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TR04

1 UNITED STATES OF AMERICA  
2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
5 THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE

6 + + + + +

7 MEETING

8 + + + + +

9 EPRI WATERHAMMER STUDY/S-REALP5 SBLOCA CODE

10 + + + + +

11 TUESDAY,

12 JANUARY 16, 2001

13 + + + + +

14  
15 The meeting was held in Room T2-B1 of the  
16 NRC White Flint Building 2 at 11545 Rockville Pike,  
17 Rockville, Maryland before the HONORABLE DR. GRAHAM B.  
18 WALLIS, Chairman.

19 PRESENT:

20 HONORABLE DR. GRAHAM B. WALLIS, Chairman

21 DR. THOMAS S. KRESS, ACRS Member

22 DR. NOVAK ZUBER, ACRS Consultant

23 MR. PAUL A. BOEHNERT, ACRS Staff

24  
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P-R-O-C-E-E-D-I-N-G-S

(8:35 a.m.)

I. INTRODUCTION

CHAIRMAN WALLIS: The meeting will now come to order. This is a meeting of the ACRS Subcommittee on Thermal-Hydraulic Phenomena. I am Graham Wallis, the Chairman.

The ACRS member in attendance is Dr. Thomas Kress. The ACRS consultant in attendance is Novak Zuber. We expect Professor Schrock to be with us tomorrow intending to explain why he is not here.

The purpose of this meeting is for the Subcommittee to continue its review of both the revised Electric Power Research Institute report, TR-113594, "Resolution of Generic Letter 96-06 Waterhammer Issues" and Siemens Power Corporation's S-RELAP5 thermal-hydraulic code and its application to Appendix K small break LOCA analyses.

The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, -- I will add that we will also ask a lot of questions -- for deliberation by the full Committee. Mr. Paul Boehnert is the cognizant ACRS staff engineer for this meeting.

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1           The rules for participation in today's  
2 meeting have been announced as part of the notices of  
3 this meeting previously published in the *Federal*  
4 *Register* on December 28, 2000 and January 9, 2001.

5           Portions of both today's and tomorrow's  
6 meeting sessions will be closed to the public to  
7 discuss information considered proprietary to the  
8 Electric Power Research Institute and Siemens Power  
9 Corporation, respectively.

10           A transcript of this meeting is being kept  
11 and the open portions of this transcript will be made  
12 available as stated in the *Federal Register* notice.  
13 It is requested that speakers first identify  
14 themselves and speak with sufficient clarity and  
15 volume so that they can be readily heard.

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

19           Now we are looking forward to winding up  
20 this matter we heard about about a year ago, I  
21 believe. So we hope that that will happen today. So  
22 I will call upon Jim Tatum of NRC's Office of Nuclear  
23 Reactor Regulation to begin.

24           MR. TATUM: Good morning. Can everyone  
25 see this okay?

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1 CHAIRMAN WALLIS: It looks good.

2 MR. TATUM: Okay. Good. Good morning.

3 II. RESOLUTION OF GL 96-06 WATERHAMMER ISSUES

4 A. NRC/INDUSTRY RESOLUTION APPROACH

5 (EPRI STUDY) - SUMMARY

6 MR. TATUM: First of all, are there any  
7 members of the public present here today? I just want  
8 to check just so if we talk about proprietary  
9 information, we will know who hears it.

10 As Dr. Wallis mentioned, we had come  
11 together a little over a year ago now to discuss the  
12 work that had been done by the industry. I basically  
13 wanted to just provide a couple of introductory  
14 comments to kick the meeting off and turn it over to  
15 EPRI and the working group to make their presentation.

16 First of all, the Generic Letter 96-06  
17 waterhammer issue endorsed the analytical approach  
18 that is discussed in NUREG TR-5220. We had accepted  
19 that as a bounding approach for doing the analysis for  
20 waterhammer and asked that if licensees want to use a  
21 different approach, that they let us know what that  
22 approach is and give us an opportunity to review and  
23 approve it.

24 EPRI took the option of going ahead and  
25 establishing the best conservative methodology,

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1 recognizing that the NUREG approach tended to be very  
2 conservative and could cost industry quite a lot of  
3 money for modifications and whatnot to address the  
4 conservative analysis that would be required.

5 So EPRI established with the industry --  
6 and from what I understand, there are about 12  
7 utilities involved with this initiative in  
8 establishing a methodology, somewhat less conservative  
9 but conservative enough to address the waterhammer  
10 concerns that are discussed in Generic Letter 96-06.

11 The methodology was initially presented to  
12 the Subcommittee in November of '99, a little over a  
13 year ago. The Subcommittee had a number of questions,  
14 as did the staff. EPRI and the working group went  
15 back, did some additional testing, reviewed additional  
16 data, reformatted the report to make it a little more  
17 user-friendly. And they're back with us here today to  
18 present the additional information and try to address  
19 the concerns that were raised previously.

20 NRC staff has been involved with the  
21 review from the beginning. And we have been in touch  
22 with the industry trying to keep on top of the  
23 direction they are going so that we could provide a  
24 timely review when they make their submittal. They  
25 recently provided the report for our review on

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1 December 20th, and we had an opportunity to look at it  
2 in some detail at this point.

3 The individual reviewers involved, myself,  
4 Jim Tatum from Plant Systems Branch; Walt Jensen from  
5 Reactor Systems Branch; Gary Hammer from Mechanical  
6 Engineering Branch; and Dr. Hossein Nourbakhsh, our  
7 contractor, are all present here today for the  
8 meeting. I would also like to indicate my Branch  
9 Chief, John Hannon, is here also for the meeting  
10 presentation as well.

11 Now, the event scenario of interest here  
12 I think that you all appreciate was discussed last  
13 time. It's very focused, very plant-specific in  
14 nature, where we're looking at a large break LOCA or  
15 mainstream line break, something that will generate a  
16 lot of heat in a very short period of time and cause  
17 a very rapid heat addition to the containment fan  
18 coolers.

19 It was an issue that was raised initially  
20 with the review that was done at Diablo. Westinghouse  
21 issued a sealer, I believe, on that. So we're trying  
22 to make sure that the industry is adequately  
23 addressing the subject.

24 The plants involved with this particular  
25 initiative are the ones that typically will have steam

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1 formation in the fan coolers during the event. And so  
2 analysis to address the waterhammer is necessary for  
3 them.

4 Other plants that we have looked at to  
5 this point typically do not have the situation where  
6 steam will form. Either they have enough dynamic head  
7 on the system where steam doesn't form for the given  
8 conditions in containment or the fan coolers are not  
9 relied upon for accident mitigation and they take  
10 measures to make sure that they will not be used.

11 So we're talking about a certain select  
12 group of plants. They have determined for the most  
13 part that they will have steam formation. And they're  
14 trying to make sure that in the analysis that they do  
15 that it's not going to be ultra conservative such that  
16 they have to make mods that may be not cost-effective  
17 in the final analysis.

18 So, having said that, let me turn this  
19 over to the EPRI working group and --

20 CHAIRMAN WALLIS: Is the concern just that  
21 the fan coolers will be inoperative or that a break  
22 would cause a pass for release of radioactivity?

23 MR. TATUM: Yes. It's a multiple  
24 issue/concern. First of all, the break could cause  
25 the fan coolers to become inoperative. And these

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1 plants typically credit the for containment cooling.  
2 So that's one issue.

3 Another potential problem that you could  
4 have is loss of containment integrity. So depending  
5 on how the break scenario works, you could have a  
6 leakage pathway through the cooling water system  
7 outside the containment.

8 The other potential problem you could have  
9 is if you have a break inside containment, it could  
10 affect the containment analysis in that you could have  
11 additional water added to the containment during the  
12 event scenario.

13 The service water system could be pumping  
14 water into the containment. And, in addition to that,  
15 you could have water, service water cooling that is  
16 needed for other components to mitigate the event  
17 being robbed from those systems and pumped into  
18 containment. So there's a number of potential  
19 problems you could have as a result of this.

20 CHAIRMAN WALLIS: Which is why I asked  
21 because you said some pumps don't rely on the fan  
22 coolers that we don't have to worry about waterhammer,  
23 but there are other effects of losing the pumping to  
24 the fan cooler.

25 MR. TATUM: Right, yes. To clarify that,

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1 what I mean by that is they don't rely on the fan  
2 coolers during the event. They remain isolated. So  
3 they don't have potential. Even though they may have  
4 steam form, they don't have the potential for  
5 waterhammer occurring and for starving the other  
6 systems, the service water and whatnot.

7 Any other questions on --

8 DR. ZUBER: Are you going to develop the  
9 end of this report?

10 MR. TATUM: Yes. We will give you at  
11 least our preliminary views coming into the review.  
12 We are going to -- we have discussed our preliminary  
13 comments with the working group, and we would like to  
14 hear their presentation and see what they have to say  
15 to address the comments that we have made. Towards  
16 the end of the presentation, we do plan to give you  
17 our perspective.

18 CHAIRMAN WALLIS: Is this report supposed  
19 to resolve an issue or be a contribution to the  
20 resolution of an issue?

21 MR. TATUM: It's a contribution to the  
22 resolution of the issue for the plants that are  
23 involved with this initiative.

24 CHAIRMAN WALLIS: But then the plants  
25 themselves have to do a lot of work as well.

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1 MR. TATUM: That's correct. They have to  
2 apply the methodology to the extent we approve it and  
3 address some additional questions we will ask.

4 DR. ZUBER: What I would appreciate, at  
5 the end of the meeting when you present your  
6 assessment, to address this questions, process  
7 information in this report, "How would you feel a  
8 utility can respond in a responsive way to our  
9 concerns?" but that there is enough specific  
10 information for a utility to use or the thing is so  
11 diffuse that you can pick and read whatever you want.

12 MR. TATUM: Well, hopefully EPRI and the  
13 working --

14 DR. ZUBER: No, no.

15 MR. TATUM: -- group address that.

16 DR. ZUBER: They will. They will. But,  
17 I mean, you as the regulator and experienced with the  
18 capability of the utilities, how do you feel they will  
19 be able to use this information in a responsive way  
20 which would meet your requirements of safety?

21 MR. TATUM: I understand. That is one of  
22 our concerns going into the meeting, but I am hopeful  
23 that the working group will be able to address our  
24 concerns and after their presentation is over, we will  
25 be in a better position, I guess, to give you our

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1 opinion on it.

2 CHAIRMAN WALLIS: The working group may be  
3 able to explain to us how these results fit into  
4 plant analyses or even show that they have been used  
5 for some plant analyses.

6 MR. TATUM: I guess I would want to defer.  
7 I don't want to speak for --

8 CHAIRMAN WALLIS: It would be nice to make  
9 that connection, I think. Thank you.

10 B. REVISED EPRI REPORT - EVALUATION OF GL 96-06  
11 WATERHAMMER ISSUES AND RESOLUTION OF COMMENTS  
12 FROM 11/17/99 SUBCOMMITTEE MEETING

13 MR. WAGONER: Good morning. I'm Vaughan  
14 Wagoner, the Carolina Power and Light Company and  
15 Chairman of the Utility Advisory Group for this effort  
16 that we have contracted with EPRI and others to  
17 provide for us.

18 First, I guess I'd like to introduce the  
19 folks on our team, if you will. I think you know most  
20 of them. Going down through the list here: Dr. Peter  
21 Griffith. Let's see. Fred Moody. I don't need to  
22 look at the list: Dr. Fred Moody; Dr. Ben Wylie; Dr.  
23 Tom Esselman from Altran Corporation; Greg Zysk from  
24 Altran Corporation; and Dr. Avtar Singh, our Project  
25 Manager, with EPRI. They let me say a few words

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1 because we provided the money for this effort.

2 (Laughter.)

3 MR. WAGONER: I've given you a handout.  
4 Frankly, I'm going to blow through the first four or  
5 five slides because you have seen this stuff before.  
6 Just for the record, the background, we know where  
7 we've been and what we have done. We came here about  
8 a year ago, talked with you. You asked us to go back  
9 and address some issues. We think we have done that.  
10 We are prepared to talk with you about that today.

11 Mr. Tatum mentioned the number of  
12 utilities that participated, about 14 utilities,  
13 representing somewhere between 25 and 30 plants  
14 depending on which day of the week it is.

15 CHAIRMAN WALLIS: Can I also ask how they  
16 participated? Did they define the problem or did they  
17 just provide money?

18 MR. WAGONER: No, sir. First we find the  
19 problem because --

20 CHAIRMAN WALLIS: He said, "These are the  
21 things we need to know"?

22 MR. WAGONER: Yes.

23 CHAIRMAN WALLIS: Is that stated  
24 somewhere? Can we see what the problem is that this  
25 addresses?

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1 MR. WAGONER: I think it was stated in  
2 terms of the original generic letter that came out.  
3 Plants individually provided specific responses and  
4 then from that came around, as I recall, a request for  
5 additional information.

6 CHAIRMAN WALLIS: For example, there were  
7 problems with, say, face separation in the fan  
8 coolers. It has to be addressed by the utility. It  
9 doesn't seem to appear in the report at all. Are  
10 there things like that which were laid out as to be  
11 addressed by EPRI that are not addressed by EPRI?

12 MR. WAGONER: In terms of the original  
13 scope of work, yes, sir.

14 CHAIRMAN WALLIS: They were? Okay.

15 MR. TATUM: We recognize that --

16 CHAIRMAN WALLIS: It might be interesting  
17 to see what that was.

18 MR. TATUM: We may be able to do that. I  
19 don't think we can do it today, but --

20 DR. ZUBER: Well, let me say my problem,  
21 in addition to what Graham said, I don't see much  
22 relation between what you have in this report and a  
23 real reactor. I think you have a discussion and there  
24 is a big gap which must be done on faith.

25 For example, in one place in Section 7.3,

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1 I guess, you say that the utility should make it for  
2 a balance, equation to balance, presumably momentum to  
3 manage, where you don't know what equation and how to  
4 do it. I think this is an important question.

5 Twenty-six years ago I reviewed the work  
6 of INEL, and I found that RELAP4 had the wrong  
7 momentum equation. That was 26 years ago. Last year  
8 Graham found that RETRAN, a product of EPRI, had the  
9 wrong momentum equation. That's a balance equation.  
10 This year I found that G.E. had a wrong mass balance  
11 and energy balances.

12 So, even these large institutions, which  
13 presumably should have the know-how and knowledge,  
14 cannot even write these balance equations correctly  
15 for courts. And now here I'm reading these reports  
16 and you are delegating these to a utility how to do  
17 it.

18 I think this is too loose a way. It's too  
19 descriptive. I think if you give it to a utility, you  
20 should have more prescriptive descriptions, "Thou  
21 shalt use" this and that. I think it will be easier  
22 for the utility and it will be easier for NRR to  
23 review it. As it is, it's an awkward question.

24 There are all kinds of questions like it  
25 in this report, which are really left open from an

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1 experiment to an application reactor. I hope that you  
2 and EPRI will really address these questions, how this  
3 information from this report can be used by a utility  
4 to answer safety issues.

5 CHAIRMAN WALLIS: Maybe that would fit in  
6 at the end, after we have heard the report. Then we  
7 could go back and say, "Well, does this really solve  
8 the problem?"

9 MR. WAGONER: Okay.

10 DR. GRIFFITH: I think the flow chart here  
11 will help a lot to clarify what the utility is  
12 expected to do and what the report has provided.

13 DR. ZUBER: Peter, you should not expect  
14 something if they don't have the capability. One  
15 would have expected EPRI had the capability to write  
16 the momentum equations. One would have expected that  
17 G.E. would have the capability to write an energy  
18 balance equation, a mass balance. And they did not.

19 And now you are really passing the buck to  
20 even a smaller entity to perform something. I think  
21 it should be more prescriptive.

22 CHAIRMAN WALLIS: Okay. You know our  
23 expert panel. They have reviewed the report and are  
24 here to talk with you about that. You know --

25 DR. ZUBER: I have got a question just on

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1 this.

2 CHAIRMAN WALLIS: Okay.

3 DR. ZUBER: How did you use this panel?  
4 How often did they meet? What was their input? What  
5 was their participation and how it functioned?

6 CHAIRMAN WALLIS: Would you like it  
7 directly from the Chairman or would you like it --

8 DR. ZUBER: I don't care. I mean either  
9 one.

10 MR. WAGONER: I can certainly give you my  
11 perspective. We hired the expert panel to provide an  
12 independent assessment of the experimental work that  
13 was being done because there were some areas in  
14 low-pressure waterhammers that there was not a large  
15 amount of technical data, especially low-pressure  
16 waterhammers in open systems where they are the kinds  
17 of things that we have looked at in terms of  
18 cushioning and air training, et cetera, that we did  
19 not have the experience or data. And so we hired the  
20 panel to help us work with our contractor to evolve  
21 the steps, to look at the --

22 DR. ZUBER: Which contractor?

23 MR. WAGONER: With Altran Corporation.

24 DR. ZUBER: Altran? Okay.

25 MR. WAGONER: Yes.

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1 DR. ZUBER: How often did you meet?

2 MR. WAGONER: We met at least three times  
3 formally and a number of times independently in direct  
4 consultation with a contractor.

5 Peter, would --

6 DR. GRIFFITH: Yes. I don't think a month  
7 went by that I didn't either go over to Altran or talk  
8 to them on the phone. And we had something like four  
9 or five formal meetings where all of the sponsors were  
10 present. We individually reviewed -- well, we all  
11 reviewed the whole report, but we spent most of the  
12 time on the parts that we were most familiar with. So  
13 the report was reviewed any number of times, probably  
14 five or six times, one way or another.

15 CHAIRMAN WALLIS: You folks signed off to  
16 this as a useful report to the utilities. Did you  
17 look at P&IDs for plants? Did you look at the real  
18 scenario in the event of these accidents to figure out  
19 what were the problems that needed to be addressed?

20 DR. GRIFFITH: We looked at some real  
21 scenarios, as a matter of fact. When the utility  
22 representatives were present, those were the questions  
23 that were raised. We had a number of things they were  
24 concerned with.

25 CHAIRMAN WALLIS: So did you ask questions

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1 like "Is it one void or many voids?" and things like  
2 that and "Where are the voids?" and "Why are they  
3 there?"

4 DR. GRIFFITH: Well, some of the problems,  
5 they were so plant-specific we didn't think we could  
6 address them in a categorical way and a lot of details  
7 which are different -- well, practically every plant  
8 is different.

9 CHAIRMAN WALLIS: That's right. That's  
10 right. So there is a lot of work for the plant to do.

11 DR. GRIFFITH: There is. There is no  
12 question about it. And when you see the flow chart,  
13 I think you will see what items we identified for the  
14 utilities to provide the information.

15 MR. WAGONER: Okay. I think we have been  
16 over these. We know what the system can do for us.

17 CHAIRMAN WALLIS: With the PIRT complete,  
18 you have this wonderful part which says, "These are  
19 the things we need to do." Does someone at the end of  
20 the project go back and say, "We did all of those  
21 things"?

22 MR. WAGONER: Tom?

23 DR. ESSELMAN: The PIRT was done at the  
24 beginning of the problem. At the beginning of the  
25 problem, we checked the plan against the PIRT. And we

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1 did go back and rereviewed that as a part of PIRT  
2 preparing the list to see that had done everything  
3 that we had identified in --

4 DR. ZUBER: Let me also ask: How do you  
5 feel about the PIRT?

6 DR. ESSELMAN: How do I feel about the  
7 PIRT?

8 DR. ZUBER: Yes.

9 DR. ESSELMAN: I think the PIRT was very  
10 useful. I think we sat down and really looked broadly  
11 and asked with Peter and Ben and Fred what things  
12 could be affecting this or that. And I think they  
13 were doing something very useful.

14 DR. ZUBER: Let me go back. Especially  
15 after I read your blessing of this report, that you  
16 agree with the PIRT, I started to read the PIRT. I  
17 found geometry, and you rate it high. What kind of  
18 geometry? What do you look at in the geometry? This  
19 is not addressed.

20 It's so vague it's almost -- to my  
21 assessment, it's almost useless to tell you the  
22 geometry is important for this program. I have known  
23 this before. How would the utility know what to look,  
24 what kind of geometry, what to look in the geometry,  
25 what is the most important thing? I don't find it.

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1                   So this is the weakness I found in this  
2 report, which is the buck is being passed to the  
3 utility. And I don't think that they have the  
4 capability of doing it.

5                   DR. ESSELMAN: Let me say that a part of  
6 what we will present is the specific actions related  
7 to the flow chart and what the utilities need to do.  
8 I believe that what the utilities need to do the  
9 utilities are capable of doing, number one.

10                  And, number two, those are going to have  
11 to be specific analyses. They are going to have to be  
12 submitted to NRR and be specifically reviewed.

13                  DR. ZUBER: Well, the question is not what  
14 they need to do it. You cite look at the voids.  
15 Voids are important. So what? I know that how to  
16 look at these voids, prescriptive, do this and do  
17 that.

18                  Then they can do it. And if they don't  
19 want to do that, they can justify not to do it but to  
20 say, "Look at the geometry. Look at the voids. Look  
21 at the subcooling." We have known this. This is so  
22 descriptive it's useless.

23                  DR. GRIFFITH: Well, I don't think we  
24 could make a general statement that would cover most  
25 of the plants. When you look at the details, they are

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1 so different.

2 DR. ZUBER: Well, the point is there is a  
3 -- you cannot do everything, but you should at least  
4 give the broad outline. Thou shalt use this and take  
5 a look at it, not necessarily look at a void fraction.  
6 So what?

7 MR. ROCHINO: Can I make a comment?

8 MR. BOEHNERT: Yes, if you identify  
9 yourself.

10 MR. ROCHINO: My name is Lee Rochino. I'm  
11 from Rochester Gaart Electric. At one point in time,  
12 the utilities that send ultra V configurations of  
13 every plant and out plant otherwise -- and Tom and the  
14 external, they look at the configurations of the  
15 participating plant. And then they went ahead and  
16 took that into consideration in considering the --

17 DR. ZUBER: You see, the thing with that,  
18 the geometry is important depending on what property.  
19 Then you say, "What aspect of geometry do you have to  
20 look at?" I think this is more in detail.

21 Maybe ten plants will not have it. Maybe  
22 about two will have it. So you have to be  
23 appreciated. You should look at this and this and  
24 that. And then you have the utility that helps NRR.

25 MR. WAGONER: It's in there.

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1 DR. ZUBER: Where? I cannot find it.

2 MR. ROCHINO: Let me make another point  
3 that as far as the utilities are concerned, we do have  
4 stuff to look at, a whole page. We've got these. And  
5 people are experiencing in this. So given the proper  
6 items, utilities can use it to --

7 DR. ZUBER: Well, as I said, I like to  
8 give you the benefit of the doubt. I said after 30  
9 years in this business, I have seen G.E. fall on its  
10 nose a few months ago. I saw EPRI fall on its nose a  
11 year ago. I saw INEL with all of their Ph.D.'s and  
12 experts make really basic mistakes. And you should  
13 really try to avoid this in this industry.

14 DR. KRESS: One way to put our mind at  
15 ease might be to tell us what geometry is important.

16 CHAIRMAN WALLIS: That's why we are  
17 waiting for the presentations.

18 MR. WAGONER: I guess the point is from a  
19 utility perspective, I feel that in the report, the  
20 things that we need to look at from a geometry  
21 perspective are addressed. We told them to look for  
22 dead legs that are in the void here. We told them to  
23 look for changes in the sizes. We told them to look  
24 for partially open or closed valves. We told them to  
25 look for orifice plates.

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1 DR. KRESS: But then you said dead legs  
2 weren't important later on in the report.

3 DR. ESSELMAN: We didn't say dead legs  
4 weren't important. We said that if you voided dead  
5 legs, they needed to be addressed on a plant-specific  
6 basis.

7 In general, our review of the P&IDs and  
8 the drawings show that it was not a predominant  
9 configuration that existed in the plants. But, yet,  
10 we did not take care of that generic -- we did not  
11 provide a method and said that if you had that, you  
12 needed to do it.

13 If your void passed an orifice plate, you  
14 needed to do a plant-specific analysis or a partially  
15 closed valve you said you needed to do from a specific  
16 analysis.

17 DR. KRESS: So these are the geometry  
18 things that you say were important?

19 DR. ESSELMAN: Yes. The whole  
20 condensation, this waterhammer evaluation is related  
21 to a vertical line --

22 DR. KRESS: And a horizontal line.

23 DR. ESSELMAN: -- transitioning into a  
24 horizontal line and what can happen when you get  
25 there. From a geometry point of view, the utility

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1 from a standard steady state flow transient basis can  
2 use a number of codes that they use all the time to  
3 model every change in direction and every pipe length  
4 to see what are the flows, what happens when you start  
5 the pipe.

6 We don't say, "Evaluate the void." We say  
7 specifically, "Calculate" during the 35 seconds or so  
8 where the void goes based upon drainage and gravity,  
9 number one; based upon pressure in the void; and based  
10 upon what your fan cooler is doing. And, as you  
11 transition, as your void goes, you need to know where  
12 it ends up because that's where the closure will  
13 occur. And if it passes an orifice on a partially  
14 closed valve, you need to do a specific plant  
15 evaluation.

16 We don't expect that to happen based upon  
17 our review of these plants. But we also say that when  
18 you uncover a horizontal leg, record from the analyses  
19 what your system pressure is because that is going to  
20 be your driving pressure for your condensation-induced  
21 waterhammer. We have a criteria that says if it is  
22 greater than or less than, you are either okay or not  
23 okay.

24 The analyses that have been left to the  
25 utility are the analyses that require them to look at

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1 the great detail in the configuration, in the pipe  
2 layout, in the vertical drop as you go from a  
3 containment location.

4 What we have dealt with is what was the  
5 most difficult to deal with. And that is: How does  
6 final closure occur? What is happening in the void?  
7 And how does final closure occur?

8 I believe we have left for the utilities  
9 to do: number one, the part of this that is very  
10 plant-specific because the fan coolers are different.  
11 Where the water is and how the drainage will occur is  
12 different. But that is also the easy part of this  
13 analysis, and that is what the utilities know how to  
14 do because they're doing steady state, generally  
15 steady state, pump start, pump stop analyses every  
16 day.

17 DR. ZUBER: Well, that is with  
18 condensation.

19 DR. ESSELMAN: Not condensation. That is  
20 what we have addressed specifically. And we have said  
21 we have asked them. And we will cover this again. So  
22 let me just jump ahead to address this specific  
23 question.

24 We have asked them to calculate the  
25 closure velocity up to the point where you haven't

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1 closed your void but you have nearly closed your void.  
2 We then have said once you know that velocity, we have  
3 given them the tables with instructions, with example  
4 problems so that they could enter the graphs and see  
5 how much cushioning they're going to get based upon  
6 how much air, how much space.

7 We have told them how to --

8 DR. ZUBER: This you got from your  
9 experiments?

10 DR. ESSELMAN: No. From experiments --  
11 well, from analyses mostly with most of the  
12 parameters, steam condensation rate being the primary  
13 parameter developed from experiment. Other than that,  
14 it's derived from a method of characteristics  
15 analysis.

16 And we use the rigid body model only once  
17 we have proved it was conservative, number one, and  
18 because we needed to do all of these parameters so  
19 that we didn't leave that to a utility.

20 We said, "All that you need to do is  
21 figure out what your lights are, how much gas you have  
22 in the void, where your steam is, and just enter this  
23 table and say that my final velocity is 82 percent of"  
24 --

25 CHAIRMAN WALLIS: We thank you for your

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1 contribution. I guess we are just indicating that we  
2 feel there are other parts to the problems. And we'll  
3 probably come back to them during the presentation.  
4 I would like to move on to that.

5 DR. ESSELMAN: What we plan to do is just  
6 to walk through a brief overview of the analyses  
7 beginning to end to hit the high points. But the  
8 first thing that I would propose that we present is:  
9 What is the process, and what does a user have to do?

10 We have a flow chart. We have taken the  
11 flow chart, and we have broken it down step by step.  
12 And we will describe what a utility has to do because  
13 it is plant-specific and NRR is going to have to do  
14 that review. But then where they get guidance, number  
15 one, the single active failure criteria, the final  
16 closure, how to deal with condensation-induced  
17 waterhammer, how to form a loading function with pulse  
18 time, all of those things that are in the report but,  
19 frankly, are the difficult things to do.

20 I believe we have left the utilities to do  
21 the things that they are very capable of doing and  
22 those things that are difficult, challenging, related  
23 to condensation and related to some of the specific  
24 geometry issues and what is the heat transfer, where  
25 is the air, and how do you get your air. Those are

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1 the things that are addressed in the report.

2 We will go through that in detail because  
3 I think it is very important. And I think that we  
4 have come a long way in the past year putting the user  
5 manual together, trying to strip out of that the  
6 science and leaving the instructions. And we have  
7 worked on sample problems that I know utilities have  
8 reviewed and have found very useful also.

9 We will go through all of that in detail.  
10 I appreciate all --

11 CHAIRMAN WALLIS: I think when we go  
12 through the detail, we may be able to answer some of  
13 these questions.

14 DR. ESSELMAN: I think so, too.

15 MR. WAGONER: That is the slide I thought  
16 I was going to blow through.

17 (Laughter.)

18 MR. WAGONER: From my perspective, the  
19 utility perspective, after spending about a million  
20 and a half dollars and looking at this thing for  
21 nearly two years, the bottom line is, first off, it's  
22 a low rise event.

23 If we had to stretch this simultaneous  
24 loop LOCA to a 24-hour period, even to get to  $10^{-6}$ , we  
25 take it down to an hour or 10 minutes, 30 minutes, and

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1 the numbers are even smaller. So we've got an  
2 extremely low probability of event. And there is no  
3 challenge to the safety function.

4 CHAIRMAN WALLIS: Can I ask you: In the  
5 report, we get pressures of 1,000 psi and so on, which  
6 seems like that you could get in the plant under some  
7 circumstances. Is that not a challenge of any sort?

8 MR. WAGONER: Well, it looks like to me  
9 there's not based on, one, bursting a pipe. That's  
10 the bottom line. If we don't break that pipe or tube,  
11 cooler tube I should say, we don't have a problem.

12 CHAIRMAN WALLIS: So these systems are  
13 designed for orders of 1,000 psi pressure?

14 MR. WAGONER: Impulses? After you look at  
15 an impulse and look at the ultimate strength of the  
16 tubes and pipes, -- and we'll go through that -- I  
17 don't believe that there is a safety challenge there.

18 DR. GRIFFITH: I think we made a good case  
19 on that. We'll get to it.

20 MR. WAGONER: Yes.

21 CHAIRMAN WALLIS: The cooler is designed  
22 for 1,000 psi internal pressure?

23 DR. GRIFFITH: There is a chart we'll get  
24 to.

25 CHAIRMAN WALLIS: Okay.

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1 MR. WAGONER: And the truth of the matter  
2 is these systems have been banged up hundreds of times  
3 in the real world.

4 CHAIRMAN WALLIS: We noticed that.

5 MR. WAGONER: Yes, for loop-only events.  
6 And, to the best of our knowledge, there has never  
7 been a failure. We have never ruptured a tube. We  
8 have never even deformed a piece of pipe, maybe shaken  
9 a concrete allowing some anchor bolts a couple of  
10 times.

11 CHAIRMAN WALLIS: Maybe shaken a few  
12 people's confidence or nerves.

13 MR. WAGONER: Well, that's okay. Back in  
14 my start-up days, I happened to be standing beside the  
15 main steam stop valves when operators hit the test  
16 button, young kids just out of college. I've never  
17 seen anything like that one before.

18 CHAIRMAN WALLIS: We had the NRC down to  
19 our lab when we were doing waterhammer tests. They  
20 ran for the door.

21 MR. WAGONER: The point is from our  
22 perspective that's a lot of real world experience that  
23 we think we are going to share that is worse than any  
24 postulated thing that we might get, and nothing  
25 happens. So what this really boils down to is a

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1 reasonable approach for figuring out hangar loads.

2 And the truth of the matter is the classic  
3 way we do this, we take that 1,000 peak pressure,  
4 stick it into our system, and run that through as the  
5 static load on the hangars, and do a p times 8. And  
6 you end up putting a whole bunch of steel, more steel  
7 in the pipe. And I think we all know that adding to  
8 steel to handle impulse loads is the wrong thing to  
9 do.

10 I've been there in balancing the plant  
11 systems when we had feedwater heaters moving. We  
12 thought, "Man, let's put more steel." And we tore up  
13 more things. When we started taking steel away and  
14 the feedwater heater had been running for ten years,  
15 we'd dance around a little bit, a couple of times  
16 during start-up. And that's the end of the problem.

17 I think that's where we are, frankly, in  
18 this process. As we go through this thing, is every  
19 step of it rigorously defended at the F = MA level?  
20 No, it's not.

21 When we step back and look at it from an  
22 engineering approach to figuring out what's the right  
23 load to put on these hangars from these impulses, I  
24 think we have a reasonable engineering approach.  
25 Frankly, I would ask you to look at it from that

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1 perspective.

2 CHAIRMAN WALLIS: I guess the sensitivity  
3 comes because there have been incidents where  
4 waterhammers have broken pipes which mattered, not in  
5 this particular system.

6 MR. WAGONER: Yes, sir.

7 CHAIRMAN WALLIS: Waterhammer does happen.  
8 It continues to happen. Since the --

9 DR. GRIFFITH: I guess the key on this  
10 system is the pressure is low --

11 CHAIRMAN WALLIS: Right.

12 DR. GRIFFITH: -- and there is air in the  
13 water. Those two things mitigate the waterhammers.  
14 There is no question about they have had waterhammers  
15 that are busted pipes, but it has been deaired water  
16 and high pressure. All right? And we have airated  
17 water and low pressure. And that makes a big  
18 difference.

19 CHAIRMAN WALLIS: Well, they have had  
20 waterhammers in fire suppression systems which have  
21 entered in the water which were not pleasant in  
22 consequence.

23 So it's not just a question of  
24 low-pressure system with air. You've got to look at  
25 the loads. I agree it's a lower load.

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1 DR. GRIFFITH: Yes.

2 MR. WAGONER: But that was what I wanted  
3 to get to. It's our perspective. And I would ask you  
4 to consider that as we go through some of the details  
5 of this thing. With that, I would like to turn over  
6 to Dr. Esselman.

7 CHAIRMAN WALLIS: Thank you very much.  
8 Thank you for your patience.

9 MR. BOEHNERT: Now, is this going to be  
10 open session? We're not going to get into closed  
11 session?

12 MR. WAGONER: I'm sorry. I needed to say  
13 that. From this point on, we are at a point where the  
14 proprietary material is pretty much interwoven with  
15 the rest of the presentation.

16 MR. BOEHNERT: Okay. So we need to go  
17 into closed session?

18 MR. WAGONER: Yes, sir.

19 MR. BOEHNERT: Okay. Transcriber, we need  
20 to go to closed session in the transcript.

21 (Whereupon, the proceedings went  
22 immediately into Closed Session.)

23

24

25

## P-R-O-C-E-E-D-I-N-G-S

CHAIRMAN WALLIS: Now I think we would like to hear from Mr. Tatum.

MR. TATUM: I guess I would like to give you the NRC's staff perspective on this going into the presentation today, which we have heard a lot. We have a lot to think about here based on the discussion, also from the Subcommittee members.

First of all, we view this as a good effort by the industry in trying to address the problem and come up with an analytical methodology, something different from what is provided in NUREG 5220. It's a possible solution for utilities to use, something that we may be able to accept, for addressing the waterhammer issue, specifically low-pressure service water systems.

Notable strengths based on our review and working with the industry on this, I think the PIRT was a good exercise for the group to go through to help I think focus their attention on what needed to be looked at and help to focus their testing.

We think the testing and data collection were also a strength to actually go out and get data where they didn't have the information, although I do understand there are some reservations from the

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1 Subcommittee on that point.

2 I think a very notable strength is the  
3 endorsement by the expert panel members. Obviously  
4 the industry took a look at what was available to help  
5 them out on this issue. And I think they came up with  
6 some real experts. I think we can place a lot of  
7 credibility in the work that was done based on the  
8 people that are involved.

9 So those are the strengths that I would  
10 mention on this. Let me get into some of the  
11 weaknesses. First of all, I guess looking at the  
12 thermal hydraulics end of it, we also shared some of  
13 the similar views that were experienced here by the  
14 Subcommittee looking at the scaling.

15 Some of the things that we were interested  
16 in and we will be discussing after the meeting I think  
17 is for the condensate-induced waterhammer, the  
18 applicability of small test data to the plant so the  
19 configuration -- water to pipe size, we have spent  
20 quite a bit of discussion here today on that point.

21 For the column closure waterhammer,  
22 condensing heat transfer and compressibility, how well  
23 those would apply to the plant-specific situations,  
24 larger pipe sizes, the NUREG TR-6519 screening  
25 criteria for the condensate-induced waterhammer,

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1 specifically the length over diameter ratio and the  
2 subcooling temperatures, to what extent they would  
3 apply for larger pipe sizes.

4 Not to belabor this, but we also had  
5 questions with regard to the deletion non-condensable  
6 gas. And we look forward to hearing back on what the  
7 resolution of that is.

8 Also, we note that there is no guidance  
9 for condensate-induced waterhammer analysis for  
10 pressures greater than 20 pounds. So we understand  
11 based on your survey of the industry, you don't expect  
12 that to be a problem in that the plants don't have  
13 that situation where the pressures would be greater  
14 than 20 pounds.

15 And also, finally, applicability of models  
16 to the plant, actual plant conditions, that was raised  
17 here. This is something we'll think about a little  
18 more, I think.

19 The other area I wanted to talk about as  
20 far as potential weaknesses has to do with the  
21 mechanical/structural area. See, in this area,  
22 looking at the different analytical approaches and  
23 whatnot, we were questioning the termination of the  
24 pulse rise time and duration.

25 We understand how that was determined by

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1 Altran. And we just questioned whether or not they're  
2 really conservative enough using the ten percent  
3 figure versus maybe some other figure going into the  
4 pulse rate, not that I would say that it's definitely  
5 a problem but something we need to think about to  
6 satisfy ourselves on; use of the single waterhammer  
7 pulse versus several cycles in the analysis and  
8 whether or not that would make any difference in the  
9 outcome and the pressure that you would see.

10 DR. GRIFFITH: Were you concerned with  
11 sort of exciting your resonance?

12 MR. TATUM: Yes. How if you had several  
13 cycles playing into it, how that would affect the  
14 overall outcome and the resonance.

15 DR. GRIFFITH: But the period is around  
16 two seconds. So I think if it was a resonance, it  
17 would have died out. The oscillation would have died  
18 out.

19 MR. TATUM: Did the data pretty much  
20 capture, Gary, on the

21 MR. HAMMER: I didn't really hear the  
22 comment. Basically, the number -- Gary Hammer.  
23 Basically we talked to them about the single  
24 waterhammer pulse versus several cycles. I think we  
25 were talking about resonance on that.

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1 MR. TATUM: Yes. And, Peter, I go back to  
2 the figure that Tom presented, where he showed that  
3 most of these lobes are founded by the analyzed values  
4 when you use this method. But there were a few points  
5 that were below that curve. Those were the ones that  
6 we think we may have seen some resonance on or  
7 something like that.

8 You can see that on some of these traces,  
9 there are multiple cycles. There is a big peak, but  
10 there is follow-up by smaller ones. And we're worried  
11 about that additional energy that could go into this  
12 system from a smaller process.

13 DR. GRIFFITH: That's what I just wanted  
14 to know, what categories you were concerned about.

15 MR. TATUM: The next item, attenuation due  
16 to fluid-structure interaction. We understand the  
17 concept and the information that is presented in the  
18 report. However, it is a fairly simplistic model that  
19 you are referring to. And I don't know that we are  
20 really comfortable accepting the attenuation concept.

21 I think it would require plant-specific  
22 analysis, rather than accepting that a licensee would  
23 apply the methodology and just come back to us and  
24 tell us that they had a certain amount of attenuation.  
25 We would like to see probably on a plant-specific

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1 basis how it is a credited attenuation.

2 I think we will be more comfortable just  
3 not getting the fluid-structure interaction,  
4 recognizing I think the general conclusion that  
5 attenuation would be overriding any amplification.

6 Structural damping value using comparison,  
7 comparing the analog versus the measured loads, is not  
8 identified. We thought that would be important for  
9 user application. We discussed that, I think. You're  
10 going to rectify that.

11 DR. ESSELMAN: He used a half of a percent  
12 damping in the analyses. We'll note that report in  
13 the revision.

14 MR. ZYSK: A tenth of a percent.

15 DR. ESSELMAN: A tenth of a percent. It  
16 was essentially zero.

17 MR. TATUM: A tenth of a percent, yes.

18 DR. ESSELMAN: We are not advocating in  
19 the user manuals how the plants should structurally  
20 run their analysis code for piping. That is certainly  
21 beyond the scope of what we are doing. We can  
22 describe what we used in our code, but, again,  
23 identified for user application ins not within our  
24 scope of work.

25 MR. TATUM: Right. We understand that.

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1 We just want to make sure that recognizing the  
2 information that is in the manual is going to make  
3 sure there's no misapplication.

4 DR. ESSELMAN: We'll make sure that that's  
5 in there.

6 MR. BROWN: Tim Brown, Duke Power.

7 We've been using the damping ratios that  
8 we use for seismic. Now let's just led by our SAAR.

9 MR. HAMMER: This is Gary Hammer again.  
10 I consider damping. Whatever value you use in your  
11 licensing basis for any other piping is okay. We just  
12 wanted to make sure that for making a comparison and  
13 demonstrating that they were showing that analog loans  
14 versus measured loans, just to understand what the  
15 basis was.

16 DR. ESSELMAN: He'll look into that.

17 MR. TATUM: Just one final point I think  
18 I'd like to make that's not reflected on the slides.  
19 The conclusion here that you all have come to is that  
20 the loop-only waterhammer would be bounding.

21 I think that's a very significant  
22 conclusion on your part and one that if it stands,  
23 then if we can accept that, I think it goes a long way  
24 to resolving the issue, at least for NRR, recognizing,  
25 as Vaughan had stated, many plants have already had

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1 the occurrence of loop without LOCA obviously, but I  
2 mean during pump casts, ESM testing and whatnot.

3 That has been a very common occurrence in  
4 the past. Plants have had problems based on  
5 waterhammer from just the loop scenario. And where  
6 they have had problems, they have gone in and made  
7 modifications. They have installed vacuum breakers  
8 and whatnot to correct the problem.

9 I think that if the conclusion is valid  
10 that the loop is a bounding situation, for those  
11 plants that can credit that, I think that would go a  
12 long way to resolving the issue because at NRR, that  
13 is something we have had experience with. We are  
14 comfortable with the plants being able to deal with  
15 that scenario.

16 That may leave the closed loop plants with  
17 a little more analysis to do, however, because in a  
18 loop scenario, they would not have had that kind of  
19 experience. So that would be a remaining issue that  
20 we would have to credit the analytical methodology,  
21 then, for those plants.

22 Let me ask John Hannon, my branch chief,  
23 to give the management perspective on this.

24 MR. HANNON: Thank you, Jim. This is John  
25 Hannon, the Branch Chief of the Plant Systems Branch.

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1 Just to start out, it's been a very  
2 interesting experience for me. It's the first time I  
3 have had an opportunity to get some technical material  
4 in quite a while. I appreciate all the good dialogue  
5 that I heard today.

6 There is a historical perspective I wanted  
7 to remind everybody about. This issue has been  
8 cooking for quite a while. Originally we were  
9 thinking when we generated the original generic letter  
10 that all of the SEs would be completed, the safety  
11 evaluations for all of the plants would be completed  
12 around August of 1998 with the expectation that was  
13 the majority and then residuals would be finished  
14 sometime during 1999. So we had extended the time  
15 period for which we thought this generic activity  
16 would be completed.

17 Joe mentioned earlier this morning I think  
18 that the complexion of the environment that we are all  
19 working in now has changed over that last couple of  
20 years.

21 We're trying to become more risk-informed  
22 in our regulatory decisions. And we are also being  
23 held to some different standards with regard to our  
24 management decisions from the standpoint of what we  
25 call the four pillars now with maintaining safety

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1 being the primary one and also enhancing public  
2 confidence and being more realistic in our  
3 decision-making and trying to be more effective and  
4 efficient.

5 Then there is the one about reducing  
6 unnecessary regulatory burden. So I think all of  
7 those new criteria have to come into play as we move  
8 forward on this particular topic.

9 So from a management perspective, I can  
10 tell you that that I am interested in seeing this item  
11 wrapped up. I would like to treat it as an industry  
12 initiative with EPRI taking the voluntary action here  
13 to come up with a solution that can be applied to the  
14 remaining plants generically.

15 What we are looking to the ACRS to provide  
16 is their considered opinion as to what we need to do  
17 to provide constraints in our safety evaluations,  
18 otherwise restrictions that would need to be applied  
19 on a plant-specific basis because we really do need to  
20 start moving this into the end game.

21 DR. ZUBER: I have a question.

22 MR. HANNON: Yes?

23 DR. ZUBER: How can the NRC make  
24 plant-specific data information when the ACRS doesn't  
25 have this information?

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1 MR. HANNON: That's a challenge for us.  
2 We think the industry has made a good faith effort, as  
3 Jim pointed out, to try to wrap up the technical  
4 issues here.

5 So the challenge is for us to now see if  
6 we can move it into a round where we could take a  
7 plant-specific application against this methodology to  
8 see if it can be considered appropriate or acceptable  
9 for regulatory purposes.

10 Again, we have to take into effect all of  
11 these considerations, regulatory burden, and ways.  
12 Are we able to say that we are maintaining safety?

13 So that is a challenge. But I think that  
14 from hearing the line of questions that I heard today  
15 through the ACRS, I think we are all on the path of  
16 coming to a leasable closure on this issue. That is  
17 the challenge I think we all have in front of us now.

18 Any other questions or comments?

19 (No response.)

20 MR. HANNON: Thank you, Jim.

21 CHAIRMAN WALLIS: I think Jim Tatum has  
22 reminded me of the loop versus loop LOCA. This report  
23 is mostly about loop LOCA. In the earlier draft,  
24 there was simply a statement that loops are worse than  
25 loop LOCAs, I mean, without much justification at all.

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1 I still don't quite grasp the rationale of  
2 why the loop is worse, to we say there is less air  
3 produced and so on. But there has to be a technical  
4 analysis or something that shows why it's worse. I'm  
5 not sure that it's here. It seems to be more of a --

6 MR. HANNON: We added a section in the PBR  
7 on loop versus loop LOCA. The conclusion that we have  
8 drawn and provided in the PBR is that if in the loop  
9 LOCA case there is no gas given off and no steam in  
10 the void, they will be the same because the same  
11 number of pumps will start.

12 There will be no cushioning or the same  
13 amount of cushioning with any gas given off, which we  
14 believe there will be. With any steam in the void  
15 that is pressurized, that final closure has to be  
16 cushioned. That cushioning will give you a lower  
17 velocity and a lower waterhammer.

18 CHAIRMAN WALLIS: So there is no air given  
19 off in the loop only?

20 DR. ESSELMAN: We think that whatever air  
21 is -- we do think that there is air given off in the  
22 loop only. We don't think that it will be less in the  
23 loop LOCA. We think that it will be more.

24 CHAIRMAN WALLIS: I think I know in this  
25 thing. Originally I looked at this curve, and it's

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1 ground for a cubic meter; whereas, the other one is  
2 ground for a liter. It's confusing, different scales.

3 MR. ZYSK: We've got roughly three orders  
4 of magnitude.

5 CHAIRMAN WALLIS: Right. That's where the  
6 orders of magnitude come from. I didn't realize that  
7 in the first slides. Maybe it is clearer, but it sort  
8 of needs to be clear.

9 Do you have a question, Tom? Do you want  
10 to raise your question or do you need some help? Is  
11 it important?

12 DR. KRESS: Yes. It may or may not be.  
13 I was looking at Figure 10-8 in the technical basis  
14 document. I don't know if you have a viewgraph of it  
15 or not, but it appears to me when you're plotting  
16 under these conditions, rise time as defined versus  
17 closure velocity, that you're basically plotting two  
18 independent variables versus each other, which would  
19 be thrown out by the scatter of the data in the first  
20 20 feet per second of closure velocity. I'm not even  
21 sure why you get a correlation above that.

22 If I had questions about the relevance of  
23 this particular plot and whether or not indeed those  
24 are variables you could correlate with each other  
25 because they look to me like independent variables.

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1 They have no relationship to each other.

2 MR. ZYSK: If I could touch on that? The  
3 idea is that that rise of pressure over a time period  
4 is proportional to the velocity of closure to some  
5 extent. In other words, if you have a fairly  
6 slow-moving mass of water, then that rise in pressure  
7 as you squeeze that final closure would be spread out  
8 fairly long. And if you have a rapid closure, the net  
9 rise is fairly abrupt. So they're not truly  
10 independent in that aspect.

11 We looked at Configuration 1, which was  
12 essentially a cold water on steam closure. So it  
13 should be as abrupt as we can get compared to, say,  
14 the Configuration 2A or 2B data.

15 CHAIRMAN WALLIS: There are  
16 non-condensibles in there except when they come out of  
17 the water.

18 MR. ZYSK: That's correct. That's  
19 correct. So the rise --

20 CHAIRMAN WALLIS: So they are not voided  
21 off or anything, then.

22 MR. ZYSK: Right. There should be  
23 virtually no non-condensibles there. So that should  
24 be as abrupt a rise as possible.

25 We also looked at if you can look at --

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1 CHAIRMAN WALLIS: Well, you could argue it  
2 had something to do with the shape of the interface  
3 and that the interface --

4 MR. ZYSK: It could be, but our --

5 CHAIRMAN WALLIS: -- is tilted because of  
6 a certain time to close --

7 MR. ZYSK: Yes. Our guidance on that from  
8 our experts was that that was kind of a secondary  
9 effect and that the shape of the interface wouldn't  
10 influence the rise time as much as the compression of  
11 the wood would.

12 If you look at also Figure 9-10, which is  
13 the same data looking at rise time versus impact  
14 velocity, this is model results. This is from our  
15 rigid body model prediction, where we actually put a  
16 gas concentration. It's on Page 9-13.

17 We actually put a gas volume or mass of  
18 gas in the void. We did tend to see a relationship  
19 between the -- you look at the exponent on our curve  
20 there. It's essentially a polytropic gas impression.

21 So based on how we enveloped pretty well  
22 all of that theoretical data. We also compared in the  
23 Figure 10-8 how we matched up with the most  
24 conservative of the test configurations that we ran.  
25 It kind of slices through the data in the 10 to 20

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1 feet per second but matches up very well in the higher  
2 closure velocities, 25, 30, 40, 17 percent.

3 CHAIRMAN WALLIS: Looking at 9-10, there  
4 are all of these points up above the curve.

5 MR. ZYSK: Yes.

6 CHAIRMAN WALLIS: So you could argue, like  
7 my colleague was saying here, that these are really  
8 two variables. They just don't correlate with each  
9 other. It's just that because of limitations on the  
10 experiment or something, there is a limit to them,  
11 which is what you have got here.

12 MR. ZYSK: Yes. And I think, again, from  
13 an engineering approach, this is a reasonable way to  
14 characterize what the rise time is doing. It's  
15 conservatively bound what our model --

16 CHAIRMAN WALLIS: But it doesn't mean to  
17 say that in some other facility, there wouldn't be  
18 some other limit.

19 MR. ZYSK: Looking at the column closure  
20 event in a pump system as essentially a  
21 one-dimensional problem, no, I don't think that the  
22 chance of this being vastly different at other  
23 facilities was really that big of a risk.

24 This particular set of model predictions  
25 at Figure 9-10 is for 4-inch, 10-inch, and 16-inch

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1 data. So it's not --

2 CHAIRMAN WALLIS: If something were really  
3 one-dimensional, there would be no air in there at  
4 all. The rise time would be zero.

5 MR. ZYSK: If there were no air, yes, the  
6 rise time would be zero if you didn't get any steam  
7 cushion or anything like that. The importance I think  
8 is in some of the existing publications. Without any  
9 basis to go on, the recommended rise time is one  
10 millisecond.

11 Assume a square width. We think that is  
12 wildly conservative. And I think there is a basis for  
13 showing that it is 10, 15, 20 milliseconds as a  
14 reasonable number for a rise time of a pressure  
15 possibility.

16 CHAIRMAN WALLIS: Now, when something  
17 closes in a bigger pipe with the same velocity, if you  
18 had, say, a slope to the front, it would take longer  
19 to close the front, wouldn't it?

20 MR. ZYSK: I would guess so.

21 CHAIRMAN WALLIS: So the rise time may  
22 scale in some way with diameter.

23 DR. ESSELMAN: A slower closing, though,  
24 would generally, as shown here, also a slower closing  
25 will give you lower loads in a piping system. So

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1 using a more rapid closure, even though we know that  
2 with cushioning and in larger pipes, it will be  
3 slower, bounding it with a curve here is conservative  
4 relative to the loads in the piping --

5 CHAIRMAN WALLIS: So your arguments about  
6 scaling seem to be that all the ways you can imagine  
7 to scale seem to indicate that it's conservative to  
8 assume that the two-inch pipe data is representative.

9 So although in the one place where you  
10 compare experiment there with the two-inch and  
11 four-inch pipes in the configuration, which is a  
12 variation of one. It's actually the four-inch data  
13 which are higher.

14 DR. ESSELMAN: I guess I don't believe  
15 that our conclusion is that two-inch data is always  
16 conservative. I think that two-inch data is  
17 representative. And by doing things like this when  
18 we're taking what we think is the conservative side to  
19 rise times, for instance, when we know that has a big  
20 impact in the structural loading, that gives you  
21 support loads doing things like this. Bounding the  
22 data this way I think gives us what we feel are  
23 conservative applications for the parameter into the  
24 structural loading.

25 Again, as we started this morning talking

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1 about supports and the kind of differential loads and  
2 rise times in the -- rise times will give you support  
3 loads being important. We think in areas like this,  
4 for instance, we have taken a conservative approach.

5 CHAIRMAN WALLIS: Is there anything else?

6 (No response.)

7 CHAIRMAN WALLIS: So we will see him  
8 again, I guess. Do you have any idea of the time  
9 scale?

10 DR. GRIFFITH: I think we've got to decide  
11 what we need to do before we give you a deadline.

12 CHAIRMAN WALLIS: Okay. My hope would be  
13 it would take less time than the last interval between  
14 meetings. I think we are ready to adjourn for the  
15 day. Anything else we have to do?

16 Actually, what we will do, we will come  
17 off the record. Then we'll discuss among ourselves.  
18 So we'll adjourn. Thank you very much.

19 (Whereupon, the foregoing matter was  
20 concluded at 4:05 p.m.)

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