correct?

A. That is correct.

Q. And after this accident, they refilled it up with water, did they not, that you just described?

A. After they finally realized what had gone wrong, they refilled it with water. That is correct.

Q. Right, and wasn't it under that condition, with a filled-up reactor vessel, that they removed hydrogen from the reactor vessel into the pressurizer, and from there outside the system?

A. That's how they removed it. That's not where

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it was generated.

Q. I'm not asking you that.

Now, if the hydrogen during, quotes, normal operation wasn't able to be eliminated from the PWR at Three-Mile Island, I don't understand why it couldn't build up in an operating BWR, also.

A. It was not the normal concentrations of hydrogen and oxygen that was a problem at Three-Mile Island.

What happened is you uncovered the fuel for a significant period of time, like on the order of two hours.

Q. I understand that's how you generated the huge amount.

A. Right. If you had only had that amount present which would have been present during normal operation, there would never have been a real concern there.

There is a mechanism for removing it in a PWR. It's just not quite as direct as it is on a BWR.

Q. Well, isn't in fact hydrogen partially condensible? Doesn't it dissolve in water to some extent?

A. It can be dissolved, but that's not the same thing as being condensible in water.

Q. What's the difference?

A. Well, the steam is a condensible. You cool it down and it turns to its liquid state, and here you've just got a gas still dissolved in a liquid solution.

Q You've lost me again. What's the difference between hydrogen in steam so far as being condensible?

A. We're talking about condensing the steam as converting it from the vapor state to the liquid state.

Q Okay.

A. All right, and the non-condensible, you're talking about a gas being dissolved in a liquid, which is the water.

Q Based on that, wouldn't we have to consider steam, then, as one of the non-condensibles in the reactor during normal operations of a BWR?

A. No, sir, it's condensible.

Q If it's condensible, why is it steam, then? Why isn't it water?

MR. COPELAND: Your Honor, this is getting ridiculous. I object to any further questions along this line.

JUDGE LINENBERGER: Mr. Scott, you are asking for a lesson in physical chemistry here, and I think this is the wrong place to get it, however interesting it might be.

Let's understand one thing, or two or three things.

The compound involved in one instance is water, which undergoes phase transitions, and it can exist

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as steam, vapor-based, or as water, liquid-based.

In none of the kinds of phenomenon we are talking about in this contention is there a phase change associated with the hydrogen or with the oxygen. It is that lack of phase change within the scope of this contention that causes those to be called non-condensible.

It's obvious that hydrogen and oxygen both are condensible in the sense that they can be made to exist in liquid form.

That's the technical irrelevancy; there is no phase change involved here. So please focus on the things that are involved in the contention.

MR. SCOTT: Well --

JUDGE WOLFE: I'll sustain the objection then.

MR. SCOTT: I was just pointing out that I was in fact pointing out the very thing that you said. Whether or not a particular substance is condensible or not depends upon its physical conditions.

JUDGE WOLFE: The Board has ruled now. Let's not hear any more argument.

Next question.

BY MR. SCOTT:

Q If we had an accident at Allens Creek -- let's back up a little first.

During normal operations, you seem to indicate

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that there's a certain amount of hydrogen and a certain amount of oxygen in the gaseous phase even during normal operations, and what I'm concerned about is in a, quotes, not normal operation, yet not a worst type of accident situation in terms of building up pressures above set points on pressure relief and safety valves, what is there that would keep five percent hydrogen existing inside the reactor vessel for some considerable length of time?

MR. COPELAND: Asked and answered at page 15 of his testimony, Your Honor, in answer to the next-to-the-last question.

MR. SCOTT: I don't see an answer there. Most of a hundred percent, it's fifty percent; most of ten percent is five percent. I don't know. That's not even true.

I don't see anything there that indicates anything that would keep four percent hydrogen from existing in the reactor vessel.

JUDGE WOLFE: Objection overruled.

THE WITNESS: Okay. If I'm understanding what you're asking correctly, you are saying you have some sort of a transient, not necessarily a full LOCA, and you want to know what prevents the buildup of the non-condensibles, whether it's hydrogen or oxygen or whatever.

If it's an event where you do not isolate -- in

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other words, you do not close the main steam isolation valves -- then the steam continues to go, say, either to the condenser or directly to the bypass valves or to the turbine if the turbine is still operating, and so you are continuously venting.

If you have an isolation event, where you close the main steam isolation valves, then the reactor core isolation cooling system, which is often referred to as RCIC, R-C-I-C, is placed into operation by the operator, and that provides makeup.

There is steam that is used to drive the turbine. The pump that pumps the water back into the vessel with that system is a steam-driven pump, turbine-driven pump. So there is some steam going down that steam line.

In the initial part of the transient you could still get some pressurization and the relief valves are used to control the pressure; and, therefore, you would be discharging steam and whatever non-condensibles are present in the relief valves to the suppression pool through the relief valve discharge lines.

JUDGE LINENBERGER: Excuse me, Mr. Scott, but on this point let me ask the witness a question here.

Let's assume that nothing is going into the suppression pool, but steam -- and however the hydrogen

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gets there, steam containing what Mr. Scott would consider to be significant amounts of hydrogen is going through the loop, are there any gas strippers anywhere in the system that extract gases from steam circulating through there?

THE WITNESS: Yes. During normal operation there is a steam jet air ejector which takes the gases out in the condenser itself; but for a transient such as this where you might be isolating it, that might not operate.

But during normal operation, yes, that strips the gases on a continual basis.

JUDGE LINENBERGER: Thank you.

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MR. SCOTT: Okay. Now, what Dr. Linenberger mentioned was what I was interested in.

Let's consider two objects here: First, that the reaction accident -- whatever we're talking about -- did not cause a closing of the main steam valves and, in fact, the -- we'll call it the stripper operation, removing of some kinds of gases is working normally.

Just how does that work, not so much in the chemical or physical sense, but in the sense of how efficient is it in removing the gases per pass through the stripper?

Do you understand what I'm saying?

THE WITNESS: I understand what you're asking. I don't know what the efficiency of the steam jet air ejector is, though.

BY MR. SCOTT:

Q Do you have any approximate ideas? I mean, it would seem to me that if ... oh, if 99 -- or maybe 90 percent of the gases were removed by the time it went through there, then that would seem to largely solve the problem.

A I would think that the equilibrium values of the objects that we've discussed earlier -- being very low -- in the .5 and .7 parts per million range would show that it is a reasonably efficient process.

But I can't give you an efficiency number.

Q How often does the gas steam cycle through that system?

A This is a continual process --

Q Right.

A -- it goes through there.

Q If I dumped a cup full of hydrogen into the reactor vessel and flipped the switch, after a certain length of time, all that cup would have had a chance to go through the loop.

A Right.

Q And I don't know if it goes through the loop three times a second or --

A I don't know the answer to that.

Q Okay. If it takes a long time to strip the gas, then wouldn't it be possible for an appreciable build-up, in the sense of several percentage points, to build up even with a relatively slow generation rate of hydrogen?

A This is being stripped for the water that would be returned through the condensate line into the feedwater. So for the whole operation, you're seeing concentrations in the feedwater, including whatever -- you know, the -- considering the fact that you've having to strip some off there ... is kept in the parts per billion, not the parts per million range.

Q Doesn't feedwater include freshwater --

MR. COPELAND: Your Honor --

MR. SCOTT: -- water that hasn't been sent through the reactor vessel previously?

MR. COPELAND: Your Honor, I object to any further questions along this line. This is right back to the discussion of how much hydrogen is generated during normal operation.

And this contention talks about abnormal operation and cites as the basis for the contention the creation of a hydrogen bubble at Three Mile Island.

MR. DEWEY: I might add, Your Honor, that a little while ago you did say that he would have just a few more questions to sort of tie this all in, about the normal hydrogen.

I don't think he has tied it in at all.

MR. SCOTT: I thought that Dr. Linenberger's question showed how it was tied in.

JUDGE WOLFE: Well --

MR. SCOTT: It's clear that I have shown that there could be normal operations ... there can be loss-of-coolant accidents, and there can be many variations in between.

Right now we're talking about a variation in between, in terms of the magnitude of the rate generation of the hydrogen.

In fact, it is the sum total of those rates -- if the hydrogen generation that are greater than normal operation and less than that required to open the safety and relief valves.

JUDGE LINENBERGER: Mr. Scott, I think the problem here is -- at least as the Board sees it -- your questioning so far has not elicited that any mode of operation short of that following a loss-of-coolant accident is going to sufficiently perturb the ambient concentration level of hydrogen in the system to permit concentrations even approaching flammability, much less detonability.

So, absent your tying in something here which shows that, the Board is reluctant to allow this line of examination to continue.

MR. SCOTT: Well, Your Honor, I agree with that. The only problem is that I don't think the burden is on me to show that that can happen; I think the burden is on this witness to show why it can't happen.

And he has neither -- he has not shown why it can't happen neither. I'll grant you he has made a bald statement that at the LOCA condition that relief valves will open. I'm not disagreeing with that.

But he has still not refuted the possibility of hydrogen building up to significant levels and other conditions.

I've been asking mostly the kinds of questions that would enable him to -- by explaining generation rates, recirculation rates, stripping rates, make some sort of logical explanation of that point. And he so far has been unable to.

The question is where are you going to put the burden.

JUDGE LINENBERGER: Well, I think we're going to put the burden on you because in none of your questioning so far have you elicited from the witness any basis for believing, as I said before, that short of a LOCA incident you will get ambient hydrogen concentration levels that are worrisome with respect to limits of flammability or detonability.

You have been asking this, and asking this, and asking this of the witness. He has given you answers. And each time you come back to the fact that one way or another the system -- and you yourself say you're not talking about a LOCA, although that is what the contention addresses -- the witness has answered that the system is able to take care of itself with the kinds of conditions you have been talking about.

Now then, the Boar' sees no reason to continue in this vein -- and we really think you had better be getting back to the LOCA condition, which is the subject of the contention.

JUDGE WOLFE: All right. The Board will rule that this line of cross-examination is ended; you will go to your next series of questions.

We will now recess until a quarter of 2:00.

(Whereupon, at 12:30 p.m. the hearing was adjourned, to reconvene at 1:45 p.m. of the same day.)

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AFTERNOON SESSION

1:45 p.m.

JUDGE WOLFE: All right.

Mr. Scott.

BY MR. SCOTT:

Q Mr. Hodges, as I remember, just before the break, we have to talk about now the other-than-normal operating conditions. So I want to talk about where we have a loss-of-coolant-water condition.

Are you aware of the water/metal reaction rates is a function of temperature of the metal?

A Yes, I am.

Q How does that work?

A It's an exponential function. I don't have the formula in my head. It starts to be significant above about 1800 degrees Fahrenheit. Below about 1800 degrees Fahrenheit, there's no appreciable metal/water reaction.

It's a recipe that's available in the open literature, and you can find reference to it, I think, in Appendix K.

Q It's going up exponentially as a function of --

A -- of temperature.

Q -- Centigrade absolute temperature?

A It's going up as a function of temperature,

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regardless of which unit you put it in.

Q. Okay. What's the normal operating temperature of the reactor, in terms of degrees Fahrenheit?

A. Are you referring to the cladding temperature?

Q. Yes.

A. Okay. The coolant is -- saturating conditions and you're in boiling, and then under those conditions the cladding temperature will be on the order of 10 to 15 degrees higher temperature than the saturation temperature.

The saturation temperature is about 544 degrees, so --

Q. Fahrenheit?

A. Fahrenheit.

-- so we're talking about a temperature of approximately 560 degrees Fahrenheit.

Q. Okay. What does that temperature go to if you've got the -- cladding temperature, what does it go to if you've got the fuel uncovered with water per se, a liquid state, but it is still blanketed with steam?

A. It depends upon whether you're talking about blanketed with stagnant steam or whether you have significant vapor generation, for example, in the lower portion of the fuel or from flashing, so that you get steam velocities sufficient to provide cooling.

If you have -- for example, if you maintain the water level at the mid-plane of the fuel or above, so that you have up to half of the fuel uncovered, the maximum cladding temperature would still not exceed 2200 degrees Fahrenheit.

But if you dropped it down lower than that for an extended period, you would indeed go above the 2200 Fahrenheit.

Q. What you uncover -- Well, okay.

I assume you're talking about the temperature up near the top of the fuel bundle?

A. That's correct.

Q. I take it the temperature down under the covered portion is still around the 560 range?

A. Whatever the saturation temperature is; you may have depressurized somewhat, and the saturation temperature will drop down as the pressure drops down. And so you're still staying a few degrees, on the order of 10 to 15 degrees Fahrenheit, above the saturation temperature.

Q. Okay. Do any of the relief valves --

A. One other point, too.

The 10 to 15 we're talking about, that's when you're operating at near full power. As you drop the

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power down, for example, a reactor scram following the initiation of the LOCA, the power level drops down -- the heat generation drops down, and the temperature difference goes down.

So now you may be talking on the order of two to three degrees difference. There is a slight dependency on power level there.

Q. Okay. The -- Other than the way they -- the pressures they open at, is there a difference in the relief and the safety valve operation?

A. There's a difference in how they are opened. They're the same valve. The difference is how you open the valve.

Q. A difference other than -- Okay. They use different sources for the pressure; is that the difference?

MR. DEWEY: Your Honor, this was the source of previous testimony. I don't know if Mr. Scott was here when we had testimony on the pressure/relief valve.

But this was thoroughly covered in other testimony.

MR. COPELAND: I would agree with that, Your Honor.

MR. SCOTT: I don't know how thoroughly it was.

I haven't heard anyone say the question I asked has been asked and answered.

MR. COPELAND: It has been.

JUDGE WOLFE: Sustained.

BY MR. SCOTT:

Q Does the safety valve -- How does it get closed once it has been opened?

MR. DEWEY: The same objection.

MR. COPELAND: The same objection here, Your Honor.

JUDGE WOLFE: Sustained.

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BY MR. SCOTT:

Q How does the relief valve get closed after it has been opened?

MR. DEWEY: The same objection.

MR. COPELAND: The same objection.

JUDGE WOLFE: Sustained.

BY MR. SCOTT:

Q Now what, if anything, is there to keep the valve -- safety/relief valve from being opened for a while and then closing by themselves? By that I mean just in response to the pressure dropping back down as opposed to somebody saying, "Now you must close"?

MR. DEWEY: Your Honor, I believe the spurious openings and closings of the relief valves has already been covered in the testimony.

MR. SCOTT: I'm not talking about anything spurious.

MR. COPELAND: I would have a different objection, Your Honor. It seems to me that the operation of those valves has been covered thoroughly, and that is really not at issue in this contention.

MR. SCOTT: I hope to show relevance of valve operation to hydrogen concentrations in the reactor vessel.

(Bench conference.)

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JUDGE LINENBERGER: Mr. Scott, the problem here is that the Board does not see a relevance; and you indicate that in your thinking there is relevance between valve operation and the achievement of an undesirably high concentration of hydrogen.

I think, Mr. Chairman, we might defer ruling on that objection for another question or two, to give Mr. Scott an opportunity to demonstrate that relevance. But absent tying it up, then I think we would have to ultimately sustain the objection.

JUDGE WOLFE: I will overrule the objection for now.

MR. SCOTT: I forget the last question, unless you remember it.

THE WITNESS: Not exactly. It has been phrased several ways.

BY MR. SCOTT:

Q Assuming we have had a true-life LOCA-type accident that has been going on for some time and then pressure drops back down below the set points for those valves, such that they would then automatically close, what do you know of that is to prevent hydrogen concentrations within the reactor vessel, after they have been closed, being higher than four percent?

MR. COPELAND: Can I ask a clarification, Mr.

Scott? Are you assuming LOCA is then terminated?

MR. SCOTT: Yes.

MR. COPELAND: Then I would object to that question, Your Honor, because we're right back to the normal operation, where you told him to go away from that, when we broke for lunch.

MR. SCOTT: Mr. Chairman, just because the LOCA reaction has been terminated doesn't mean we can't inquire into the consequences and the conditions that are left after that LOCA.

MR. COPELAND: That's why I asked my question, Your Honor, was he assuming the LOCA was terminated. If it is, then it seems to me you're back to normal operation.

MR. SCOTT: My definition of the LOCA being terminated means the fuel is now covered.

MR. COPELAND: With water?

MR. SCOTT: With water.

MR. COPELAND: Then you've got no hydrogen generation problem, by the witness' own testimony.

MR. SCOTT: I'm talking about the hydrogen that was generated during the LOCA that's not getting removed because all of a sudden the valves -- the escape point has been closed off.

MR. COPELAND: All right. So the scenario is that the LOCA has ended, the fuel is covered, and the pressure has dropped to the point that the valves can close again?

MR. SCOTT: Yes.

MR. COPELAND: All right.

THE WITNESS: Okay. I think I understand what you're asking.

In the first place, if you're in that situation, you still have some decay heat generation. You're in either one of two situations: Either you're isolated -- you've got the main steam isolation valve closed and no feedwater coming in, et cetera, in which case the decay heat is going to build the pressure back up again, and the relief valves are going to open; and this is going to occur relatively soon.

So there's not going to be a very long time to get any build-up of the non-condensables. If you don't have that situation, if you've got the main steam isolation valve open, then you can be dumping the steam that's being generated, as well as the non-condensables, to the condenser, and again there's not going to be a build-up.

BY MR. SCOTT:

Q Well, under the scenario that I was assuming, the build-up is already there. And there's nothing

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left, except some sort of possible decay.

A. First, you have to have postulated that you had the situation where you had no vent path while you were building it up. And I don't think we've discussed that possibility yet.

You either have the break and you're depressurizing through the break; or you've got a relief valve open, or you've got a RCIC system running with the steam going to RCIC turbine; you've got multiple vent paths.

So if you are assuming the fuel is uncovered for a period of time, while this is uncovered there is still multiple sources for venting any hydrogen or oxygen that is generated.

Now, you're saying once you recuperate -- you recover with water then and the valves close -- I thought that's what you were asking. That's what I was responding to.

Q. I am. That's what I was asking. The thing that you and I seem to be differing on our emphasis is that I am assuming -- tell me if it's incorrect -- but I am presuming that during this LOCA we've got a situation where we're generating rapidly huge amounts of hydrogen that we might in fact have a huge percentage of the gases escaping being hydrogen.

A. Well, that's part of the testimony I have is that for the small-break situation, which is the one where -- you've got to worry about the pressure staying like that and not having a vent path, that you've got several systems which are capable of putting water in.

You have an unambiguous indication of the water level, so the operator can maintain the water level in the vessel. He never uncovers the fuel, and it doesn't get there in the first place.

Q. Okay. Now, for the large break?

A. For the large break, it's not going to re-pressurize, and you'll continue to vent through the break.

Q. Could the large break be a valve that was open and later closed?

A. You can postulate such a thing, yes. First off, a valve which was open -- I'm assuming you're -- unless you're talking about like a relief valve being open and then later closed, there are no large valves on the vessel that will give you a break like that.

You have to have a breach of a pipe or something, in addition to that valve being open and then later closed.

Something like a relief valve, it's still not in the really big break category. And it's also a steam discharge, so -- and it's at the top of the vessel.

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Your systems can make up the inventory losses quite readily.

I don't understand where you're coming from.

Q. You seem to be saying we can't have a small-break LOCA?

A. No, that's not what I said. What I'm saying is it's extremely unlikely you will have a small break LOCA .n which you uncover the fuel for any sufficient time, so that you get all of the hydrogen or oxygen generation that we're trying to discuss, the reason being that the operator knows where his water level is; he has multiple sources of indication of t. . The level is measured directly on the vessel, and all ot e operating procedures direct him to provide makeup to the vessel, to get the level back up, so he won't uncover the fuel.

Q. Has the No. 1, the Commission as a result of Three Mile Island, required that there be some method of detecting hydrogen inside the reactor vessel for any type of nuclear power plants?

A. Since I have been following primarily the boiling water reactors, I'm not sure exactly what all has been done on the PWR's. It has not been required on the boiling water reactors.

There are requirements that they be able to

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take samples and analyze what's in the sample. And that's for both PWR's and BWR's.

But that's different from what we're talking about here.

Q I don't see the difference. Why would you have to have the ability to take a sample on a BWR, if there could not be dangerous concentrations of gases built up? Why would they make that a requirement?

A. The sample would not just look for gases. It would look for gases, particulates.

Q I thought I had understood you to say they specifically would have to be able to take samples of hydrogen.

A. No. I'm saying samples of the coolant and analyze what's in the coolant.

Q Okay. You don't know of a Commission requirement of PWR's that requires the ability to take samples of the hydrogen concentrations inside the containment?

MR. COPELAND: That's a different question.

THE WITNESS: That's different. You said "inside the vessel."

BY MR. SCOTT:

Q You're right. I mean inside the vessel.

A. No.

Q Okay.

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What is the -- under a large break condition -- under whatever is allowed to be the worst type of condition, so far as the fuel being uncovered, the maximum generation of hydrogen from the water/metal reaction taking place, what kind of maximum concentrations of hydrogen is expected to be able to occur inside the reactor vessel?

I am presuming that it's generated at a certain rate, escaping out through the holes at a certain rate. At some point there is a concentration of hydrogen.

Do you happen to know what that concentration is?

A. No, I do not.

Q. Do you have any ballpark feelings?

A. We know what total hydrogen generation is for the worst cases. It has been calculated.

Q. You mean because it says, "We've got a certain amount of metal, and it's going to all react to generate hydrogen"?

A. No, the calculation shows what fraction of that metal reacts to generate hydrogen.

Q. Isn't it 100 percent?

A. No, sir.

Q. What percentage is it?

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A. There is a limit that Appendix K requires, of like 17 percent.

But that is calculated for a BWR-6, in the neighborhood of 1.5 percent, if I recall correct. 1.3 to 1.7, somewhere in that range.

Q. Well, maybe you can clarify this for me. I thought after Three Mile Island there had been a requirement that you would have to consider the pressure build-up for 100 percent water/metal reaction.

My knowledge of it is what you're talking about is what happened before that latest change.

MR. COPELAND: You asked him that as a matter of fact, of what the calculation shows; and now you're asking him what the regulations require consideration of, Mr. Scott.

MR. SCOTT: I meant to be asking what the regulations required. Surely, we wouldn't have silly regulations.

THE WITNESS: Some people may disagree with you on that.

I'm not aware of one that shows that. Maybe you can point one out.

BY MR. SCOTT:

Q. I think it has to do with the rulemaking on ATWS.

MR. DEWEY: Your Honor, unless Mr. Scott can be more specific, I move we move along to some other line of questioning.

MR. SCOTT: I'm trying to find the thing that I was reading during the lunch hour. I'm confident the Staff's attorney knows where I could come across a hundred percent. Maybe if he could help, what the hundred percent related to.

(Pause.)

BY MR. SCOTT:

Q. Would it change your answer if I was asking you about the amount of water/metal reaction that was required to be considered under the degraded core accident rulemaking insofar as keeping the containment hydrogen concentrations at safe levels?

MR. COPELAND: I object to that question, Your Honor. That goes beyond the scope of the contention. The contention talks about hydrogen build-up within the reactor vessel itself.

MR. DEWEY: I agree with that objection.

MR. SCOTT: What was the objection again? Because we're talking about containments instead of reactor vessels?

MR. COPELAND: Yes.

MR. SCOTT: That I don't think is a valid

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objection.

MR. DEWEY: We've already had testimony of the hydrogen in the containment.

MR. COPELAND: That's correct. The Staff's witness was Mr. Mel Fields. He has testified on that subject.

The Applicant called Mr. Weingart and Mr. Robertson. We've already gone into that contention.

MR. SCOTT: I am not asking this witness or anybody to consider hydrogen concentrations and build-up in the containment.

I am only pointing out the degree of water/metal reaction that has to be considered in calculating that hydrogen concentration in the containment.

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MR. SCOTT: We operate in a world of consistency. And it's required -- you know, the hydrogen all comes from the containment, it all comes from the same place.

So if you have to consider a hundred percent of one, you have to presume that a hundred percent is possible ... you know, it had to go through the reactor vessel to get to the containment.

MR. COPELAND: Well, Your Honor, I don't see where this is going. The witness has testified repeatedly that it's all going to be swept out of the reactor anyway, so it doesn't matter whether it's a hundred percent or 90 percent, or whatever the percent is.

That's his testimony.

MR. SCOTT: First of all, his testimony doesn't say anything about it all being swept out. He uses the word "most."

JUDGE WOLFE: Then why don't you get to the ultimate question and question him directly about that, Mr. Scott?

Once again, I don't think really we're getting -- you're not boring into the meat of the contention and the meat of this witness' testimony. I really don't.

And I don't know why you just don't ask direct questions. You can expect an expert to give an honest answer.

If you don't get an honest answer, we'll know that it's not honest, and you can home in on that.

But, ask your questions.

MR. SCOTT: Okay.

BY MR. SCOTT:

Q What --

JUDGE WOLFE: And I will sustain that objection, Mr. Scott.

BY MR. SCOTT:

Q What is the maximum concentration of hydrogen generated in the reactor vessel during a loss-of-coolant accident?

MR. COPELAND: That question was answered by the witness previously, Your Honor. He said he had to know the conditions of the loss-of-coolant accident, depending on what kind of -- what the state of the steam was in the reactor vessel.

MR. SCOTT: That's no answer. When you ask a question of maximum, and he just goes through all those states, he just picks out the one with the biggest number.

MR. COPELAND: Well, I'll withdraw my objection. Go ahead.

THE WITNESS: The problem I have with answering

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your question is I have never seen a number that says, "This much hydrogen is in the vessel at any one particular time."

I've never calculated that number. The problem is that you're continuously venting steam, you're venting the hydrogen, you're venting oxygen. And as it's being generated, it's being vented. So --

MR. SCOTT: Okay, fine.

BY MR. SCOTT:

Q. At the point that you close the reactor vessel again, even if no more is generated, you've captured whatever was -- the concentration was that was going out at the time that it was closed off. That's what I want to know -- what that concentration is. If you don't know, which apparently, is your answer, say you don't know.

A. I don't know.

MR. SCOTT: No further questions.

JUDGE LINENBERGER: Mr. Scott, I have to observe here that the question you put to the witness, I think, is not capable of being answered without further specification of conditions and parameters.

It's a broad loose question that just is incapable of being answered, and the witness chose not to argue with you and said he didn't know; and I think it's --

for -- as far as I'm concerned -- for obvious reasons having nothing to do with his technical competence.

Now, it's your privilege to desist, to stop your cross-examination at this point. But I am just constrained to say that I think you have put an impossible question to the witness.

MR. SCOTT: Well, I'll try to flesh that out a little bit.

BY MR. SCOTT:

Q Do you want to put some conditions on your answer? Are there some conditions where, in fact, you could tell us what the concentration would be?

A The only one that I have a direct number in my hand today would be for the normal operating conditions. And we know that as long as you stay less than 1800 degrees Fahrenheit, that there is very little additional generation.

For the worst case situation, where there's like a large break LOCA, where there are calculated temperatures in the neighborhood, but not exceeding 2200 degrees Fahrenheit, then for a BWR-6 type of reactor, you're talking about conservative calculations showing something on the order of 1.5 percent of the hydrogen being generated -- that would be capable of being generated, if all of the cladding were oxidized.

5-28

I have not tried to convert that into a percentage of oxygen -- you know, in volume percent; and I don't have the capability to sit here and do it at the table.

But under that situation, I'd say there's no reason for there to be a build-up because you've got a big hole in the vessel.

Q. This 1.5 percent, if I'm understanding you right, is the -- that's the amount of hydrogen generated under the -- I guess pretty bad, if not worse case -- allowed anyway -- loss-of-coolant accident, where you can reach temperatures of around 2200 degrees Fahrenheit for, I guess, some significant amount of time.

Is there any limit on the time that it stays at 2200?

A. Well, the amount of hydrogen that you generate is time dependent. It's just time at temperature. So it's how long you stay at those high temperatures.

Q. But to get the 1.5 percent, that has got to be based on some length of time?

A. It's based upon a length of time in the calculation, that's right.

Q. Do you know what length of time that is?

A. I can only give you a ball park number. The total transient is just turned around, and the temperatures

5-29

are well back down in the normal range for these calculated cases on the order of 300 seconds, so the time that you would be at that elevated temperature, you may be talking about 100 seconds, for a ball park number.

Q. Okay. Now, hydrogen is a gas, light weight, fills some space rapidly.

Do you have any idea, based on the amount of metal in the reactor, what kind of volume of -- volume, standard temperature, pressure -- of hydrogen gas would be generated if only 1.5 percent of the total metal that could have reacted has, in fact, reacted?

A. I haven't done any calculating. I don't know that number, no.

Q. Would you have a rough idea? All I'm trying to get at is whether or not --

MR. DEWEY: Your Honor, I think the witness has already stated that the gas would all be vented. So I don't know what the relevance is in him determining what the number would be.

MR. SCOTT: Mr. Chairman, he has not said all of the gas would be vented.

And even to the extent he said most of it would be vented, I'm trying to show that there are scenarios which, even if most of it had been vented, you could be capturing concentrations that were above four

5-30

percent.

I have to be careful and not try to mix up this 1.5 percent. That's not -- the hydrogen concentration of the reactor vessel is 1.5 percent; it's just that 1.5 percent of the metal is reacted.

And it may be that one-tenth of one percent of the metal reacting, you could generate enough hydrogen to fill up that reactor vessel three times.

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JUDGE WOLFE: Objection overruled. Answer the question.

THE WITNESS: What am I answer now, what question?

BY MR. SCOTT:

Q. I'm trying to find out what -- What I'm really trying to find out is what would be the hydrogen concentration under those conditions where we've got loss of coolant, we're generating hydrogen at the maximum rate which we're allowed to think about it (or that you have so far, anyway), and then the opening is closed off.

At that point you have captured whatever the conditions were for hydrogen at that time.

A. I think I've already answered, I don't know what the volume of hydrogen would be.

I can say that the reason for the "most" rather than "all" in the testimony is because at any pressure or set of conditions you can reach an equilibrium where you've got a small fraction of the hydrogen or a small fraction of the oxygen, each contributing their own partial pressure to the total pressure that is there. And even if your system is all the way down at atmospheric pressure, you will have vented essentially all of the gases out of the vessel, but you will never eliminate altogether everything that is there.

The "most" is a qualifier saying you will never get rid of everything. That's not to imply that there's still going to be a large concentration.

JUDGE LINENBERGER: Mr. Hodges, backing into that word "most" from the opposite direction, what does it mean with respect to the amount of hydrogen necessary in the vessel to produce a flammable concentration?

THE WITNESS: For hydrogen I'm not sure. I think for oxygen it's about four percent. I'm not sure how much hydrogen.

JUDGE LINENBERGER: I'm asking you the significance of the word "most" in that context.

THE WITNESS: Yes.

JUDGE LINENBERGER: Does "most" mean that there's no way you can be left with concentrations that high, or does "most" mean something else?

THE WITNESS: Yeah, "most" means that you would not be left with concentrations nearly that high.

They are concentrations that would be on the order of what you would see, I presume, during normal operations. Once you've vented the thing down to atmospheric pressure, if that's where you are down at, you just can't vent any further; you've got a stagnant mixture of steam and these non-condensible gases.

These contribute some of their own partial pressures into the water that's there. It's an insignificant amount, but rather than say "all."

JUDGE LINENBERGER: Thank you.

BY MR. SCOTT:

Q. I take it based on that answer, you are saying then that you do know the maximum concentration inside the reactor vessel of hydrogen gas will be less than four percent?

A. Yeah. You are generating -- you are venting it the full time you are there, and so I see no real mechanism for getting it up to four percent.

Q. Well, there must be some way to calculate what percentage of the atmosphere in the reactor vessel is hydrogen under the conditions that you've just got enough steam reacting with the metal to generate hydrogen at the maximum rate.

It is possible, I could imagine, to have enough water around to react that it would somehow mean that you'd still have mostly steam in the reactor vessel.

On the other hand, that's not totally clear. I can almost imagine that you could have a situation where you had almost a pure 100 percent hydrogen flow through the containment, just enough steam that was there down in the bottom -- a little water there at the bottom and it could be totally reacting to convert to hydrogen so that by the time it got to the top of the reactor vessel, no steam and all hydrogen.

JUDGE WOLFE: Now what is your question?

MR. SCOTT: I want to know why that scenario can't be true where you've got essentially 100 percent hydrogen in the containment.

MR. COPELAND: I object to any question about hydrogen in the containment. That's beyond the scope --

MR. SCOTT: Well, I meant reactor vessel.

MR. COPELAND: Well, I would object to that, then, as asked and answered.

This witness has explained why the scenario like he's explained it just can't happen, Your Honor.

JUDGE WOLFE: I'll sustain the objection, Mr. Scott.

Now, the witness has said what he's said. You may well disagree with him and we've given you a shot at asking the question and follow-up questions; but when you repeatedly ask the same questions and go around again, it's just taking up our time.

MR. SCOTT: He can make a statement and then I'm allowed to impeach that statement, and that's what I'm doing.

Granted, he has said what he said initially when he climbed on the stand about most of it would go out the hole.

I'm asking now why it is that condition can't exist where it would be pure hydrogen.

MR. DEWEY: He just answered that question.

MR. SCOTT: No, he didn't. You all objected before he said a thing.

JUDGE LINENGERGER: Mr. Scott, he answered that question when it was posed by me as to what was the significance of the use of the word "most," and he said --

MR. SCOTT: He didn't explain it.

JUDGE LINENBERGER: -- that significance was that the amount remaining would be small compared to anything that was worrisome from the point of flammability.

Now then, that is an answer to your question. If you don't like that answer, you have two options: Accept it or ask other questions to determine what is the basis for that conclusion, but don' keep repeating the same question.

MR. SCOTT: Perhaps I'm doing that awkwardly, but that's what I was trying to do, to get at the basis. Instead of asking leading questions, I was giving all sorts of background and saying this is the conditions, a small amount of water coming in --

JUDGE WOLFE: Your question to the witness now?

MR. SCOTT: Essentially, it's the one you overruled based on the --

JUDGE WOLFE: That's right.

MR. SCOTT: Okay, I'll do it slowly.

BY MR. SCOTT:

Q What is your basis for saying the maximum hydrogen concentration generated in the reactor vessel would be less than four percent, even under the conditions that almost all of the water is gone out of the reactor vessel, there was just a small amount of water reacting with the metal in the lower portion of the reactor vessel, such that by the time the steam reacted -- it wasn't steam anymore obviously, because it was now hydrogen and oxygen?

A What I said --

JUDGE LINENBERGER: Mr. Hodges, you are more patient than I am. To me that is an incomprehensible question.

You had very little water reacting with the clad, and then you went into a long exposition, Mr. Scott, about whether there would or would not be steam, and you've left the parameters of that question so vague, so confused, that there's no way the witness can give you a meaningful answer. You've got to tighten it up, and you keep forcing the witness into accident parameters and configurations that are not consistent with, as he keeps trying to explain to you, BWR behavior as the Allens Creek design will dictate.

Now, I'm trying to help you, Mr. Scott, but jeepers, you are not getting anywhere and your questions are not giving the witness anything to get his teeth into.

MR. SCOTT: I don't know what to say. It seems like a simple straightforward clear question. Where's the confusion?

If you'll mention that, I'll tell you what -- What's the uncertainty in my question, and I'll put a limit on it.

JUDGE LINENBERGER: In the first place, I have not heard you describe a realistic off-normal configuration of the contents within the reactor pressure vessel upon which to base a question that is meaningful for the witness to answer.

That is my problem.

JUDGE CHEATUM: My problem is this. Your scenarios are incredible, if not impossible.

MR. SCOTT: Well, it seems like the witness should say that.

(Bench conference.)

MR. SCOTT: One of the problems....

JUDGE LINENBERGER: Mr. Scott, one of the most obvious questions I think you might want to ask the witness is whether or not there are any remotely conceivable accident scenarios wherein the behavior of the

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insides of the reactor pressure vessel would not be in accordance with his testimony and might result in objectionable concentrations of hydrogen.

You are trying to invent scenarios, and so far you haven't invented one that is meaningful; but perhaps there are some that the witness knows about and could tell you about wherein things might not behave the way his testimony indicates that it would be expected to behave.

Now that's a possibility you might want to explore.

BY MR. SCOTT:

Q. Mr. Hodges, what this whole thing most of the day comes down to, the real basics, the real bottom line, is what is the relationship or the ratio between the rate of hydrogen generation and the rate of removal of the hydrogen in the reactor vessel?

That's what it comes down to. Now, I've tried to ask you numerous times to give me numbers for both or either of those numbers. So far I don't have any feeling of confidence that you know either of those numbers. If you do, please explain it to me.

A. I think I've said I can't give you the exact volumetric hydrogen generation rate, except --

Q. Give me ratios.

A. Let me go a little bit further.

While you are in the process of generating this hydrogen from this metal/water reaction, that's because you are oxidizing the cladding, and so in the process of doing that you are taking up the free oxygen.

Now, to get the flammable mixture you've got to get up to a four percent oxygen. It's not just a hydrogen concentration; it's also an oxygen.

So you are talking about a four percent oxygen, and I don't think you've postulated any source for the oxygen in the vessel. We're talking about in the vessel.

Q Have you responded to my question? I don't remember asking you anything about oxygen.

JUDGE WOLFE: That's a question not to be asked of the witness. If you don't think the witness has answered your question, tell him so and state it all over again.

MR. SCOTT: I ask that his answer be struck because it was not responsive.

(Bench conference.)

MR. DEWEY: I feel that the witness was attempting to help Mr. Scott and it is relevant to his question.

MR. SCOTT: No. My question was very simply the ratio between the rate of generation and the rate of removal of hydrogen.

MR. COPELAND: Wel Your Honor -- excuse me.

MR. SCOTT: Another question is about the four percent of oxygen, but we'll get to that later.

MR. COPELAND: Well, I think that in explaining the rate of hydrogen generation that the witness was explaining that that is absorbing oxygen, and that that is a relevant factor that has to be taken into consideration.

So I think it was at least partially responsive to the question.

The problem he keeps putting the witness in is he keeps asking the witness questions that are not answerable; and I think Mr. Hodges is showing a remarkable degree of restraint here in trying to explain things to him. He keeps having to explain them over and over again, and it's incredible that Mr. Scott would now move to strike his testimony.

MR. SCOTT: Mr. Chairman, I agree that Mr. Hodges has been very patient. I wish all the witnesses were this patient, but included in the answer of removable of hydrogen, if Applicant's Counsel is correct, would be considered the removal of hydrogen by the reaction with oxygen.

It generates two hydrogen molecules and one of them reacts with the oxygen and then there's only one left. That would be part of the removal rate and that

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would be in the question. If it is, explain it, and I won't object to that portion of it.

(Bench conference.)

JUDGE WOLFE: The Board has consulted. We think the answer to the question was responsive. Motion to strike denied.

BY MR. SCOTT:

Q. Okay, now, considering the total methods of removal of hydrogen and total methods of generation of hydrogen, what's the approximate ratio of the two under the case where hydrogen concentration would be increasing at its maximum rate? I mean net generation of hydrogen increasing, considering losses and gains.

A. I don't know.

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Q. How can you know the vent leads to concentrations of less than four percent hydrogen?

MR. DEWEY: He's answered that.

THE WITNESS: I didn't say four percent hydrogen. I said four percent oxygen.

You are the one, I think, that said it was four percent hydrogen. I think that's still small, but.... I think it's on the order of that, but I don't know an exact number for the hydrogen.

BY MR. SCOTT:

Q. So you don't think the flammability limits for hydrogen is four percent?

A. I think you'd have to have four percent oxygen in order to get the four percent. I'm not sure what the hydrogen concentration is that's required, but without more than four percent oxygen it won't be flammable.

Q. Are you now saying you don't have any idea what the concentration of hydrogen would be in the reactor vessel? You are not even saying that it would have to be less than four percent?

A. I'm saying it can't build up to any substantial amount because you've got the vents. I can't give you a number of what it would be.

Q. How can you know it won't be a substantial amount if you don't know the generation rate and the removal rate? I'm not trying to be hard with you, but this is just purely logic. Without knowing those two terms, you can't know net result.

Someone may have told you, you may hope, but how can you know? That's the question. Is there some other way you can make it clear?

A. The venting capability will take out extremely large volumes of gases. I don't know the absolute ratio of these numbers. I can't give them -- I think the venting capability is much larger than the generation rate of the hydrogen that you're talking about, but I don't know the ratios.

Q. Then why do you even think that the generation rate would be less than the removal rate?

A. That's -- I don't have a good answer for that. I really don't know the generation rates, so I can't give you an extremely good answer for that.

MR. SCOTT: No further questions.

JUDGE WOLFE: Mr. Doherty.

CROSS-EXAMINATION

BY MR. DOHERTY:

Q. Well, would it be true, then, that in order to -- well, let's get up a minute here.

Didn't you testify earlier that there was what I think you called radiolytic decomposition of water

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in the RV?

A. Yes.

Q. Wouldn't that make some oxygen available?

A. That's a process that's going on whenever the reactor is operating, yes.

Q. Well, wouldn't that make some oxygen available in the event of some situation where hydrogen began to be generated, or would that oxygen be, in your opinion, out of there too fast?

A. Well, I think I quoted the amount of oxygen that is present normally as being in the vessel in the range of .5 to .7 parts per million.

That's considerably less than the four percent that's required for flammability.

Q. Okay. Now --

A. And that's considering the radiolysis and whatever.

Q. Would it be your belief that for any oxygen to be produced because of consequences of the LOCA that there would have to be -- I'm not saying this is possible at this point -- a hundred percent oxidation before you could get any oxygen free to explosively combine with hydrogen?

A. You are asking me basically if the oxidation of the cladding takes up more oxygen than is broken down through the radiolysis.

I really don't know the answer. I don't think radiolysis makes more, but I can't give you a definitive answer.

Q. Well, I was trying to get away from radiolysis. What I was trying to get at was the metal/water reaction considered alone -- I think you stated earlier that there would be no -- that the oxygen from any molecule of water that produced hydrogen would have to be used up or taken up by the zirconium in the oxidation of the zirconium or the clad, whatever it is. Is that right?

A. You are having an oxidation process with the cladding and so you are taking up oxygen that's available while you are doing that, yes.

I'm not sure I answered that in exactly the same way you asked it, but I'm not sure I understood exactly what you've asked.

Q. Is the zirconium such a strong oxidizer, that is, has such a strong affinity for the oxygen that it would take any oxygen out of that?

A. Once you get up to the point where this oxidation process -- excuse me -- this metal/water, then that's a very rapid process, yes, and a very strong process.

Q. Would you say it's sort of like a protective process against the generation of hydrogen/oxygen explosion?

A. I don't normally think of it in terms o. a protective process since it generates a lot of heat; but yeah, it should consume a fair amount of oxygen.

Q. I think Mr. Scott a moment ago located something with regard to a rulemaking where they apparently were considering the probability of a hundred percent oxidation of the zirconium cladding.

Do you feel that that's reasonable to even consider such a thing, or do you think that's just being super conservative?

MR. COPELAND: Are you talking about for purposes of generating hydrogen in the reactor, Mr. Doherty, or in the containment?

MR. DOHERTY: I'm really not thinking in terms of either of those. I'm thinking of it in terms of just doing that.

BY MR. DOHERTY:

Q. Does that make any sense to do that, whether you are trying to figure out how much hydrogen will spread out over a whole city or in a small containment building or a reactor vessel?

MR. COPELAND: Well, I don't think that there is any reason for asking this witness that question, Your Honor. If that's the Commission's rule, it doesn't matter whether he thinks it's reasonable or not.

MR. DOHERTY: He's the witness. He can be asked that.

He's come through earlier and spoke about a smaller percentage as if that were adequate. Now there is a similar concern, although addressed to a different container, that says we ought to consider a hundred percent.

All I'm trying to find out is what he thinks of that. He's an expert and he might have some opinion on that.

(Bench conference.)

JUDGE WOLFE: Objection overruled. We'll hear the answer.

THE WITNESS: First, that's not a requirement yet. That's still a proposed rule and it's undergoing a lot of debate, but my personal opinion is that is maybe an excess conservatism. I don't know that you ought to consider all of it; even for a bad situation like Three-Mile Island, you didn't get anywhere close.

BY MR. DOHERTY:

Q. Yeah. You mention Three-Mile Island down here. Is there any firm feeling about the percent of clad oxidation at Three-Mile Island or is it a loose who-knows kind of thing still?

A. I have heard people who were supposed to be in the know speculate. I can give you those speculations. I

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haven't had direct access to that. It's on the neighborhood of 25 or 30 percent.

Q You spoke on page 15 in the first answer about the confusion in water level indicators at Three-Mile Island. Then you say, "ACNGS has unambiguous water level instrumentation."

Will there be an assumption during the operation of this plant that if we're uncovered, if the fuel is uncovered, then there's hydrogen? Is that going to be the essential idea? No one is going to -- Do you follow me?

A You started asking if it's uncovered and then what? I don't --

Q All right.

Will that be sort of an automatic conclusion of anybody operating the plant? Will they be told, "If you've uncovered, you've got hydrogen"? Is that your understanding of what this idea is?

JUDGE LINENBERGER: Excuse me. The Board needs a clarification here.

Are you asking his understanding of what kind of orientation operators are given with respect to interpreting water level instrumentation readout and the consequences therefrom? Is that the thrust of your question, Mr. Doherty?

MR. DOHERTY: Let me try to rephrase it. I'd hate like getting into administrative procedures, what that almost starts to sound like.

BY MR. DOHERTY:

Q. Where you mention the ACNGS water level instrumentation, are you saying there that the assumption will always be that if there's uncovery, there's hydrogen generation?

A. First of all, the operator is the one who is watching the level indicators and he has been schooled in what can happen if the fuel remains uncovered for some period of time. So he is aware you can generate hydrogen, but his concern, what he's responding to is not let's not generate hydrogen or how much hydrogen do you have built up, but let's make sure that the core is covered. Let's put enough water back in to maintain the fuel cover so you don't generate any hydrogen, you don't get the high temperatures in the first place.

I don't think his thinking is in terms of hydrogen. It's more of let's not let the fuel fail.

Q. In the design base loss of coolant accident, which I think is reviewed for all reactors, do you know for the Allens Creek plant how long -- For that design base accident, do you know how long, if at all, the fuel is assumed uncovered, assuming correct operation of the emergency core cooling system?

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A. I believe Allens Creek references the generic BWR-6 calculations, and for those, I've seen the curves and the total period of uncovery, you're talking about maybe 100, 150 seconds at the most. I don't recall the exact time. It's been a while since I looked at those curves.

That's available in the SAR, though.

Q. Now, will there be steam cooling available so long as there is water in the vessel?

A. There will be steam cooling available as long as there is some water in the core, or if the vessel is depressurizing.

Q. Okay, so that only by -- even the plenum, the lower plenum, that has to be emptied as well before steam cooling would stop; is that right?

A. Well, if you are depressurizing, then the liquid or plenum would flash into steam and would provide steam cooling.

Also, early on in the transient, before you've taken the heat that is stored in the vessel wall itself, that can generate steam from that water. So it depends upon when you are talking about in the transient, but generally, after the first, let's say, 100 seconds in a transient, the heat from the wall is not that significant anymore, and you are primarily saying are you depressurizing or do you have the field covered; you're talking about the steam cooling.

Q Now, in the event of a loss of coolant accident and --

A Excuse me. There's one other source of steam cooling, and that's if you have the core sprays on. You may have the vessel essentially empty of water -- that is, the fuel region empty of water, but you are spraying water on the top, and that turns into steam and provides steam cooling, also, so there's another source of steam cooling.

Q All right. Following a loss of coolant accident, the RPV is refilled. Is it refilled to the normal operating level or above it?

A Okay. It depends on where your break is as to how far it can refill. Normally, we'll try to refill to the normal operating range.

Q Now, considering such an event, would there then at that moment be a quantity of hydrogen, assuming that the accident went to uncovery, a quantity of hydrogen sitting above the liquid in the open space there?

A What are your other conditions?

Q That we had a design base loss of coolant accident and that we have now refilled following that to the --

A Are you sitting at a thousand pounds pressure or are you down at atmospheric pressure?

Q. Well, is that part of the design based event? Why would there be any -- I was counting on you to fill in the pressure on that, on a design based accident.

A. Okay. For a design basis accident, once you are down and you refill -- and let's assume you can fill back up in that range, there can be some small amount still in the upper head. Some is going to be carried out the break still.

Q. Okay. Now --

A. Wherever the break is.

Q. Would the residual heat itself be enough to generate pressure in the RPV such that the other valves -- one of the safety/relief valves or any number of them had to open? Would that as a source of heat be sufficient to cause that?

A. It would depend on how big a break you have and whether or not you've got cooling from other sources. If you can take the heat out with a heat exchanger or if you've got your residual heat removal system on.

Q. Okay. That would take heat out, right?

A. Yes, for the design basis event, a big break, it would not repressurize. You would be taking enough energy out of the break.

Q. All right. So would there then be the possibility of stagnant hydrogen sitting in the reactor vessel or would there be some way in which that hydrogen would get forced out into the containment atmosphere?

A. You could have some hydrogen sitting in the upper head. You would also have fluid that -- you've got hydrogen that's being generated that's being carried out through the break, so -- but yes, there could be some sitting in the upper head.

Q. If by any chance that hydrogen detonated, in your opinion, could that harm the fuel, or would the water in the vessel protect it?

MR. COPELAND: I object to the question, Your Honor. He hasn't established that there's any basis for that assumption that that hydrogen in the amounts up there in the head as the witness has described it could in fact detonate.

MR. DOHERTY: Well, we are practically at a Three-Mile Island situation which had people arguing extensively in '79.

I think I would face a lot of argument if I tried to go ahead and make the hypothetical matchup, getting some source of oxygen in there and all that; but I think it's just a reasonable question to ask.

After a loss of coolant accident there's bound to be some confusion as to just what happened. To that extent I would think it would be a good inquiry to find out if he thought there was enough gas there for that kind of problem.

MR. COPELAND: Well, Your Honor, I don't think there's any basis for his statement that there's some confusion about that at TMI. In fact, our witnesses have testified to the contrary on the record in this case.

It seems to me that my objection stands that it's a hypothetical question without any basis in fact from the witness.

(Bench conference.)

JUDGE WOLFE: I'll sustain the objection. You may start with a foundation question, however.

MR. DOHERTY: I have no further questions, Your Honor. Thank you.

JUDGE WOLFE: Redirect, Mr. Dewey?

MR. DEWEY: No, sir.

JUDGE WOLFE: Board questions?

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BOARD EXAMINATION

BY JUDGE LINENBERGER:

Q. Forgive me, sir, if this is a question that you think you've already answered, but I'd like to ask it anyway.

Are you aware of any feasible accident scenarios which are feasible in the context of applying to Allens Creek type of plant design, which might give rise to conditions whereby the gas venting picture that you've portrayed in your prefiled testimony would not function in the way you have described it or where non-condensible gases would behave very differently from the way you've described it?

A. The only, I think, further thing you could say on that, basically I don't see any source of generation of the large amounts of hydrogen and oxygen at the same time in the vessel to get to the flammable conditions.

For the situation where you've covered the break up and so you have a large gaseous volume at the top and you are still at low pressure so you don't have the RCIC system operating and you don't have the safety/relief valves opening automatically, they can either be opened manually, or there are also separate head vents which can be used to vent in addition.

Normally, the head vents don't vent into the

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suppression pool as does the relief valves.

But I don't know of any plausible scenario at any rate that would generate large quantities of hydrogen and oxygen in the vessel simultaneously.

Q. Well, let's break that down just a moment. Let's accept what you've said with respect to simultaneous generation of hydrogen and oxygen, and it's certainly understandable why you are interested in simultaneous generation, but is there a credible accident scenario for an Allens Creek type of plant design such that you might not get the kind of venting activity that your testimony describes and result in a large buildup of just one non-condensible, such as hydrogen?

A. I'm having a difficult time imagining such because the relief valves themselves open on a high pressure so that if you bottle up and you can't vent the stuff, the vessel is going to pressurize, and with 19 valves on top of it, it's hard to imagine that at least a few of those won't open if need be.

So even if your RCIC was not operable and you couldn't open your head vents and for some reason or another you didn't have a break. You were just isolated, so you had nothing going out the break.

I have a hard time seeing a situation where you could continue to build up.

Q. So in essence, you are saying you see no mechanism whereby even one non-condensible ingredient, gas, could build up?

A. Each of those relief valves will handle on the order of 800,000 pounds per hour of steam. So if you are talking about a comparable flow of the gases and the steam mixture, you are talking about a lot of gas that could be carried out even one valve. And I really have a difficult time seeing that much generation that you couldn't get rid of it.

Q. All right. Now, your general description in your testimony of how the system will behave and vent must be based to some extent on your own or somebody's analytical treatment of state points, flow rates, pressures, pressure drops, hole sizes and so forth.

Your discussion here is generally qualitative. Can you give me some feeling for what kind of hard analytical support may exist somewhere, whether you've done it or not, but somewhere to support some of the things you've said here about the way things behave?

A. There is a NEDO report. It's a General Electric report, NEDO-24708, which was a response to the BWR Owners Group to a series of questions from the Bulletins and Owners Task Force, where they provided their best estimate analyses of a wide range of accident scenarios from normal types of LOCA calculations to situations with extremely degraded conditions where various components would not work and where there were assumed things like operator intervention or operator error occurring at various times during the transients to try to see just what would happen under a very wide range of conditions.

There have been, also, some -- I have done some audit calculations, not nearly to the extent that they have, and some other people in NRC have done some, to try to verify these calculations.

There are some additional audit calculations in the planning at this point, but the basis for the system's response basically is this set of analyses combined with what you would normally expect.

For example, we requested that they analyze breaks, small breaks that were small enough that they would repressurize the vessel and see what happens.

It was anticipated you could get in that situation and we specifically asked for those types of analyses so we'd have a range of analyses on both sides of that type of condition.

Does that help?

Q. Has the Staff in any sense undertaken anything to verify the validity of what's done in NEDO-24708?

A. At this point all we've done is evaluate small

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parts of it.

Q That's the audit calculations you were talking about?

A. The break flow models, doing audit calculations on those. We have a contract with Brookhaven National Lab to do an audit calculation, a full-blown analysis of several of the events that are covered in there, but those have not been completed as yet.

However, the analytical model that was used has also been compared against TLTA data and done reasonably well.

Q Okay. With regard to your mention of the unambiguous water level instrumentation for ACNGS vessel, you have characterized it in your testimony as unambiguous.

Have you satisfied yourself personally that it's unambiguous or has somebody told you this? What is your basis for characterizing that instrumentation in such a way?

A. Okay. First of all, I have studied the design of the instrumentation to ascertain how the instrumentation works.

I know where the pressure taps are located on the vessel. I've seen test data that shows how the instruments respond under transient situations.

I'm familiar with the effects of things like containment temperature and flashing in the legs on what the instruments will give you, what conditions are needed to get to that situation.

I'm familiar with the redundancy and the fact that you've got on a reactor like Allens Creek at least eleven different indications of level, separate indications of level. So that even if one or two for some reason or another fail, you have a backup indication.

Q. Okay. Given, then, that you're satisfied this water level instrumentation is unambiguous, what is it that satisfies you that operator actions will be keyed to maintaining or restoring water level in the vessel.

Mind you, I know that you know that's important. What assures you that -- what makes you believe that the operators are going to know that's important and that their reactions in an accident situation are going to be focused on that primary objective of keeping the core covered?

A. Partially at the insistence and arm-twisting of that Bulletins and Owners Task Force of which I was a part, and partially of their own accord, the BWR Owners Group have proposed a new set of emergency procedure guidelines, a set of uniform guidelines for boiling water reactors.

There are some variations depending upon whether it's a BWR-6 or a BWR-4, for example, but basically, uniform type of guidelines for writing the procedures.

These procedures and guidelines are [illegible]ptomatic in nature so they don't respond to what event the oper[illegible]tor thinks is happening. The operator is responding to the symptoms he sees, and the key procedure or the key guideline that exists there is water level.

That's what he -- everything steers him to maintaining water level first, and then proceeding with the rest of the plant. So there is an extremely heavy emphasis in those guidelines on maintaining water level.

Q All right, sir.

Now, one final little thing here. You have emphasized in response to several questions the absence of a credible mechanism that would allow in an arbitrary post-accident situation oxygen concentration to build up as high as four percent, as though that concentration of oxygen is one that one should stay away from.

I have inferred, but I'm not sure correctly, that what you are saying is that if one had in the pressure vessel a rather high concentration of hydrogen by whatever mechanism, it would be desirable to avoid at all costs letting oxygen [illegible]ld up to as much as four percent because of the hy[illegible]oxygen reaction. Is that the point of your comment there?

A. That is correct.

Q. Let me turn things around the other way. What is it that prevents there being enough air under some post-accident circumstances in the vessel such that buildup of hydrogen to approximately four percent -- and I understand that that may be approaching the threshold of flammability of hydrogen in air -- can't happen?

A. Okay. Basically, your vessel is going to be, even once you depressurize, at a slightly higher pressure than the surrounding atmosphere.

So flow is generally going to be from the vessel -- as far as the gases, it's going to be from the vessel to the surrounding.

You will obviously be pumping some water in and things of this nature which will have some dissolved air in it, but to get the concentrations of oxygen or air that you're talking about, I don't see a flow path. The flow will be outward from the vessel for those things.

Q. So you are saying there's no conceivable mechanism to get enough air in there in the first place such that a four percent concentration of hydrogen could cause a problem?

A. One of the first things you do when you start the reactor up is you use your steam jet air ejector to get all the air and everything out, and then you operate without it.

As long as you are at higher pressure, if you are not putting something from the outside to get it in, I don't see the source.

If you are putting water in, it will have some dissolved air in it, but I don't see that giving you the very high concentrations.

JUDGE LINENBERGER: Thank you very much, sir. That's all I have, Judge Wolfe.

JUDGE WOLFE: Mr. Copeland, cross?

MR. COPELAND: Yes, sir, just one followup on that very last.

RECROSS-EXAMINATION

BY MR. COPELAND:

Q. I think Judge Linenberger asked you the question, as I understood it, do you see any way of getting four percent oxygen buildup in the reactor vessel. I think a clear statement on that would be helpful from you, in addition to your last answer.

A. I don't know of any way of getting it right now.

Q. All right, sir, and if you do not get a buildup of four percent of oxygen in the reactor vessel, isn't it true that it's irrelevant how much hydrogen is in there for purposes of flammability or detonability?

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MR. DOHERTY: Objection. That's a leading question.

MR. DEWEY: It's cross-examination.

MR. COPELAND: I don't think I'm prevented from asking a leading question.

JUDGE WOLFE: This is a cross-examination. All right, answer the question. Objection overruled.

THE WITNESS: It's my understanding that even if you had a very high concentration of oxygen, you'd need at least four percent oxygen to get to be flammable.

MR. COPELAND: All right, sir. Thank you. No further questions.

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JUDGE WOLFE: Mr. Scott.

MR. SCOTT: Yes.

RECROSS-EXAMINATION

BY MR. SCOTT:

Q. This general idea of the possibility of getting four percent oxygen -- I guess you'd infer from that four percent hydrogen outside the reactor brought in as opposed to generated inside the reactor, is there a possibility of a scenario in which we have some huge break big enough that the pressure inside the reactor vessel goes all the way down to atmospheric pressure, then air comes into the reactor --

A. By what mechanism?

Q. Just through the hole.

A. It has got to have a driving force.

Q. But if the reactor is already at atmospheric pressure, the diffusion will provide that.

A. Okay. You're going to diffuse air in.

Q. And such that --

A. And is your containment inerted?

Q. No.

A. Okay.

Q. Try to envision some way that we can get air that you or I are breathing now, even with its pollution, into the containment and then you start filling it up or shutting it off and start adding the water, is some of that air going to get trapped somewhere, most likely in the upper portion of the containment?

A. You're postulating a very stagnant situation in which you get air diffusing in. And if you've got such a situation, yes, I suppose you could get a pocket of air, but I have a hard time visualizing a stagnant situation where the diffusion of air in through some break like that is going to be significant in relation to whatever else is going on.

Q. Okay. Expound upon just what kind of -- I also -- it seems difficult for me to imagine the pressure inside the reactor vessel dropping down to atmospheric pressure.

What kind of conditions would it take to enable that to happen?

A. By atmospheric pressure -- basically you're talking about -- the same pressure as the containment. And your containment has to be at atmospheric pressure, too.

If you had a big break, it can come into equilibrium with the containment eventually, and it would eventually get down -- both of them at atmospheric pressure.

Q. Well, for that to happen, wouldn't you have to have a -- essentially a very cool reactor vessel?

A. You would have had to remove a lot of energy to get there.

Q. Yes. And wouldn't that be very difficult to do?

A. Yes.

Q. In --

A. In reality, you're going to always be a few pounds higher, at least.

Q. Even with a great big --

A. Even with a great big break.

Q. Even with a great big break?

A. Yes.

Q. Okay. In that regard now, you know, at some pressure -- you've already acknowledged that a certain amount of air -- dissolved air in the feedwater and whatever has been brought in.

Do you happen to know how much hydrogen, oxygen -- I don't mean in terms of percentage, but just critical mass -- you know what I'm talking about -- how much it is going to take in order to -- even if it explodes, to, quotes, rupture the reactor vessel?

That's a bit unclear to me --

MR. DEWEY: I object. This is not anything that was brought up on Board questions.

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MR. SCOTT: I don't think that the Board mentioned those exact words, but I think it's implicit in the description about getting air into the reactor vessel.

JUDGE WOLFE: All right. Objection overruled. It was implicit in the Board questioning.

THE WITNESS: No, I don't know how much it would take to rupture the vessel. That's outside my expertise.

MR. SCOTT: Okay, no further questions.

JUDGE WOLFE: Mr. Doherty.

RECROSS-EXAMINATION

BY MR. DOHERTY:

Q We spoke about the water level indicators being unambiguous a minute ago. I had a question with that.

Isn't the water level taken -- Aren't those indicators actually located in the annulus or outside the shroud?

MR. COPELAND: I object to that question. I think that is beyond the scope of the Board's questions.

What do you mean discussion, about how -- about how this witness became familiar with them, what work he had done, what the significance of them were -- of the reasons were to the operators?

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(Bench conference.)

MR. DOHERTY: Well, the Judge did ask about the wording of the -- on Page 15 of the written testimony with regard to the lack of ambiguity of water level indication, why he thought that was so.

I think this ties into that.

JUDGE LINENBERGER: Well, Mr. Doherty, to be as fair as possible here, I was trying to determine whether he had a basis for making that statement beyond just hearsay from somebody else.

I would say that if you know something about the water level indicators that could cause their functioning to mislead somebody under accident conditions, it seems to me that that would be an implicit follow-on from the thrust of the Board's questions.

But to start asking him just the location of things, we would have a problem.

JUDGE WOLFE: The objection is sustained.

BY MR. DOHERTY:

Q. Do you know of anything that might make the water levels not unambiguous because of the location of the water level indicators?

A. There was a negative in there. I'm not sure how to answer. Did you say "not unambiguous"?

Q. "Not unambiguous."

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A. There are two taps for each level indicator. One is at the steam space, which is well above the shroud region that you're talking about.

The other taps for the narrow range indicators are above the shroud area -- around the fuel, they're up around in the standpipe area for the steam separators. There are taps in and around the shroud area for the wide range indicators.

So there are pressure taps for these level indicators that occur at various elevations.

The fuel zone range indicators, for example, are in the throat of the jet pumps for the variable leg.

Q. Do you know any -- the problems with them such that they did not give the reading inside the shroud?

A. We've looked at this in fairly considerable detail. And I've only been able to postulate two mechanisms that might make the level outside the shroud different from what the -- in other words, from what you're reading on the indicators outside the shroud different from what you would be seeing in the core for a plant like Allens Creek.

One would be if you had initially during the LOCA stage with the core spray system on, and you had flooding at the top of the core and a build-up of large water level, you might conceive of a pressure -- a large pressure resistance through that that would, if you had a level in the core, and you add that pressure drop on that -- that exact level, you would be reading in the core with a level above the fuel also, it would not be the same as the level outside.

Also, if you had a situation where the core really got very degraded and you had extreme blockages across the core, like you had at Three Mile Island, with 95 percent or so blockage in the core, then the resistance of the flow through the core would be such that the level in the core would not be the same as the level being indicated in the shroud region.

However, to get there, you would already have had to have lost your water level and then gone through quite a bit. And so what we're saying is prior to getting to that point, the operator knows his water level extremely well; and he's doing everything he can to keep the water in there, and he's not going to let the water get down there.

Q Well, with respect to this level -- or this sort of first possibility --

MR. DEWEY: Your Honor, I'd like to make a statement or an objection about any further questioning along this line because there is going to be testimony on reactor water level indicators coming up this week where this subject will be -- at that point can be thoroughly aired.

I think we're spending a lot on this contention.

MR. DOHERTY: Will this witness be available for cross-examination on that issue?

MR. DEWEY: He will be included with Witness Huang of the Staff for this area.

MR. DOHERTY: Will he be adopting the testimony of Mr. Huang -- or Dr. Huang?

MR. SOHINKI: Mr. Chairman, it has already been indicated to the Board and the parties in the previous hearing session and on a schedule that was filed by the Applicant that Dr. Huang and Mr. Hodges will be on the panel together.

MR. SCOTT: That doesn't answer the question, though.

MR. SOHINKI: Obviously, if they're going to be on a panel together, Mr. Hodges will be adopting the testimony filed by Dr. Huang.

MR. DOHERTY: Well, having that represented to me, I have no further questions.

JUDGE WOLFE: All right. Redirect, Mr. Dewey?

MR. DEWEY: No, sir.

JUDGE WOLFE: All right.

We'll recess until a quarter of 4:00.

(A brief recess was taken.)

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JUDGE WOLFE: All right, Mr. Dewey, proceed.

MR. DEWEY: Yes, sir. Mr. Hodges will next testify with respect to TexPirg Contention 55 regarding steam line breaks.

At this time we offer him for cross-examination.

JUDGE WOLFE: Mr. Copeland.

MR. COPELAND: No questions, Your Honor.

JUDGE WOLFE: Mr. Scott.

CROSS-EXAMINATION

BY MR. SCOTT:

Q Is it your contention that -- isn't your testimony essentially saying that the steam line break would be frothy but -- because of decreased reactivity; therefore -- is that essentially your testimony?

MR. DEWEY: Your Honor, I object to that question. I think it should be rephrased and be made so it's more understandable.

MR. SCOTT: Okay. I'll break it up in two parts.

BY MR. SCOTT:

Q Do you agree that the rapid depressurization would cause frothing?

A Yes.

Q Do you also state frothing would cause decrease in reactivity?

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A. The void formation there, yes, results in a decrease in reactivity.

Q. Is that because you equate the void with the froth?

A. The void is basically filled with steam, so -- which is much lower density than the water. That's why we refer to it as void. It's not an absolute void. It's a steam bubble or a large number of steam bubbles.

Q. The void is just less dense water, right?

A. It's steam rather than liquid water, vapor.

Q. Do you agree that the circumstances in the contention will cause an increase of water without voids or water with decreased voids to be sucked into the lower portion of the core, to arrive at the lower portion of the core?

A. I'm not sure what you are asking me, but if you are asking me if I agree that the scenario as postulated in the contention is a realistic scenario, no, I don't agree with that.

Q. In other words, you -- well, what part of it is unrealistic?

A. The part that is unrealistic is when you get the depressurization, you will be forming the voids in the core because it's at saturated conditions, and so you are not going to suck a lot of cooler water in there and

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increase the reactivity, as the way I read your contention.

Q Do you find it impossible or unlikely for these two things to be going on at the same time; namely, that as the pressure decreases, at least in certain portions of the core the percentage of voids will increase, and at the same time cooler water is sucked into the reactor, in a portion of it. It would in fact have less voids in that portion of the water than was there before the depressurization?

A. The core is undergoing a depressurization, also. It's not just the lower plenum that's being depressurized.

So you are generating the voids. You've got the flashing of the water and the steam that's in the core itself. That has to go somewhere.

As you generate more voids from that, you get a resistance to the upward flow, so I would think that what you are winding up with is an increase in voids.

I don't see a mechanism for trying to suck this water that you're talking about, cold water with no void in it up into the core.

If you are postulating such, I don't know the basis you use for assuming it's there.

Q Isn't there a source of feedwater coming into the core normally?

A. The feedwater comes into a sparger ring in a region outside the core shroud, outside the stand pipes for the separators, an elevation above the fuel.

It mixes with water which is very close if not at saturated conditions, and then is drawn into the jet pumps by the recirculation flow.

Once it gets down in the lower plenum, it's got on the order of 20 degrees sub-cooling. So it is at near saturation there, also. You are not getting cold feedwater in the lower plenum.

Q. Now, that's under, quotes, normal conditions that you just described?

A. That would be existing under normal conditions. Under a steam line break, if you still had feedwater coming in, if your recirculation pumps were still operating, that would still be the condition.

If you trip your recirc pumps, then you are still mixing with the other water, but you don't have mixing with the recirculation flow.

Q. Tell me if I'm wrong about this, but I'm trying to visualize two situations: One, normal operation of the reactor; two, the situation where the pressure in the reactor vessel has decreased.

I am presuming that under the decreased pressurization scenario, there would be less resistance to feedwater entering into the reactor vessel; is that --

A. You are talking about in the first three-and-a-half seconds of the transient, because that's how long it takes the rods to go in. You are trying to say what's going to change in that first three-and-a-half seconds of the transient before the rods go in. Will you get an increase in reactivity due to drawing colder water in there?

Q. No. Maybe eventually I was getting to that, but initially all I was wanting to know is as the pressure is decreased inside the reactor vessel, will there not be a tendency for the feedwater to come in at a faster rate than it did before?

A. All I'm saying is it doesn't make much sense for us to talk beyond that first few seconds, because after the first three-and-a-half seconds the rods are in and we're tripped, and you are subcritical.

Q. Okay, but let's get down and talk about that first three-and-a-half seconds.

MR. COPELAND: Well, I object to anything other than that, Your Honor, because the contention is clearly talking about that.

It says in the second sentence, "This movement of water will cause an increase in reactivity before the scram system will be effective." So it has to be talking about that three-and-a-half seconds.

MR. SCOTT: I don't see anything in the record

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that says three-and-a-half seconds is how long it takes it to scram.

MR. COPELAND: That's what the witness just testified.

MR. SCOTT: That doesn't make it true. I don't know why we're restricted to three-and-a-half seconds at this point is the only thing I'm saying.

It may be that we are restricted to prior to scram. I'm not arguing that.

JUDGE LINENBERGER: Well, Mr. Scott, I've got a little bit of a problem here because the witness has testified to something and you say that doesn't necessarily make it true.

Okay, in one context, I guess I can follow that; but at the same time, then, he's talking about water and you could start talking about sodium and say, "Well, he said water but I'd rather talk about sodium in the Allens Creek system."

So at a certain point we have to start with some givens. Now, if the three-and-a-half seconds value bothers you with respect to the competence of this witness to establish that, then go to that point.

Don't assume the witness has misled you and try to, forgive the expression, trap him to test the basis of his knowledge that that three-and-a-half seconds is correct.

Don't assume it's wrong to give you the right to range over any time scale you wish to. That is not the way we're going to let you approach it.

You either accept the witness' three-and-a-half seconds or find out why he thinks he knows it is three-and-a-half seconds; but you are not free to say, "No, that's not right. I want to talk about 15 or 20 seconds or an hour or whatever."

MR. SCOTT: Well, he's got the burden of proof.

JUDGE LINENBERGER: Mr. Scott --

JUDGE WOLFE: We're telling you how to go about cross-examining this witness and we now sustain the objection.

We've told you how to go about cross-examining, and it's the Applicant that has the burden of proof, if you want to get right down to it.

This is a Staff witness. I don't want to get into that. I'm just telling you to go ahead and cross.

MR. SCOTT: Okay. I never had any trouble with the three-and-a-half seconds. I wasn't even concerned with that.

BY MR. SCOTT:

Q The point I'm trying to get is a very narrow one, whether or not the feedwater, everything else being equal, is going to come into the reactor vessel faster if the pressure is lower in the reactor vessel?

MR. COPELAND: And the witness has answered that question, so it's been asked and answered.

MR. SCOTT: It's never been answered. I've asked it several times and it has never been answered.

If it has, please point to the place in the transcript that --

MR. COPELAND: Now come on, Mr. Scott. I don't have a transcript.

MR. SCOTT: He's only been talking three minutes. It's got to be in the first three minutes here if it's been answered.

(Bench conferences.)

JUDGE WOLFE: The Board has forgotten, but we don't know whether or not the exact question as posed was put to the witness. So we'll overrule the objection.

THE WITNESS: I'll have to qualify my answer a little bit, because I don't recall for sure whether Allens Creek has motor driven or steam driven feedwater pumps; but if they are motor driven, then I would expect as the pressure goes down, to get some increase in the feedwater flow.

For a turbine driven pump, I would expect the feedwater flow to remain essentially constant as the pressure dropped down.

We're talking about, again, the very first few seconds of this transient, and even if it increased, you will see some slight increase in the sub-cooling, but it takes a couple of seconds for the water to get from the area of the feedwater sparger down to the lower plenum.

So you are not going to be changing the temperature in the lower plenum very significantly in that first three-and-a-half seconds. You have a lot of thermal inertia.

Q. Of course, thermal inertia, you mean because the water is high or you've got a lot of water or --

A. You've already got water in there and it's hot and you are adding feedwater flow in and mixing it in with other water that's at saturated or near saturated conditions.

And even if your feedwater flow goes up, you are still mixing it with a pool, if you want to call it that, of near saturated or saturated water that's in the region outside the stand pipes of the separators, and so you may be bringing in a little bit more water, but you are still going to be very close to the same temperature.

Q. Then apparently you are saying in the reactor vessel we've got a lot of water. It's slightly super-cooled or maybe not even super-cooled once the pressure has dropped?

A. In the region, the water -- you have a feedwater sparger. It's a ring sparger just inside the reactor vessel.

There's a water level above the feedwater sparger that goes up to about the mid-plane of the separators.

The water above these spargers is saturated. It's at saturated conditions for the pressure that you are at.

Because you are mixing feedwater in with this mixture, below that feedwater sparger ring you have some sub-cooled water, but it's just this feedwater coming in at like 420 degrees Fahrenheit and saturation temperature is 544 degrees Fahrenheit. So it's not cold water. It's still fairly hot water you are feeding in there, and mixing in with the water in this large area of the vessel.

And the fact that you increase the flow a few percent, maybe five percent or something like that, due to depressurization in this early part of the period is not going to cause the temperature to go down a lot.

It will decrease, don't get me wrong, but it just won't be a massive change.

Q. Okay. As I understand it, you are saying there won't be a massive change in the temperature reaching the core for at least two reasons. One, it's already coming in as warm water, 420 degrees; two, it takes (you used the word) a couple of seconds to come down into the core region --

A. Transport time.

Q. -- and during that time a couple of things are going to be happening. Number one, it's going to be getting heated up and number two, it's going to be mixing with a larger quantity of warmer water so that the dilution effect won't be that big?

A. I think the normal recirculation flow ratio is about three to one, so you have -- excuse me, that's the wrong number for that.

You have the feedwater flow coming in is roughly one-tenth of the total flow that's going through the core.

So you are mixing in a tenth of the water at whatever the feedwater temperature is -- initially it's 420 -- with nine-tenths of the water which is up at saturated temperature, to come up with conditions that are in the lower plenum.

That's why the lower plenum is only like 20 degrees sub-cooled -- in fact, it's not even 20 degrees. It's 20 BTU's sub-cooled BTU's per pound.

That doesn't correspond exactly to 20 degrees.

Q. Why, because of pressures or what?

A. That's the enthalpy. That's how much sub-cooled it is in terms of the enthalpy. One degree Fahrenheit does not mean one BTU per pound on the enthalpy at that pressure range.

Q. Would it at atmospheric pressure?

A. It comes close at atmospheric pressure, yes.

Q. Okay. Now our water in here typically is -- what did you say, 500-and-something degrees?

A. About 544 --

Q. Five hundred and forty degrees, and the water coming in is about four hundred and twenty degrees?

A. That's right.

Q. And it's only about a tenth of the water coming in as compared to the water circulating.

A. Right.

Q. It's getting mixed with --

A. Anywhere from one-tenth to one-fifteenth. It's somewhere in that area, yes.

Q. It's getting mixed in the jet pump region; is that where it's getting mixed?

A. It mixes above the jet pump and then gets sucked into the jet pumps.

Q. At what point does this first -- this water at whatever temperature start affecting the fuel? I guess once it gets next to the fuel, right?

A. I suppose there could be some second order effect as far as the reflector and such, but the major effect is when it starts getting up in the fuel region within the core.

Q. Then it has to come down to the bottom of the fuel?

A. Yes.

Q. So if there's a 120-degree difference there, I take it that it's your testimony that -- well, there must be some difference in the temperature between the top and bottom of the core in the water?

A. The water coming in is slightly sub-cooled; not much, but it is slightly sub-cooled.

Q. Coming in at the bottom of the core?

A. Coming in at the bottom of the core. It's typically 20 BTU's per pound sub-cooled.

Q. And by the time it's what, halfway up the core, it's then saturated?

A. No. By the time it's a foot or a foot and a half from the bottom of the core it's saturated. It gets saturated very quickly, maybe two feet.

Q. What is saturated? Is that when, quotes, starts bubbling?

A. That's when you are in saturated boiling.

Q. Does that mean when you first start seeing

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bubbles?

A. You can start seeing bubbles in sub-cooled boiling.

Q. Does the reactivity care if the bubbles are sub-cooled or saturated bubbles?

A. Probably not.

Q. Is the water that's going through the core largely recirculating right back through the jet pumps as opposed to going out through the main steam line?

MR. COPELAND: I object to the relevance of that question, Your Honor.

MR. SCOTT: The relevance is we're trying to mix water here and in order to properly decide which water we are mixing, which amounts, we have to know the flow paths, how much is going through each path.

MR. COPELAND: We're only talking about three-and-a-half seconds here, Your Honor, and I can't imagine how what happens to the steam once it gets outside the reactor has any relevance to that time frame.

MR. SCOTT: Well, just that if it's outside the reactor, it can't be circulating back through the jet pumps.

(Bench conference.)

JUDGE LINENBERGER: Mr. Scott, maybe you can spiral in on that relevance a little more. How does the question relate to the possibility of a reactivity increase before scram action can take place? I'm missing that connection.

MR. SCOTT: Well, there's a certain flow rate of water going up through the core next to all the fuel rods.

After it goes through that area, then a certain portion of it circulates back through the jet pumps and another certain portion leaves the reactor.

Then the temperature rise that's taking place in the region of the core is going to depend upon how much of the, quotes, cooler water is mixing with how much of the other water; and if --

JUDGE LINENBERGER: Maybe you could find a good place to resume your questioning. What is the significance of that particular effect with respect to reactivity?

See, you are postulating all kinds of things here trying to spiral in on this, but if you hit it direct, I think you can find out whether or not this is a lot of questioning that is worth pursuing, and save us all time.

MR. SCOTT: I think you asked me a question, didn't you?

JUDGE LINENBERGER: Yes. I asked you why you didn't ask that very question directly of the witness.

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MR. SCOTT: I'll ask it --

JUDGE LINENBERGER: I'll change that and withdraw that question and suggest that you ask that very question of the witness.

BY MR. SCOTT:

Q Do you remember the question?

A No, not completely.

MR. SCOTT: Ask it again. The witness said he doesn't completely remember.

JUDGE LINENBERGER: You asked it and I said it was a fine question for you to put to the witness.

MR. SCOTT: I've forgotten.

THE WITNESS: If you are referring to how much water is recirculated back through -- Was that your question?

MR. SCOTT: That was one of them. I'm not clear if that's the one he --

JUDGE WOLFE: We sustain Mr. Copeland's objection, because the question as posed was not relevant.

Now, Judge Linenberger has suggested to you to pose a question to the witness.

Now, do it or not, whatever your pleasure is.

MR. SCOTT: My problem is not knowing what's been said and what I said. I will attempt.

It's not an avoidance thing if it doesn't come out the same way.

BY MR. SCOTT:

Q Mr. Hodges, what percentage of the water that's going through the core is recirculating back through the jet pump, and I assume in the other percentage, the difference between that and 100 percent went out through the main steam line?

MR. COPELAND: That was the question I objected to, Your Honor.

JUDGE WOLFE: That's, again, the question we are sustaining the objection to.

MR. SCOTT: Dr. Linenberger, what question did you suggest I should ask him?

JUDGE LINENBERGER: Your choice, Mr. Scott, but we are requiring that you establish relevance between this line of questioning and the onset of an increase in the reactivity in the first however many seconds it takes a scram system to function.

BY MR. SCOTT:

Q Mr. Hodges, will not the reactivity in the particular volume of the core, depend on whether or not the water at that bottom of the core is, quotes, solid liquid water versus water with voids in it?

A Yes.

Q Wouldn't the amount of the core that was free

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of voids increase if the water coming into the bottom of the core was at a lower temperature, everything else being equal?

A. That's correct.

Q. If as a consequence of the depressurization, the increased flow of the cooler water was high enough, then that could in fact override the decreased reactivity that takes place from the fact that you get a higher void content with a decreased pressure?

A. Just because you might have an increase in the feedwater flow, it does not necessarily follow that you would have an increase in the core flow. It may well just mean you have an increase in the water level.

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What we're saying is when you have the depressurization event, it's dominated by the creation of the voids in the core and you are not drawing in a lot of colder water as a result of the event; you are creating voids due to the reduction in pressure.

Q. Well, I realize you said that and I understand what you're saying; but what I don't understand is the factual basis for saying that the void formation impact in reactivity is necessarily going to override the fact that you've got more water now without voids in the lower portion of the core because of the cooler water coming in, impact on the reactivity.

I understand how both of them react and I understand what you have said, but I don't understand your basis for saying that.

MR. COPELAND: Well, Your Honor, I don't think the witness ever said that. That's Mr. Scott's hypothecation.

The witness said that in his opinion he didn't see that the reactor would draw in any cold water in the three-and-a-half seconds during scram.

MR. SCOTT: I didn't hear the witness say that.

(Bench conference.)

JUDGE WOLFE: Well, has Mr. Scott paraphrased what you've said correctly, Mr. Hodges, or not?

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THE WITNESS: I think for the scenario that he postulated where you bring the cooler water in, I think he paraphrased what I said fairly well; but I didn't say that you were going to be -- I think I did say earlier on you would not be drawing in a lot of cooler water.

So the Counsel for the utility is correct in that, also.

MR. SCOTT: I don't think there's any disagreement. What I wanted to know is your basis for saying these two conflicting impacts on the reactivity, as I understand it, you are saying that the net result is not going to be an increase in reactivity, but a decrease in reactivity because of the void formation overrides the lack of void formation in the cooler water?

THE WITNESS: Yes.

BY MR. SCOTT:

Q. What's your basis for saying that?

A. Basically, two things. We have seen steam line break analyses and you don't see a reactivity increase due to drawing in of the colder water. You see the voiding causing a reactivity decrease, and we've also seen depressurization tests in TLTA which also show the voiding rather than the drawing up into the core region of colder water.

Q. Okay. What did you use, TLTA?

A. It stands for two-loop test apparatus. It's an experimental facility in San Jose.

Q. Is that a BWR? It probably is if it's GE?

A. Yes, it is. It's a BWR simulator. It does not use nuclear fuel.

Q. Okay. I think you said you are aware of model simulation tests and some actual experimental data on a simulator that shows when voids are formed, reactivity does not increase?

A. Well, the simulator in this case is the TLTA. It's an experimental facility that uses an electrically heated core. In that sense I'm calling it a simulator.

Q. Right.

A. That shows that when you depressurize, you get the flashing and that's dominating; and the analyses that have been provided for the steam line breaks show a decrease in reactivity, not an increase in reactivity.

Q. Okay. Do you happen to know either from that analyses or from some of your own understanding of physics of what's happening there, explain that in terms of reactivity coefficients, you know, just void reactivity coefficients? Temperature reactivity coefficients of the water? Can you explain it in terms of those things?

By that I mean to the best of your knowledge, putting in numbers to describe numbers, 440, 540, plugging in those water change temperatures for the reactivity coefficients. Can you explain that?

A. When you are getting into the reactivity coefficients, you are getting a little bit outside of my area, but I do know that the void coefficients are much larger in absolute value than the temperature coefficients for a boiling water reactor.

But as I say, that's not my area of expertise.

Q. Okay. You don't know which way the temperature coefficient works? I'm talking about the water moderator temperature coefficient.

A. I believe it has a negative temperature coefficient, so as the temperature goes down, you would get an increase in reactivity.

Q. Okay, so the two would be counteracting each other, would they not?

A. They work in opposite directions.

Q. I thought I could understand your explanation that if the feedwater is supplied by an electrically driven pump, that the decreased pressure in the reactor vessel, the same force from the pump, you would get more feedwater inflow; and I was not able to follow why you said the same thing wasn't true if it was steam driven turbine.

A. Your driving pressure, the steam pressure is dropping while you are depressurizing, and so the enthalpy

10-5

of the steam that you are supplying is decreasing.

Q. Supplying to the turbine, you mean?

A. Yes.

Q. Okay. Wouldn't the turbine be some considerable distance away from the reactor vessel, the turbine that is driving the steam water flow?

A. Yes.

Q. Is the communication or the traveling of the change in pressure from the reactor vessel to the turbine essentially instantaneous?

Is there a pressure wave flow? I would think, for example, that if it took three-and-a-half seconds for the impact on the pressure, that the pressure vessel to show up at this turbine, then there would be no change.

A. Obviously, steam is compressible and it takes an amount of time for the pressure change to travel down a pipe, but if it's --

Q. How long is that?

A. I don't know how long the pipe is.

Q. Well, okay. Feet per second, any kind of measure? I'm trying to get a feel if we're talking about a millionth of a second or a second.

A. You are probably talking on the order of a second or two for that, also.

Q. Would that have something to do with the speed

10-6

of sound and Mach 1, Mach 2 and the speed airplanes travel and sonic booms and all that?

A. If you are talking about how fast a pressure wave will travel in the steam, it has nothing to do with Mach 2 or something like that.

Q. Isn't that the reason you have sound waves?

A. We're not exceeding the sonic velocity.

Q. Wouldn't the speed of sound be the maximum rate that the pressure wave would travel down that pipe?

A. That's right.

Q. Isn't that about 640 foot per second?

A. For steam it's several hundred feet per second. I just don't recall the exact amount. It's a function of pressure and everything else. I just don't recall the exact amount.

That's not far off probably. I'm assuming you have got a very long pipe when I say on the order of a couple of seconds.

Q. Isn't the pressure in a BWR typically on the order of a thousand psi?

A. Yeah.

Q. If the pressure drops in half down to 500 psi, would the flow rate into the reactor vessel, the feedwater flow, in the region right near the entrance into the reactor vessel tend to double, if the pressure is cut in half, forgetting about the friction of the water flowing down the pipe, just in the area right where it's going in there?

A. Not necessarily, no.

Q. Why not?

A. It's just not a linear relationship between the head the pump is pumping against and the flow rate. It's not necessarily a 45-degree line sloping down.

Q. Well, assuming you've got a constant force, namely the force put out by the turbine or the electric motor pump, if the pressure that it's being pushed into is cut in half, why wouldn't the flow double?

MR. COPELAND: Your Honor, I'm going to object to any further questions along that line, unless he establishes as a matter of fact that the pressure could be cut in half within three-and-a-half seconds.

MR. SCOTT: I don't see any point for me to have to go proving a scenario before we talk about it. I could have picked 300, 900, any other number. I was just trying to illustrate the relationship between the flow rate into the reactor vessel and the pressure in the reactor vessel.

JUDGE WOLFE: If you are going to ask a hypothetical question of any witness, you have to establish certain facts of record on which you base your hypothetical question.

You have not done so and I will sustain the objection, but you may lay your foundation.

BY MR. SCOTT:

Q. Mr. Hodges, how fast can the pressure drop in the reactor pressure vessel?

MR. COPELAND: Within three-and-a-half seconds.

BY MR. SCOTT:

Q. How fast during that first three-and-a-half seconds? Do you know if it's an uneven drop? Can you describe that?

Can you describe what size hole or what valve opening or whatever you are using for that illustration?

A. I'll have to kind of work backward to get to your number, because it would take on the order of five minutes, three to five minutes, to depressurize completely, if you let that continue to --

Q. To what?

A. To depressurize completely all the way down to, say, 50 pounds or lower.

Q. Under what conditions?

A. With this break we're talking about, the steam line break.

Q. You mean the big pipe?

A. Take one big steam line and break it. You are

10-9

talking about five minutes to depressurize down to, say, 50 pounds.

Q. Is that a linear --

A. It's not a linear relationship. It just starts out very steeply and tails off. I'm trying to think backwards from that.

In three minutes you are down to about 250 pounds. So without seeing the curve, just backing up from that, I would expect you might be down in the neighborhood of somewhere around 800 pounds, 800 to 850 pounds in that first three-and-a-half seconds.

Q. So you might drop a couple of hundred pounds in three or four seconds?

A. You might drop a couple hundred pounds in the first few seconds.

Q. Okay.

A. We can work on that point. That may be a little bit high but on that order.

Q. With that as background, I'd like for you to answer my past question, with the substitution of 800 pounds per square inch where I previously said 500, talking about the 20 percent increase in flow rate as opposed to 50 percent?

A. No, it would not necessarily be a 20 percent increase in flow rate, because the head flow curve for the

0-10

feedwater pumps, as I say, is not like a straight line sloping down at a 45-degree angle.

In fact, it's relatively flat over a fairly wide flow range, so that it's definitely not a linear relationship.

There would be an increase in flow, but to say it's 20 percent, I think, would be going excessive. It may be five percent or something like that.

Q. I can understand why you are saying what you are saying if you are considering the whole loop including the pump, but I'm having trouble with why my scenario wouldn't be true if all you are doing is talking about that area within a few foot of the reactor pressure vessel.

A. The water has to come from somewhere.

Q. But if it's already there.

A. We're talking about the feedwater. That is near incompressible, and so when you drop the pressure down there, you are seeing that pressure all the way, and if it's trying to come at 20 percent and you are only supplying it at an increase of 5 percent, you start drawing a vacuum in that line and it doesn't like that, and it will back off very quickly.

So it can't exceed whatever the pump is putting out there, except for a very minute fraction of time, because it's near incompressible fluid.

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BY MR. SCOTT:

Q Well --

A. Let me rephrase what I said, "in a vacuum." It's not really done in a vacuum. If it starts to try to flash, you're getting down to the vapor pressure; if you were down at atmosphere, you'd be talking about drawing a vacuum. It's the same concept.

Q One of the little problems that I'm having here, it seems to me like you have treated the core as an entity. And I'm not clear why the core, in fact, is not many little entities.

You've mentioned, for example, that the decrease in pressure causes the water in the core to, quotes, flash. Isn't it going to, quotes, flash first in the higher regions of the core?

A. It's going to flash all over the region where it's saturated, which is most of the core.

Q But isn't it less -- or more saturated at the higher portions of the core?

A. Once you're saturated, you cannot get more saturated. You can have a higher void content to start with.

Q Isn't it less subsaturated -- subcooled, I guess is the word, in the top of the core -- the middle portions of the core?

11-2

A. From about the -- once you're up about two feet into the core from the bottom, it's saturated. You don't get more saturated as you go up. You just generate more voids.

Q. Let's break down this core into two types -- two parts, namely, the saturated portion -- all parts of the core above the bottom two foot and the bottom two foot of the core.

Tell me if it's reasonable -- and if not, why not, that the flashing in all the core above the bottom two foot doesn't, in fact, create a pressure that increases the pressure in the bottom two foot of the core, making that ... you know, less likely to flash and more influenced by the cooler water.

A. What occurs is, as you're generating the additional void -- the additional steam in the top, you can draw an analogy to saying you've got water going through a roughened pipe; it's like roughening the surfaces on a pipe if you want an analogous situation.

And so the resistance to the flow is increased.

Another way of looking at is if you put in some ping-pong balls -- let's say -- it reduces the effective flow area that the water is going through, so that now it's like an increased resistance. What you're doing is you're retarding the flow actually as a result of that. And you should get -- Now, that water in the lower part has a longer residence time, and therefore, should be heated up.

Q. Okay. But during the -- During this residence time that you're talking about, the increased residence time in the unit length of the bottom part of the core, wouldn't the pressure on it be higher there than it was just before the water above it flashed?

A. Okay. Let's back up just a little bit and see if we can just walk through what might happen.

You get the break, and you start to depressurize. And essentially simultaneous with that you get a reactor trip signal.

The rods start to move. The technical specifications for all of the plants that I'm familiar with -- and I can't quote technical specifications for Allens Creek because they haven't been generated yet and won't be generated until after the review at the operating license stage is near completion. But, typically, the technical specifications require that the rods be inserted with 3.5 seconds.

They start inserting from the bottom and go up to the top. Within 3.5 seconds the rods are fully inserted. So you're talking about a travel time of --

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well, I think the insertion has to be started within nine-tenths of a second. It's less than a second.

Now, the time for the water that you're talking about coming from the feedwater to mix in with the lower plenum water, the travel time from up around the feedwater sparger down to the lower plenum is more than that fraction of a second.

So now you're talking about how long it takes the cooler water to come down and get transported up; you've already got the rods going in at the lower portion where you're worried about; you're generating more voids in the upper part of the core; and that's reducing the reactivity.

When you're talking about the reactivity of the core, you're treating the core as a lump. That's a kind of artificial parameter that you're calculating to measure how the neutrons are being generated.

And the total reactivity for the core is going down. And, indeed, in the first, roughly, one second, the rods have already started into the lower portion of the core.

Does that help?

Q. I think you just described the same scenario that you put in your testimony, right?

A. With a little more detail.

11-5

Q Yes, okay.

I'm still left, though, with the -- You have lumped the core together. The question while ago, I prefaced it that I thought you had --

A. Well, you lumped the core together when you started talking about the reactivity for that.

Q Huh? When did I lump the core together?

A. You're talking in terms of the reactivity. That's -- You're talking about a methodology that does a lumping there.

Q I realize that's one way. But --

A. What's important are the neutrons.

Q In my scenario here that I'm trying to get at would have the following occur. Overall the core reactivity would go down. But the reactivity in the portion of the lower part of the core --

A. That's right --

Q -- would actually increase --

A. But the rods are in the lower portion of the core within the first second.

Q Okay. But the first nine-tenths of a second here, we've got room for a lot of multiplications of the reactivity.

A. Where's the colder water coming from?

Q No, no. I'm having it -- The cold water will not have impacted the reactivity. You have said earlier that the core -- that the void reactivity is a bigger factor than the temperature reactivity effect.

And I'm trying to envision a situation where a portion of the lower portion of the core where maybe there was some -- let's say, we're two foot and six inches from the bottom of the core where there was a void.

Now, because of the tremendous void appearing five foot above the bottom of the core, it has caused a pressure increase of the area two foot and six inches from the bottom of the core, such that we have in that area now even less voids than we had before --

MR. COPELAND: Well, Your Honor, I object to that question. I believe you've used the phrase, "Loose lips sink ships," and I think with that long description, Mr. Scott just explained himself out of his question because he said during the course of that that he was assuming that water was not drawn into the core. And that is exactly the contention.

The contention says that their assumption is that water is drawn into the core, and that causes an increase in reactivity.

So I think with that, he has clearly gone beyond the scope of the contention now; and I would object to any further questions along this line.

Furthermore, I think the witness has already explained why all of that can't happen.

MR. SCOTT: Mr. Chairman, that's a way too simple an explanation of the contention. The contention says because of depressurization following reactivity changes can be harmful to health and safety.

There is some talk about dragging in water, and we've got admissions that water will be drug in. My only admission, if you want to call it that, to this witness just now is that the water drug in under his explanation, assuming that's right -- I don't know that it's not -- would travel that 10 or 12 foot (whatever it is) to reach that point within nine-tenths of a second.

So it wouldn't have affected -- that wouldn't have kept the other effect that I'm talking about, which in fact is real, from accomplishing the same thing; namely, having the reactivity go up to a point that you have fuel melting, and all that kind of stuff.

Maybe it's real; maybe it's not. It's certainly relevant, though.

JUDGE WOLFE: We sustain the objection on the ground that the question was asked and answered.

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11-8

BY MR. SCOTT:

Q In your answer, you talk about swelling of the two-phase level? What do you mean by that? I think I know what two-phase is, but what do you mean, "two-phase level"?

A. The water and steam mixture that's in the core and above the core has some level that it establishes -- it can swell somewhat similar to a head on a glass of beer.

You can have a level on the head, which is a two-phase --

Q In other words, the bottom of the two-phase condition?

A. The top of the two-phase -- the mixture -- and above that would be a single steam phase.

Q Would below that be a single water phase?

A. Below that would be a region of two-phase mixture and then below that would be a single phase.

Q Okay. So the --

A. But the level that we're talking about is the interphase between the two-phase mixture and, say, a single phase steam.

Q Swelling at the two-phase level, so you're saying that the two-phase region would rise up into what was the single phase steam; is that what you're saying?

A. It's -- Pouring a glass of beer is a reasonably good analogy. If you pour it out, there are gases that get released, and you see swelling of the level, where if you pour it very gently, you don't release those gases instantly and the levels remain lower.

And so what you're seeing when you depressurize is that you're changing the steam -- the water into steam and you're increasing the total volume of the mixture, which causes an increase in the level.

The diameter of the vessel remains the same, so the level has to go up to hold it all.

Q. Maybe I'm imagining things, but it seems to me -- I don't pour much beer, but I pour Coke -- it seems to me like it goes down and up both. Is that wrong?

A. If you take your bottle of Coke and shake it so you release the gas, you see an increase in the level. Now --

Q. But won't it increase the level of the bubbles also --

A. -- what we're talking about --

Q. Won't what used to be Coke become bubbles?

A. That's right.

Q. Okay. So there would be a decrease in the level of the bubbles?

A. A decrease in -- A lowering of the lower interphase between no bubbles and solid liquid.

Q. Right, okay.

A. So the voids travel in both directions.

Q. So we're where you've said that the water in the core is saturated. I think you've clarified that since then to say that the water in the core, except for the lower couple of foot, is saturated.

A. That is correct.

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MR. SCOTT: No further questions.

JUDGE WOLFE: Mr. Doherty.

RECROSS-EXAMINATION

BY MR. DOHERTY:

Q I thought I understood your testimony before we started, and now I'm not sure.

MR. SCOTT: I have accomplished my task.

BY MR. DOHERTY:

Q Would a steam line break produce the most rapid depressurization?

A You would probably get a slightly more rapid depressurization if you opened all of the ADS valves, for example.

Q Okay.

A But you're at the point where it's not going to make a lot of difference anyway. But it's slightly more rapid.

Q The sentence, "However" -- this is on Page 16 -- "because the water in the core is saturated and the water in the lower plenum is subcooled, the water in the core will flash before the water in the lower plenum."

I have a lot of trouble with that. And I think part of my problem is with the use of the term "saturated."

I think you said saturated by 20 degrees

11-12

Fahrenheit.

A. No, no.

Q. Is "saturated" the wrong word there?

A. I'm saying that the lower plenum water is sub-cooled, I mean it's at a temperature lower than the saturation temperature.

Q. Now, what is the saturation temperature? What does that mean exactly?

A. That's the temperature at which -- if you go to change phase, going from -- as an example, for water at atmospheric pressure, if you start to boil and you get up to 212 degrees, that's the saturation temperature of the water at atmospheric pressure.

If you add more heat, you would generate vapor; but, yet, the temperature will not increase.

Q. Okay.

A. And at the operating pressure of roughly 1040 pounds, you're talking about about 544 being the saturation temperature.

Q. I see. So --

A. 550, something like that.

Q. Okay. Now, then, in the next sentence, you say, "There would be a delay before the lower plenum water would swell into the core region."

Now, by that I guess you mean rise. It would

11-13

only go one direction there, right?

A. That's right. But that's due to the flashing also.

Q. How does the flashing hold back or delay this process? Or do you just mean to describe that it takes time there?

A. All I'm saying is that as you depressurize, you are already at the saturation pressure for most of the water in the core.

So as you start to depressurize, it starts to change into steam right away.

Q. Uh-huh.

A. As you drop the pressure down, you get down to the saturation temperature -- saturation pressure for the temperature of the water in the lower plenum. It will then start to flash, but there is some delay and the initial flashing will have come from the water in the core; and that will add voids and so cut down on the re-activity.

Q. This entire description, is this your own? Did you work it out, or did you read an account of this sort of thing, or where did this come from? Is there someplace this might have come from?

A. These are my words.

Q. Okay.

11-14

MR. DOHERTY: No further questions, Your Honor. Mr. Scott took a lot of it.

JUDGE WOLFE: Mr. Dewey, redirect?

MR. DEWEY: We have no redirect.

JUDGE WOLFE: Board questions?

JUDGE CHEATUM: I have no questions.

BOARD EXAMINATION

BY JUDGE LINENBERGER:

Q. Mr. Hodges, you indicated sometime back when asked about the quantitative foundation for this behavioral description that you have given here, you referred to results -- experimental results out of the TLTA facility, and you referred to another source or category of information.

It wasn't clear to me what that was.

A. Those were steam line break analyses that are presented in a typical safety analysis report.

Q. Such steam line break analyses, are they -- are the analyses themselves purely theoretical in their entirety; or do they have certain empirical inputs to them; or are they tested against any empirical information?

A. The analyses are done with the compute. codes that have various correlations that are based upon separate effects types of tests. I don't know of any steam line break tests, per se, that have been run to try to verify them.

The closest thing that we have -- it was in the two-loop test apparatus, we did a small break test and had an opening of an ADS valve, which would be similar to a steam line break, and predictions of what's going on there. And the methodology was compared against that test.

Q. When you speak, as you did, with Mr. Doherty about the lower plenum water swelling into the core region, I'm not quite sure I understand what is happening there.

If I do understand what is happening there, then I would say that is equivalent -- and correct me if I'm wrong -- to saying that the two-phase level has progressed downwards into the lower plenum, as the result of heating the water in the lower plenum.

Is that --

A. No.

Q. -- correctly what happens?

A. It has progressed down because you're lowering the pressures, and now you're down to the saturation pressure of the lower plenum.

Q. Okay. So it's a pressure lowering rather than a heat transfer phenomenon?

11-16

A. Yes.

Q. That causes the two-phase level to lower into the lower plenum, which is the equivalent of water swelling in the lower plenum, or reducing density --

A. That's correct.

Q. -- and therefore, forcing --

A. That's correct.

Q. Thank you.

There has been some discussion throughout cross-examination about a number on the order of 3.5 seconds, which I believe you indicate represents the time it would take for the control elements to reduce the reactivity of the core --

A. I think I said that was the technical spec limit on the rod insertion time.

Q. Okay. That -- You did indicate that when asked about the 3.5 seconds. And I guess what I want to tie this down to is what is it about reactor kenetics, about fuel behavior, about steam/water actions, what is it about something in the real life behavior of these systems that has led the NRC to want to see specifically a 3.5-second figure in the tech specs?

Why is 3.5 all right, rather than striving for 1.5, or why isn't 10 seconds all right if the rods don't have to get up and go quite so fast? What

11-17

causes -- What is it that makes this 3.5 seconds significant, other than somebody said, "Thou shalt do it"?

A. This would also be the value then that would be assumed in the analysis. And so there's a basis to support the adequacy of the 3.5 seconds -- an analytical basis, whereas if it were longer, you could say, "All ·ht, it's five seconds."

And you could go back and postulate a set of conditions that you could operate the plant under that would be acceptable for five seconds possibly, but we have 3.5 seconds.

I don't know of any other reasons.

Q. I should think at least phenomenologically, however, that the 3.5 seconds would have some tie to system kenetics in some way; and I'm just looking for whether there is a tie; and I'm not asking you to speculate.

If you just happen to know, I would appreciate your --

A. I really don't know.

JUDGE LINENBERGER: Okay, thank you very much, sir. That's all the questions that I have.

JUDGE WOLFE: Cross on Board questions, Mr. Copeland?

MR. COPELAND: No, sir.

JUDGE WOLFE: Mr. Scott?

MR. SCOTT: I don't have any.

JUDGE WOLFE: Mr. Doherty?

MR. DOHERTY: None, Your Honor.

JUDGE WOLFE: All right. Well, we'll recess now until tomorrow morning at nine o'clock.

(Whereupon, at 5:02 p.m. the hearing was recessed, to reconvene on Tuesday, October 6, 1981, at 9:00 a.m. in the same place.)

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This is to certify that the attached proceedings before the

NUCLEAR REGULATORY COMMISSION

in the matter of: HOUSTON LIGHTING & POWER COMPANY

Date of proceedings: October 5, 1981

Docket Number: 50-466 CP

Place of proceedings: Houston, Texas

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

Mary L. Bagby
Official Reporter (Typed)

Mary L. Bagby
Official Reporter (Signature)