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**ORIGINAL**

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Future Plant Design Subcommittee Meeting  
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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION  
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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
(ACRS)  
COMBINED THERMAL-HYDRAULIC PHENOMENA/  
FUTURE PLANT DESIGN: SUBCOMMITTEE MEETING

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FRIDAY

FEBRUARY 15, 2002

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, T2B3, 11545 Rockville Pike, at 8:30 a.m., Thomas S. Kress, Chairman, presiding.

COMMITTEE MEMBERS:

THOMAS S. KRESS	Chairman
DANA A. POWERS	Member
VIRGIL SCHROCK	Consultant
WILLIAM J. SHACK	Member
JOHN D. SIEBER	Member
GRAHAM B. WALLIS	Member

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1 STAFF PRESENT:

2 Paul A. Boehnert

3 Medhat El-Zeftawy

4

5 ALSO PRESENT:

6 Walton L. Jensen

7 Jared Wermiel

8 Ed Throm

9 Mike Corletti

10 Ralph Landry

11 Edward Cummins

12 Bill Brown

13 Rick Austin

14 Jerry Wilson

15 Milorad Dzodzo

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

Time: 8:33 a.m.

CHAIRMAN KRESS: This is a continuation of our Joint Subcommittees on Thermal-Hydraulic Phenomena and Future Reactor Designs, dealing with the subject of Phase 2 review of the AP1000 certification.

I guess we will ask if the members want to have any preliminary thoughts before we start. If not, Ill call on Jared Wermiel to introduce the set.

MR. WERMIEL: This is Jared Wermiel. I am Chief of the Reactor Systems Branch.

This morning we are going to talk about the review that was performed under the Phase 2 of AP1000 of the those computer analysis codes for accidents in transients and for containment analysis.

The first discussion will be with Walt Jensen of my staff. In the Reactor Systems Branch we had a team of my staff review NOTRUMP, LOFTRAN and WCOBRA TRAC, those codes being used for analysis of accidents in transients for AP1000, in order to determine the applicability of these codes for AP1000 utilizing the information that we obtained during the AP600 review and the new information that was provided by Westinghouse as part of this Phase 2 review.

After Walt finishes, Ed Throm from the

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1 Plant Systems Branch will talk about our review of  
2 WGOthic, the code that is being used for analysis of  
3 containment performance for AP1000.

4 So I'll let Walt go ahead.

5 MR. JENSEN: I am Walt Jensen, NRC staff,  
6 and I am going to talk to you about our review of  
7 LOFTRAN and NOTRUMP for AP1000.

8 (Slide change)

9 MR. JENSEN: First let me show you some --  
10 the background slide. This details the differences  
11 between AP1000 and AP600 for the passive safety  
12 systems. We concentrated on the differences between  
13 the two plants and how NOTRUMP and LOFTRAN would  
14 handle the differences, because we just finished  
15 reviewing both of these codes and approving them for  
16 AP600.

17 So a lot of the review we didn't want to  
18 repeat again, but as you can see, the makeup tank is  
19 a little bit bigger than AP600, but they are the same  
20 height but they are fatter. I believe that it was  
21 Steve Bajorek in review of the scaling concluded that  
22 the CMTs for AP1000 were still within the scale of the  
23 CMT test data.

24 The accumulators are the same size. IRWST  
25 is just about the same. They are going to pull a

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1 little bit more water in, and the lines going to the  
2 reactor system are larger. So they will have more  
3 flow.

4 ADS-1, 2,3 are the same. ADS-4 is larger  
5 with a lower line resistance and will remove steam and  
6 water a lot faster than they did for AP600 -- or they  
7 would for AP600.

8 (Slide change)

9 MR. JENSEN: The passive RHR is slightly  
10 larger, the same design. The lines going to the  
11 passive RHR are larger, larger lines with less flow  
12 resistance. So more flow will flow through heat  
13 exchangers, and more heat will be removed.

14 I have some containment data, and Ed Throm  
15 will talk about the containment when I'm done.

16 CHAIRMAN KRESS: On your other slide, the  
17 first one --

18 (Slide change)

19 MR. JENSEN: This one? All right. Okay.

20 CHAIRMAN KRESS: Down at the bottom it  
21 says the ADS-4 venting is designed to allow for stable  
22 IRWST/sump injection during long term cooling. What  
23 does that mean?

24 MR. JENSEN: I guess I can't elaborate on  
25 it.

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1 CHAIRMAN KRESS: Does that mean it has a  
2 certain capacity to the pump and the sump, and you  
3 want to match the drainage out this way, out this  
4 thing to it?

5 MR. JENSEN: This would be for the --  
6 There are check valves that open to the reactor  
7 system, once the blowdown was completely finished, and  
8 allow the sump water to drain into the reactor system,  
9 and the ADS-4 then depressurizing the reactor system  
10 completely. Then this is part of the long term  
11 cooling process.

12 This is not modeled in NOTRUMP, but it is  
13 modeled in WCOBRA TRAC which is picked up after the  
14 NOTRUMP analysis is completed. The NOTRUMP, work  
15 stops when the IRWST begins to inject.

16 CHAIRMAN KRESS: One reason I asked the  
17 question is I thought that valve was designed so that  
18 you can depressurize at the right rate to get the  
19 injections from the other systems during the  
20 depressurization, and that this might also be a  
21 consideration.

22 MR. BROWN: I think it's more -- You know,  
23 think of it in terms of -- Bill Brown from  
24 Westinghouse -- that it probably -- When I hear this,  
25 it makes it sound like this really is maintaining the

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1 depressurization so that, as you would send the steam  
2 out, that essentially you don't repressurize; because  
3 if you didn't, then you would have this continual  
4 cycling of having to get some injection. You would  
5 have to wait for the depressurization to occur through  
6 the valve again, if it was undersize, for example, and  
7 then have to wait for that whole thing to clear out,  
8 and then you get some more injection again, where by  
9 the sizing of it and design, you can keep the pressure  
10 -- once you depressurize it, keep it down rather than  
11 repressurizing and going through a cyclic --

12 CHAIRMAN KRESS: That fixes the minimum  
13 area then?

14 MR. BROWN: Pardon me?

15 CHAIRMAN KRESS: That fixes the minimum  
16 area.

17 MR. BROWN: Yes, what you need to do that,  
18 yes. Yes.

19 CHAIRMAN KRESS: Thank you.

20 (Slide change)

21 MR. JENSEN: LOFTRAN -- I'll talk about  
22 LOFTRAN first. It's probably the easiest. This is an  
23 old code that Westinghouse has been using for years to  
24 calculate transients, Chapter 15 transients in the  
25 reactor system, including steam generator tube rupture

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1 and steam line break.

2 It is used with other codes to evaluate  
3 the maximum reactor system pressure, fuel temperature  
4 and DNBR that would be experienced for various Chapter  
5 15 transients.

6 It was approved first after a lengthy  
7 review in the mid-eighties and then again for AP600 in  
8 1998. It models the entire reactor system, but it  
9 doesn't handle two phase conditions very well except  
10 in the pressurizer. Pretty much if two phase occurs,  
11 it is assumed to be homogeneous. So one should avoid  
12 conditions for which two phase would occur with a  
13 LOFTRAN analysis.

14 (Slide change)

15 MR. JENSEN: For AP1000, we looked at some  
16 of the accidents that might occur. ADS-1, 2 and 3  
17 could be analyzed with the code in a manner similar to  
18 a stuck open relief valve, but the analysis stops  
19 before any two phase conditions occur, and it's for  
20 DNBR only. The inadvertent ADS-4 opening would be  
21 done by a LOCA code.

22 The PRHR is larger and has a higher heat  
23 flow -- higher heat flux. The data -- The  
24 correlations in the code have been benchmarked and fit  
25 to the actual test data, and the data includes --

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1 Excuse me.

2 CHAIRMAN KRESS: Did they fit that test  
3 data by putting a penalty on the area?

4 MR. JENSEN: This is the -- They use a  
5 Rohsenow correlation, I believe, and they fit the  
6 exponents in the equation just so they would --

7 CHAIRMAN KRESS: Oh, they adjusted the  
8 correlations.

9 MR. JENSEN: They adjusted the  
10 correlations so it would fit the test data. The test  
11 data then includes the conditions that would be  
12 encountered in AP1000.

13 CMT draining -- Let's see. Oh, yes, the  
14 split cold legs -- LOFTRAN doesn't directly model the  
15 split cold legs for AP1000, but an external model is  
16 used to calculate the flow rates for asymmetric cold  
17 leg conditions such as a stopped reactor coolant pump,  
18 a locked rotor or sheared shaft.

19 The flows are calculated outside the code  
20 and input into LOFTRAN. The models were reviewed for  
21 AP600, and we think the same models should be  
22 appropriate for AP1000.

23 MEMBER WALLIS: Well, if LOFTRAN is no  
24 good for two phase flow, why is it used for split cold  
25 leg?

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1 MR. JENSEN: It can -- As long as the flow  
2 is single phase, it can be used for --

3 MEMBER WALLIS: But it's not, is it?

4 MR. JENSEN: Pump -- reactor coolant pump  
5 trip, and they would evaluate the DNBR, and this would  
6 be done before two phase conditions occur.

7 MEMBER WALLIS: Before two phase  
8 conditions?

9 MR. CORLETTI: Walt, this is Mike Corletti  
10 at Westinghouse. Could I just clarify?

11 I think the split cold leg that you are  
12 talking about there is not a LOCA. I think you are  
13 talking about the fact that we modeled two cold legs.

14 MR. JENSEN: Ah, yes. Then again, CMT  
15 draining is not expected. So they don't worry about  
16 the void --

17 MEMBER WALLIS: You mean it treats both  
18 cold legs as the same?

19 MR. CORLETTI: Yes, Dr. Wallis.

20 MR. JENSEN: Treats them as the same.

21 MEMBER WALLIS: By split, you mean they  
22 are different. That split means that there's a  
23 different flow in each one. Is that what you mean?

24 MR. JENSEN: Yes, sir. That's what I  
25 meant to say.

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1 CMT draining is not expected, and no void  
2 formation is expected to occur in the pressure balance  
3 lines. Westinghouse does have a penalty factor here  
4 to use in case CMT -- in case the pressure balance  
5 lines do become voided, but they don't think this will  
6 occur.

7 The steam generators are larger than  
8 AP600, and we were concerned that steam formation  
9 might occur in the reactor coolant loops in the steam  
10 generator tubes perhaps, in the top of the U-bend or  
11 in the CMT pressure balance line in a place that  
12 hadn't been reviewed.

13 So Westinghouse did not submit a steam  
14 line break and proposed to do that in Phase 3. So  
15 this is open right now, though we have done a  
16 preliminary steam line break which shows that no void  
17 formation occurs in the system besides the upper head.  
18 So this should be resolved fairly easily in Phase 3.

19 (Slide change)

20 MEMBER SCHROCK: Did you say 2 or 3?

21 MR. JENSEN: In Phase 3 Westinghouse will  
22 submit the steam line break.

23 CHAIRMAN KRESS: Now just for my  
24 edification, this code, LOFTRAN, looking at it, and  
25 it's used for a certain portion of the accident

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1 analyses, and you have these considerations that you  
2 listed on the previous slide which were things you  
3 thought might be things to be concerned about and to  
4 look at.

5 Now you are jumping to a slide that says  
6 LOFTRAN is acceptable. My question for my edification  
7 is: What went on in between these concerns and  
8 reaching this conclusion? Did you take the code  
9 calculations that Westinghouse made and looked at them  
10 and somehow made judgments about those concerns or did  
11 you -- What is the review process that gets you to  
12 this point?

13 MR. JENSEN: Okay, good question.  
14 Westinghouse submitted their input manual and their  
15 user guidelines to running the code for AP1000. We  
16 reviewed those. The code has been benchmarked against  
17 SPES data and CMT data and PRHR data.

18 The scaling of the data was reviewed and  
19 found to be appropriate to use for AP1000. We did a  
20 RELAP analysis, a steam line break analysis which  
21 showed very little cooling.

22 RELAP entrained a lot of liquid in the  
23 steam generator as we blew the steam generator down,  
24 and carried a lot of liquid away, where LOFTRAN  
25 conservatively assumes only steam that's relieved in

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1 a steam line break. The water stays in the steam  
2 generator and is available to remove more steam to  
3 boil and remove more heat from the reactor.

4 So this is a conservatism, and then, of  
5 course, it had just been reviewed for AP600 and we  
6 rely on that review for things that are similar  
7 between the two plants.

8 CHAIRMAN KRESS: I thought you said a few  
9 moments ago that the code should not be used for a two  
10 phase problem. But now you've just described a  
11 problem with two phase in the steam generator.

12 MR. JENSEN; Yes. I should have added to  
13 the components that the code has been designed to  
14 model in two phase. I should have added the steam  
15 generator secondary side, and the code does handle two  
16 phase in steam generator secondary and in the  
17 pressurizer, and everywhere else it assumes  
18 homogeneous. So I need to thank you.

19 Well, that's all I have for the LOFTRAN:

20 CHAIRMAN KRESS: We didn't dwell on that  
21 open issue. Would you? We would like to know.

22 MR. JENSEN; Yes, sure can. The open  
23 issue -- Well, I mentioned the steam line break that  
24 Westinghouse -- for phase 3.

25 CHAIRMAN KRESS: Now that's the open issue

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1 you just talked about.

2 MR. JENSEN: But preliminary analysis  
3 shows they don't get boiling except in the upper head  
4 and the steam generator and the pressurizer, and they  
5 calculate a return to power. But we will be looking  
6 at that in detail in phase 3.

7 MEMBER POWERS: You indicated that this  
8 particular code had been benchmarked against data from  
9 the SPES facility, I believe.

10 MR. JENSEN: Yes.

11 MEMBER POWERS: If I developed a  
12 substantial masochistic streak and wanted to look at  
13 that comparison against the test data, where would I  
14 go to find it?

15 MR. JENSEN: It is in the topical that was  
16 submitted for AP600, the final --

17 MEMBER POWERS: Maybe you could just give  
18 me that reference before you leave today.

19 MR. JENSEN: Okay, I sure will. You're  
20 going to have to remind me so I don't forget.

21 MEMBER POWERS: I think I have most of  
22 that someplace.

23 MR. BOEHNERT: Well, we've got it here,  
24 too, I think, if you don't.

25 MR. JENSEN; I expect you do have it.

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1                   MEMBER POWERS: Well, I am reminded of a  
2 presentation once when a fellow said I benchmarked my  
3 code against some data. We asked him to see that, and  
4 the data and the predictions were at right angles.  
5 Whereas, he had indeed done what he had said, it's  
6 just that the comparison was very poor.

7                   MR. JENSEN: Well, you have already seen  
8 this, because you reviewed it for AP600. It's not  
9 something you have to review again, I don't think. Do  
10 you know?

11                   MR. LANDRY: Dana, Ralph Landry from the  
12 staff. That is all in the submittal that was on the  
13 LOFTRAN for AP600, and it is in the -- can't remember  
14 the WCAP number that it had, but the LOFTRAN submittal  
15 had all the RAIs and all the responses to the RAIs.

16                   What Walt is referring to was in RAIs and  
17 responses, but that is in the two binders on LOFTRAN  
18 for AP600. All those comparisons are shown.

19                   MR. CORLETTI: This is Mike Corletti,  
20 Westinghouse. I believe it was in the LOFTRAN  
21 validation report. I have two WCAPs here. I'm not  
22 precise on which one it is for sure, but it's either  
23 WCAP 14234 or WCAP 14307.

24                   MR. LANDRY: I think it was 434, Mike.

25                   MR. BOEHNERT: 234 or 434?

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1 MR. LANDRY: 234.

2 MEMBER POWERS: Maybe if somebody just  
3 scribbled this down, I would have some hope.

4 MR. JENSEN: Thank you, Mike. Anything  
5 else on LOFTRAN?

6 CHAIRMAN KRESS: So, basically, your  
7 conclusion is, its use for AP1000 is okay with the  
8 possible exception of this one open issue that you're  
9 going to look into further?

10 MR. JENSEN: Right. That's right.

11 CHAIRMAN KRESS: Let me understand that  
12 open issue and be sure I understand it. LOFTRAN  
13 predicts not much voiding, and you got a lot of water  
14 left in there to keep the core cool.

15 MR. JENSEN: No, no. LOFTRAN is single  
16 phase. What we are worried about with the things we  
17 are looking at with LOFTRAN is DNBR before the rods go  
18 in, and maximum pressure for the surges up in the  
19 pressurizer. Maybe it's used to input the code to  
20 calculate the seal temperature, but there's no core --  
21 that would be calculated with LOFTRAN. That would be  
22 with the LOCA code. It's transients, DNBR.

23 CHAIRMAN KRESS: Okay, but what is it you  
24 are worried about with the open issue again?

25 MR. JENSEN: Yeah, okay. Well, if there

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1 are voids in the system that are calculated in the  
2 system, LOFTRAN doesn't separate the voids. It's all  
3 homogeneous.

4 CHAIRMAN KRESS: And you did RELAP  
5 calculations that said there might be voids there?

6 MR. JENSEN: No, I didn't. RELAP didn't  
7 calculate any voids.

8 CHAIRMAN KRESS: Just worried that there  
9 might be voids there?

10 MR. JENSEN: There were no voids in RELAP,  
11 but we were worried that the code would not be capable  
12 of analyzing the physics of what's going on in the  
13 system if voids occurred, except in a limited number  
14 of places.

15 CHAIRMAN KRESS: Okay, I think I  
16 understand.

17 MEMBER SCHROCK: This evidently didn't  
18 include a systematic review of the parameter range for  
19 the applications of the correlations in the code, or  
20 did it? Two are mentioned.

21 MR. JENSEN; Not systematic, no. No, we  
22 didn't do that. We did look at the PRHR heat  
23 exchanger correlations and assured ourselves that the  
24 data they used was within range. The code was  
25 reviewed in a lot more detail for AP600, and I suspect

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1 this was done. I don't know.

2 MEMBER SCHROCK: Thank you.

3 (Slide change)

4 MR. JENSEN: NOTRUMP: Now NOTRUMP -- It's  
5 a small break LOCA code, and it's used to calculate  
6 the inventory in the core and whether the core becomes  
7 uncovered or not. And if it does become uncovered,  
8 Westinghouse's model, small break model, includes the  
9 SB LOCTA code that's used to calculate peak cladding  
10 temperature.

11 Westinghouse is hopeful that there will be  
12 no core uncovering calculated by NOTRUMP, and so they  
13 won't be in need for a core heatup calculation. But  
14 again, this was -- The NOTRUMP code was -- It's an old  
15 code, and it was approved by the staff for operating  
16 plants after a long and rigorous review in 1985, and  
17 then again for AP600.

18 It uses five conservation equations with  
19 slip models to evaluate the steam and the water  
20 velocities. It does not -- The present model doesn't  
21 include momentum flux for area and density changes.

22 Westinghouse did a study --

23 MEMBER WALLIS: Those are the ones that  
24 are usually controversial. So they just leave them  
25 out?

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1 MR. JENSEN: Well, yes. It also made the  
2 code -- Apparently, it made the code run unstably.

3 MEMBER WALLIS; Easier to run. It makes  
4 it easier to run. No, really. You can do that. You  
5 can make the code unstable with momentum flux term.

6 MR. JENSEN: Yes. Now they did a  
7 sensitivity study for AP600 and concluded that the  
8 momentum flux had very low effect except for ADS-4,  
9 because of the high velocity effect.

10 CHAIRMAN KRESS: And they did something to  
11 compensate for not having those. Is that where they  
12 artificially reduced the water level?

13 MR. JENSEN: Yes, sir, they did that, and  
14 they also talked about adding a resistance, extra  
15 resistance in the IRWST line.

16 CHAIRMAN KRESS: To account for the what  
17 would have happened if you had momentum.

18 MR. JENSEN: Right, and they propose to do  
19 a similar thing with the resistance for AP1000.

20 CHAIRMAN KRESS: But not do the penalty on  
21 the head of the water level in the IRWST? To do the  
22 resistance instead?

23 MR. JENSEN: That is true, to do the  
24 resistance and not the water level penalty.

25 CHAIRMAN KRESS: And that resistance would

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1 be determined by comparing with SPES data?

2 MR. JENSEN: This was determined for OSU,  
3 I believe, in this case.

4 CHAIRMAN KRESS: OSU data? Okay, OSU  
5 data.

6 MR. JENSEN: And then I think they added  
7 some additional resistance for conservatism. Now  
8 would that same thing be appropriate for AP1000?  
9 Well, that's kind of tied up in the overall --

10 CHAIRMAN KRESS: That's the question,  
11 isn't it?

12 MR. JENSEN: Yes, that's the question. We  
13 have a number of issues involving ADS-4 that need to  
14 be worked out.

15 (Slide change)

16 MR. JENSEN: Well, we made a RELAP model  
17 for AP1000, and we tried to make it as close as we  
18 could, to use the same assumptions that NOTRUMP was  
19 using, so we could compare the two codes, one against  
20 the other.

21 There's a single failure. One of the ADS-  
22 1 lines had assumed ANS plus 20 percent, and the  
23 containment back pressure is set to atmospheric, just  
24 like in NOTRUMP.

25 The first thing we did, we got one of the

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1 old AP600 runs, and yes, it does have a lot of hash in  
2 there.

3 CHAIRMAN KRESS: Is that numerical or is  
4 it real?

5 MR. JENSEN: Numerical, mostly on the back  
6 part.

7 MEMBER WALLIS: We don't have any real.

8 MR. JENSEN: Some of it may be real, but  
9 I think this is numerical, and particularly it's  
10 caused by the steam properties at low pressure, and  
11 they were doing -- The code had trouble converging.

12 This is an older version of the code, too.  
13 It's 2.3.3 gamma, and they have recently released a  
14 3.3 beta to the count numbers, and that's what we used  
15 for AP1000, but this is an old run for the older  
16 plant.

17 What you see is that --

18 CHAIRMAN KRESS: This is like inducing a  
19 LOCA by opening up ADS-1?

20 MR. JENSEN: Yes, that's the way it is.  
21 ADS-1 sticks open.

22 CHAIRMAN KRESS: Well, then does the  
23 depressurization continue through ADS-2, 3, and 4?

24 MR. JENSEN: Yes, sir. As I said, this is  
25 predicated on the draining of the CMT.

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1 CHAIRMAN KRESS: Draining of the CMT.  
2 Okay.

3 MR. JENSEN: And then, of course, the  
4 accumulators inject. CMT injects, and things are  
5 pretty stable until ADS-4 opens, and that causes the  
6 void fraction in the core to soar. That's this big  
7 soaring in the void fraction.

8 CHAIRMAN KRESS: I see.

9 MR. JENSEN: And then the peak is turned  
10 around the IRWST injection, which continues to inject  
11 and then drops the void fraction to a fairly low level  
12 which, unfortunately, in this version of the code kind  
13 of jumps around.

14 MEMBER SCHROCK: This code to code  
15 variation might give you a warm feeling, but don't you  
16 need some demonstration through data as well? Are  
17 there some data for this type of accident?

18 MR. JENSEN: Well, yes, AP600. Of course,  
19 there was the staff test and OSU and ROSA test, and  
20 RELAP was benchmarked against numerous of those tests  
21 back in the AP600 review.

22 MEMBER SCHROCK: Well, benchmarked could  
23 mean a lot of different things, I suppose, in terms of  
24 the data compared with the prediction. But have you  
25 looked again at how well RELAP did for this particular

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1 transient in order to satisfy yourself that using it  
2 as a comparison now against NOTRUMP provides useful  
3 insight?

4 MR. JENSEN: Yes, I think it did a pretty  
5 good job on stuck open ADS-1. Well, maybe -- I don't  
6 remember whether they did a 1 or what, but they did a  
7 stuck open ADS, I'm pretty sure, out of the  
8 pressurizer. I think it did a pretty good job.

9 It had some trouble on some of the OSU  
10 beyond design basis runs, and it had problems with  
11 ADS-4 entrainment. One of the reports, I believe,  
12 thought that there was too much entrainment in ADS-4,  
13 and another report thought there was too little  
14 entrainment. But, yes, it has the problem.

15 So we are not going to review AP1000 based  
16 on what RELAP says. It helps us to understand what's  
17 going on, so we get an idea about the conditions in  
18 the plant and helps us to know what questions to ask  
19 to Westinghouse. But I wouldn't put a great deal of  
20 confidence in what RELAP predicts, other than it did  
21 do a pretty good job on a lot of these test results.

22 CHAIRMAN KRESS: Do you have a similar  
23 curve for -- calculated by NOTRUMP, just to see what  
24 they look like?

25 MR. JENSEN: No, not -- Well, what I

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1 wanted to show you now was for the AP1000.

2 (Slide change)

3 MR. JENSEN: As you see, the hash has gone  
4 away. I do have some comparisons with NOTRUMP I'm  
5 going to show you in a minute.

6 MEMBER WALLIS: You are going to show  
7 comparisons with the sort of map that Dr. deMarzo  
8 showed us yesterday of the actual level of the liquid  
9 in the core at the critical time?

10 MR. JENSEN: What I was looking at here  
11 mostly was the void fraction. But, yes --

12 MEMBER WALLIS: Inventory versus time or  
13 something like that. She showed us a plot of total  
14 amount of liquid versus time, and depending on what  
15 you assumed about entrainment, you got different  
16 answers.

17 MR. JENSEN: Right. Okay. Well, of  
18 course, the minimum liquid in the core, if you looked  
19 at the collapsed core level, would occur when the void  
20 fraction is the highest. That's right before the  
21 IRWST injects.

22 CHAIRMAN KRESS: What exactly do you mean  
23 by void fraction here? This is in the core?

24 MR. JENSEN: This is the top node of the  
25 core.

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1 CHAIRMAN KRESS: So the top node of the  
2 core. Okay.

3 MR. JENSEN: Now RELAP has nine nodes, I  
4 believe, in the core.

5 CHAIRMAN KRESS: But it's the top node you  
6 are dealing with.

7 MR. JENSEN: Right.

8 MEMBER WALLIS: So that would mean here  
9 that the top node void fraction is almost one in this.

10

11 MR. JENSEN: That is true.

12 MEMBER WALLIS: The question I would ask  
13 is what's it in the node below that, and so on?

14 MR. JENSEN: Right. I didn't bring it.  
15 It's lower in the node below it.

16 MEMBER WALLIS: It is.

17 MR. JENSEN: It finally gets down to -- IN  
18 the bottom of the core, it gets down to a void  
19 fraction of around 50 percent in this tail that comes  
20 out.

21 MEMBER WALLIS: Well, the collapsed level  
22 is going to be less than half of this that you've got  
23 here, if the minimum void is 50 percent.

24 MR. JENSEN: The collapsed level is  
25 probably around 30 percent. I did look at some of the

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1 collapsed levels, and it's around 30 -- 33 percent, I  
2 think. So it's pretty low, but the pressure is low,  
3 and the steam takes up a lot of room.

4 So if you just looked at the quality, you  
5 looked at the mass ratio, and it would be -- mass  
6 ratio would be -- It would look a lot better. It  
7 would be like 30 percent or 50 percent.

8 CHAIRMAN KRESS: But this is telling me  
9 that with AP1000 for the same accident sequence for  
10 AP600 that your top node of the core is pretty well  
11 uncovered or pretty high void in it?

12 MR. JENSEN: It has a lot of voiding.

13 CHAIRMAN KRESS: It stays there quite a  
14 while?

15 MR. JENSEN: Yes, sir. That's exactly  
16 what I wanted to show you, that there's more voiding  
17 than AP600, and the voids are higher, and they stay  
18 there high a long time.

19 CHAIRMAN KRESS: For this particular  
20 sequence?

21 MR. JENSEN: Right, and other small break  
22 LOCAs look very much like this, because actually, once  
23 the CMTs start to drain and ADS opens, they all look  
24 pretty much the same. Then they are all really  
25 controlled by the ADS, especially ADS-4, because it's

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1 just so big compared to these little breaks. But they  
2 all look pretty much the same.

3 MEMBER SCHROCK: You have containment  
4 pressure as a parameter on the slide. Does  
5 containment pressure play any role here?

6 MR. JENSEN: Yes, it would.

7 MEMBER SCHROCK: Isn't it critical flow  
8 through the break throughout this time period?

9 MR. JENSEN: No, it goes down to  
10 subcritical flow.

11 MEMBER SCHROCK; In 4000 seconds?

12 MR. JENSEN: Yes. It's about the time  
13 that the IRWST begins to inject that the flow drops to  
14 subcritical. If the pressure is higher in the  
15 containment -- Westinghouse in fact did some  
16 sensitivity studies, and they got substantially less  
17 voiding when they used a higher containment pressure.

18 Of course, they used a constant  
19 containment pressure, I believe, and if one was going  
20 to take credit for containment pressure being higher,  
21 one would have to calculate it. It would probably  
22 still be pretty low until ADS-4 fired off. ADS-1, 2  
23 and 3 go down into the IRWST and get quenched, and  
24 only when ADS-4 goes off then is there a large flow  
25 into the containment.

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1           So it would be somewhat more work and  
2           cause probably some iterations between codes to take  
3           credit for the containment pressure.

4           CHAIRMAN KRESS: So what is it about the  
5           AP1000 that makes this difference between it and 600?  
6           Is it because your flow out to ADS-4 is greater, and  
7           it can't be made up as fast by the passive systems  
8           that are feeding water into it?

9           MR. JENSEN: That's part of it, and  
10          probably a lot that -- mostly, it's the power. The  
11          power is bigger. The power density is higher.

12          CHAIRMAN KRESS: So it's pouring out more  
13          steam.

14          MR. JENSEN: More steam. More steam is  
15          coming out. The accumulator is the same size. CMT is  
16          just a little bit bigger, and so more reliance is  
17          being placed on the ADS-4 to depressurize the plant  
18          and get injection from the IRWST.

19          MR. CORLETTI: This is Mike Corletti from  
20          Westinghouse, Walt. Could I just --

21          MR. JENSEN: Oh, please do.

22          MR. CORLETTI: The main focus of the phase  
23          2 was really looking at the code applicability and the  
24          performance of the code and how -- are the phenomena  
25          similar between the two plants.

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1 I think what we are going to find -- What  
2 we did is a preliminary set of analyses with bounding  
3 power shapes. I think what we probably find -- I  
4 don't think Walt really focused on is it safe -- the  
5 safety of the plant was not -- They weren't really  
6 making judgments on that.

7 CHAIRMAN KRESS: That's not the issue  
8 here. Just looking to the applicability.

9 MR. CORLETTI; Right. And I think what  
10 we'll see for our safety analysis that we present in  
11 the design control document you are going to see -----  
12 With the AP1000 specific power shapes and some of the  
13 other specifics that we've put in, you are going to  
14 see voids probably not quite this high as presented  
15 here. But that will be all reviewed as part of the  
16 phase 3 design certification.

17 CHAIRMAN KRESS: Okay. That's a good  
18 clarification.

19 (Slide change)

20 MR. JENSEN: Now here I do have a  
21 comparison between NOTRUMP and RELAP, and this is for  
22 a two inch cold leg break. This is actually the only  
23 --

24 MR. BOEHNERT: Could you take that other  
25 slide off, Walt? It's hard to see.

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1 MR. JENSEN: Oh, I'm sorry. Sure. And  
2 should I turn the projector off?

3 MR. BOEHNERT: Yes. Thank you.

4 MR. JENSEN: All right.

5 CHAIRMAN KRESS: Now this would be almost  
6 like that ADS-1 case you just showed?

7 MR. JENSEN: They look very similar.

8 CHAIRMAN KRESS: Very similar

9 MR. JENSEN: This break size is the only  
10 break that we really can compare to, this two-inch  
11 break, with NOTRUMP. There were a number of analyses  
12 done by Westinghouse about a year ago, and they were  
13 with some old assumptions for AP1000. So only  
14 recently have they redone this one. So we are  
15 comparing the RELAP analysis.

16 They thought this would be the best to  
17 compare with RELAP. But this is the only one we have  
18 right now for comparison. So what we'll get for the  
19 other breaks remains to be seen.

20 So as you look down this table, you see  
21 there are some differences. The first thing you see  
22 is the reactor trip. We tripped ours on a  
23 overpressure delta T at 9.4 seconds, and Westinghouse  
24 has tripped a lot later.

25 They wait until they get a lower pressure

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1 signal in the pressurizer before they trip, and that  
2 occurred a little bit later. I guess they don't take  
3 credit for the overpressure delta T.

4 The safeguard signal came in about the  
5 same time. This would be on low pressurizer pressure.  
6 Reactor coolant pumps tripped on the safeguard signal  
7 about the same time, but we are using a 15 second time  
8 delay that was in AP600, because that then is just a  
9 modification of the old AP600 that we used for that  
10 plant. It's probably about the biggest RELAP deck  
11 ever made.

12 So it looks like we got some different  
13 delay times that we are using between us and  
14 Westinghouse. So we're going to need to work out some  
15 of these differences.

16 MEMBER SCHROCK: This table is AP1000?

17 MR. JENSEN: This is all AP1000. I'm  
18 sorry, sir. Yes.

19 MEMBER SCHROCK: Do you have a  
20 complementary table for AP600?

21 MR. JENSEN: No, sir, I don't. I didn't  
22 want to spend much time on AP600, because we had  
23 already done that one.

24 The CMTs begin to drain a little sooner in  
25 this NOTRUMP analysis. Accumulator injects sooner,

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1 and then look at ADS-1. It's really a lot faster than  
2 RELAP.

3 ADS is based on the core make-up tank  
4 volume. So apparently we are losing more core make-up  
5 tank volume or CMT volume, losing it faster in NOTRUMP  
6 than in RELAP.

7 Then we got the high void fraction, 90  
8 percent. It even, in fact, goes up to 95 percent at  
9 3660 seconds when the IRWST injects.

10 So everything -- We've compared a number  
11 of the parameters, the ADS-1, 2, 3, and 4 flow, CMT  
12 injection, and they all looked very similar except for  
13 a shift, because NOTRUMP is doing everything faster.  
14 So why is NOTRUMP boiling down faster than RELAP?

15 MEMBER SCHROCK: Was that supposed to be  
16 best estimate? Isn't NOTRUMP the conservative code?

17 MR. JENSEN: That is true. That is true.  
18 But part of it is the way the plant is described, and  
19 it looked like to us it was the break flow model.

20 This is what RELAP calculates for the  
21 break flow. This decompression difference occurred  
22 before any of the ADS started to inject. The only  
23 thing being lost when the system was compressed was  
24 coming out of the break.

25 So what you see here looks pretty much a

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1 conventional plant for a small break LOCA. There is  
2 a subcooled blowdown.

3 CHAIRMAN KRESS: Now this is the NOTRUMP  
4 here?

5 MR. JENSEN: Excuse me. This is RELAP.

6 CHAIRMAN KRESS: This is RELAP?

7 MR. JENSEN: This is RELAP. This is where  
8 RELAP says the break flow is. I'm going to show you  
9 the comparison in a minute, and I wished I had -- I  
10 should have written RELAP on here.

11 So we have a subcooled blowdown where  
12 RELAP is using the Henry Fauske correlation, and then  
13 we have a saturated blowdown, which is this flat part,  
14 and then a two phase blowdown where it comes down.  
15 ADS is open here, and sludge, water and steam are  
16 coming out of the break at this time.

17 So this is what RELAP gets. Now what does  
18 NOTRUMP do?

19 (Slide change)

20 MR. JENSEN: I got a lot of things on  
21 here. The solid line is AP600. It just happened to  
22 be on this slide. I wish it wasn't. This is a  
23 Westinghouse figure, but the dashed line is NOTRUMP  
24 for AP1000. So that's what we want to look at, this  
25 dashed line for AP1000. You see it?

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1                   They, too, got the subcooled blowdown.  
2                   They used the Zaloudek correlation, which gives a --  
3                   It is conservative, and it gives a higher flow than  
4                   RELAP does in the subcooled blowdown.

5                   Then they have the flat saturated part.  
6                   But then they get the big spike of water coming out of  
7                   the break that RELAP doesn't calculate. All right.  
8                   Now what it looked like to us that caused this was the  
9                   downcomer description in the codes.

10                  RELAP divides the downcomer into eight  
11                  radial nodes between the downcomer and the core  
12                  barrel. So the eight radial nodes of the CMT line are  
13                  in individual nodes. I had a figure that said  
14                  Westinghouse Proprietary. So I didn't bring it.

15                  Each pole leg is a individual node. So  
16                  it's a highly segmented downcomer. So when the break  
17                  occurs in the cold leg, the flow reverses in that  
18                  section of the downcomer, but the CMT water is free to  
19                  continue the flow down to its segment into the lower  
20                  plenum and up into the core.

21                  Now Westinghouse does not segment their  
22                  downcomer. So they have it in a single segment like  
23                  a pipe with -- I think they have maybe three axial  
24                  nodes.

25                  So what happens in NOTRUMP when the CMTs

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1 eject, the whole downcomer, being a one-dimensional  
2 pipe, tends to flow the break and carries the cold CMT  
3 water with it. When this cold subcooled water comes  
4 to the break, the critical flow model that is their  
5 Zaloudek correlation for a subcooled blowdown, just  
6 blows out a lot of water out of the system.

7 So this is why they are losing water, we  
8 believe, faster than we are. I suppose it's  
9 conservative to do this, to lose water faster. This  
10 is why we are different, I think.

11 MEMBER SCHROCK: This flow rate does not  
12 include the ADS flows. It's the flow through the  
13 break?

14 MR. JENSEN: This is the break flow.

15 MEMBER WALLIS: So we get a difference of  
16 something like 200 pounds per second for about 200  
17 seconds. That's 40,000 pounds of water. Now is that  
18 important compared with the inventory of the system?

19 MR. JENSEN: I think it's a lot of the CMT  
20 water.

21 MEMBER WALLIS: How much water is in the  
22 CMTs?

23 CHAIRMAN KRESS: 2500.

24 MEMBER WALLIS: Twenty-five?

25 MR. CORLETTI: There's 5000 cubic feet of

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1 core makeup tank.

2 MEMBER WALLIS: How many pounds is that?

3 MR. CORLETTI: Times 62.

4 MEMBER WALLIS: So it's hundreds of  
5 thousands of pounds of water.

6 MR. JENSEN: So let me go back to my  
7 comparison slide again.

8 (Slide change)

9 MR. JENSEN: So we got very similar  
10 answers to NOTRUMP for this break. The void fractions  
11 we got were slightly higher, but they were pretty high  
12 in NOTRUMP, too.

13 We did some other breaks, too, and we did  
14 a pressure balance line and, of course, we did ADS-1.

15 MEMBER WALLIS: I think what you are  
16 saying is the details are very different, but the  
17 overall picture, when you look at the whole thing, is  
18 about the same. Now the timing of events is different  
19 from RELAP and Westinghouse, and the amount of water  
20 you get in and out at various times is quite  
21 different, but when you look at the overall picture at  
22 the end of things, result is about the same. Isn't  
23 that what is happening?

24 MR. JENSEN: That is true, and the details  
25 are similar except for the break flow. I wanted to

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1 tell you, too, we did a double-ended DVI line break,  
2 and we got a little bit of core uncovering with RELAP.

3 RELAP had a hot channel in it -- hot pin.  
4 It didn't have a hot channel. It had a hot pin, and  
5 it calculated a peak cladding temperature of about 400  
6 degrees Fahrenheit. So it's not anything -- not a big  
7 core uncovering, but it dipped down at the core a little  
8 bit in RELAP, and we don't have an up to date DVI line  
9 break from NOTRUMP. So we don't know what that is.

10 Then again, we're not going to approve the  
11 plant or disapprove the plant based on RELAP, because  
12 we are not sure we believe it.

13 MEMBER WALLIS: Well, I don't know. You  
14 have to use some sort of judgment here. If RELAP is  
15 predicting disaster, then you really want to know why  
16 there is no disaster.

17 MR. JENSEN: That's true. It has been  
18 benchmarked against the data, and we have some  
19 confidence in it, but we think it may be a little weak  
20 for the entrainment in the ADS-4 line and the hotleg.  
21 That's the same trouble that we're having with  
22 NOTRUMP, and we'll have to iron in phase 3.

23 MEMBER WALLIS; You didn't show any  
24 comparisons between your predictions and, say,  
25 something like the APEX facility or something that

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1 would give some confidence that you were not too far  
2 from reality with your predictions?

3 MR. JENSEN: Well, like with LOFTRAN, that  
4 was all done in great detail for AP600, and I could  
5 give you some references for that, too, if you would  
6 like.

7 CHAIRMAN KRESS: Now I recall those  
8 comparisons for AP600. They had these three  
9 categories, good, better and best, or something like  
10 that. It depends on where the calculations fit within  
11 the uncertainty band on the data.

12 Best I remember, for most of the accident  
13 tests run, they fell within the uncertainty bands of  
14 the data, which gave me some confidence that they were  
15 doing pretty good.

16 MR. JENSEN: It looked pretty good. It  
17 did.

18 MEMBER WALLIS: But then if I look at what  
19 you just showed us for the break, the AP1000/AP600  
20 curves are very different. We don't have any modeling  
21 of AP1000 by something like APEX. So we have to take  
22 it on faith that --

23 MR. CORLETTI: Dr. Wallis, this is Mike  
24 Corletti. We had hoped that our scaling was really  
25 showing that APEX was scaled for AP1000. So that was

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1 the basis for using the same validation.

2 MEMBER WALLIS: I don't quite know what  
3 you mean by scaling here. They are certainly not  
4 getting the same curves. Look at that curve you  
5 showed us just now with the flow right out the break  
6 versus time. It's certainly not the same scenario.

7 MR. JENSEN: This one?

8 MEMBER WALLIS: No, no, no, no, the one  
9 with RELAP 5, AP600, AP1000, two-inch 49, whatever  
10 that is.

11 MR. BOEHNERT: This one right here.

12 MR. JENSEN: The break flow.

13 MEMBER WALLIS: And we got three curves.  
14 RELAP5 seems to be absolutely fascinated with 200 and  
15 stays along there. Is that what the crosses mean?

16 MR. JENSEN: Yes, it does. It stays  
17 there, because the -- Then the flow to the break is  
18 saturated. It's saturated water in there. I mean, it  
19 just kind of sits --

20 MEMBER WALLIS: If I look at these two  
21 curves, I'd say, well, AP600 and AP1000 don't have the  
22 same response, do they?

23 MR. JENSEN: No, they don't.

24 MEMBER WALLIS: Quite different. So  
25 what's being scaled by something like APEX? Is the

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1 APEX response like the 600 or like the 1000 or  
2 something else entirely? I don't know.

3 MR. JENSEN: Of course, the difference in  
4 the break is the same size for both AP600 and AP1000,  
5 and with the break the same size --

6 MEMBER WALLIS: Ah. Not the same scaled  
7 size. Is that what it is?

8 MR. JENSEN: No, the break is not scaled  
9 in this. The break is a two-inch break.

10 MEMBER WALLIS: It's not a scaled break.  
11 So you shouldn't compare based on the same size, but  
12 we should perhaps compare some other break size which  
13 is properly scaled between 600 and 1000? That's  
14 probably the trouble.

15 MR. CORLETTI: Dr. Wallis, in our report  
16 that we submitted that was precisely what we showed,  
17 that it appeared that the larger break -- To get  
18 equivalent performance, you needed a little bit larger  
19 break for AP1000.

20 Really, what we saw was really a time  
21 shift for breaks of the same size. So that seemed to  
22 be consistent with -- That led us again to a judgment  
23 that the plants really do operate from a scale basis  
24 the same.

25 MR. CUMMINS: Dr. Wallis, Ed Cummins.

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1                   To me, those curves look alike, with the  
2 AP1000's spike just delayed. If you just translate it  
3 to the right, then they look very similar.

4                   MEMBER WALLIS: I don't know quite what  
5 you mean by similar.

6                   MR. CUMMINS: On AP600 we also got a  
7 spike. It was just earlier in time.

8                   MEMBER WALLIS: And Everest looks like Mt.  
9 Washington, if you take two foot out and put them  
10 close together.

11                  MR. CUMMINS: They look a lot closer to  
12 RELAP.

13                  MEMBER WALLIS: This is not very -- I  
14 think the real thing is that, if you scaled the break,  
15 you'll be able to show a much better comparison. That  
16 would be more meaningful than maybe trying to wring  
17 something out of this picture which is not very  
18 meaningful.

19                  CHAIRMAN KRESS: And when you scale the  
20 break, the size that you scale it to is going to be  
21 different, depending on which one of those periods you  
22 are in, because one of them, you are going out  
23 critical flow, and the other one going out subcooled,  
24 and you will get a different scaling ratio for the  
25 break size.

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1           So you have to be careful with just saying  
2           how you scale it. But I agree with you. If he scaled  
3           it to the break size for the different periods on that  
4           curve, why you will probably get similar.

5           MEMBER WALLIS: I think we concluded for  
6           AP600 that you got all these bathtubs indirectly and,  
7           depending on some rather small changes, it can make a  
8           difference whether this bathtub goes in before that  
9           one and all that. But at the end of the day, if you  
10          look at whether or not you get uncovering that period,  
11          it doesn't matter too much what you did before.

12          That's perhaps where the focus should be  
13          in these studies, whether or not you get uncovering and  
14          how sensitive it is to where all these different  
15          things are happening before, which really don't really  
16          make that much difference at the end state.

17          MR. BROWN: All right. Bill Brown. I  
18          think what we'll find is that if you take all those  
19          and get -- Once you get ADS, I think these will all  
20          look the same. I think that you are going to see some  
21          differences up front a little bit, but once you get  
22          ADS --

23          MEMBER WALLIS: Once you get ADS-4.

24          MR. BROWN: Exactly. I think they  
25          basically will look very, very similar and will

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1 converge to that.

2 MEMBER WALLIS: Well, the idea of ADS --

3 MR. BROWN: Is to turn it all into -- a  
4 little break into a bigger break and all look the  
5 same.

6 MEMBER WALLIS: What happened before  
7 doesn't matter.

8 MR. BROWN: Right. Right. All the  
9 history is lost.

10 (Slide change)

11 MR. JENSEN: Now these are some of the  
12 components we looked at in the AP1000 review. The  
13 accumulators are the same size. ADS1, 2 and 3 are the  
14 same size, and the CMT -- they are the same height and  
15 fatter, and these were all compared to test data in  
16 AP600. So --

17 CHAIRMAN KRESS: Is each CMT 23 percent  
18 more volume or is that the total for the two of them?

19 MEMBER WALLIS: Probably both.

20 MR. JENSEN: II think each one would be 24  
21 percent more volume. Now the PRHR heat exchanger is  
22 22 percent larger, but because the inlet and exit  
23 paths have a reduced resistance, it's designed to  
24 remove 72 percent more heat.

25 Now NOTRUMP has some problems with high

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1 heat flow in a PRHR heat exchanger. I told you how  
2 for LOFTRAN that they had modified the exponents in  
3 the Rohsenow correlation to fit the test data.  
4 NOTRUMP uses the Tome correlation for boiling in the  
5 IRWST, and Westinghouse didn't fit the X points in the  
6 T correlation.

7 MEMBER WALLIS: Pretty nostalgic. This  
8 has worked on in the late fifties.

9 MR. JENSEN: Probably so.

10 CHAIRMAN KRESS: It modified the exponent  
11 or the coefficient?

12 MR. JENSEN: I don't remember what this --  
13 Probably both of them, but they refit the curves. Now  
14 so Tome is nonconservative in comparison to the PRHR  
15 test data at high heat flows. So Westinghouse has  
16 benchmarked against a 1.5 foot per second flow rate in  
17 the tubes.

18 So then the question is what is the flow  
19 rate in the PRHR heat exchanger tubes, and is it  
20 greater or less than 1.5 feet per second? So this is  
21 another RELAP calculation.

22 So anyway, the flow rate, we found, is  
23 considerably higher than 1.5 feet per second. So what  
24 did they do with NOTRUMP in this area where the code  
25 is stated not to be completely out?

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1 Well, PRHR heat exchanger heat flow is  
2 just a medium in points, and it probably doesn't have  
3 a great deal of significance for a small break LOCA,  
4 and Westinghouse has even done a preliminary study  
5 that they reduced the heat transfer area by 50  
6 percent, and it made very little difference in the  
7 course of the LOCA. But they are going to qualify  
8 their assumptions during phase 3 for the PRHR heat  
9 exchanger flow.

10 CHAIRMAN KRESS: Now this PRHR heat  
11 exchanger is mostly there for the long term cooling?

12 MR. CORLETTI: No. A PRHR heat exchanger  
13 is primarily there for transient. So it's there on a  
14 LOCA event, but it really was not the sizing basis.  
15 What we've seen in most of the LOCAs is, once you  
16 depressurize, go two phase, it really does not become  
17 a big factor in the transient behavior.

18 CHAIRMAN KRESS: This is one place where  
19 you have a pump, and it's an active system?

20 MR. CORLETTI: No. This a passive RHR  
21 heat exchanger. It sits in the refueling water  
22 storage tank.

23 CHAIRMAN KRESS: It's that C-shaped thing?

24 MR. CORLETTI: Yes.

25 CHAIRMAN KRESS: It's the water flowing

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1 to the inside of the tubes?

2 MR. CORLETTI: Right. It's by natural  
3 circulation.

4 CHAIRMAN KRESS: By natural circulation.

5 MR. CORLETTI: Yes. And it's really a  
6 sizing basis. It's for transients like loss of normal  
7 feed, feedwater line break, those sort of events. But  
8 it is modeled in NOTRUMP in the LOCA, and it doesn't  
9 have much effect unless you have a very, very small  
10 break.

11 CHAIRMAN KRESS: What's the heatsink on  
12 that when you get outside the IRWST?

13 MR. CORLETTI: The refueling water storage  
14 tank, and if it would -- for a long transient would  
15 heat up and boil, steam would condense on the  
16 containment shell, and we have it return back to the  
17 refueling water storage tank. So it essentially can  
18 stay as a heatsink --

19 MR. CUMMINS: Using containment then,  
20 basically.

21 MEMBER WALLIS: I wonder if we could move  
22 on to the bottom line?

23 MR. JENSEN: The bottom line? Sure, the  
24 bottom line.

25 MEMBER WALLIS: This is a real bottom

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1 line? This hasn't been manipulated by the accountants  
2 in some way?

3 (Slide change)

4 MR. JENSEN: This is where we are right  
5 now with phase 2. So we think NOTRUMP is pretty good  
6 except for three areas, and maybe just two, and the  
7 big one is the liquid entrainment from the core into  
8 the upper plenum and out the hotleg and out ADS-4.

9 Westinghouse proposes in phase 3 to  
10 benchmark NOTRUMP against the WCOBRA/TRAC.

11 MEMBER WALLIS: I don't see how that  
12 works. I mean, you say one code against another. The  
13 physics is wrong. How is that going to help you?

14 MR. JENSEN: Okay. Then they are going to  
15 benchmark WCOBRA/TRAC against test data.

16 MEMBER WALLIS: Ah, they are going to do  
17 that. That's going to be essential.

18 MR. JENSEN: Finding the right test data  
19 may be where the difficulty lies.

20 MEMBER WALLIS: You're going to hold the  
21 line there?

22 MR. CUMMINS: Yes.

23 MEMBER WALLIS: Not to say it remains an  
24 issue, but supplemental verification will be performed  
25 or something.

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1 MR. WERMIEL: Ultimately, Dr. Wallis --  
2 This is Jared Wermiel. Ultimately, we will need some  
3 confirmation either through test data or some data  
4 that we can all agree that it is valid that, indeed,  
5 if they do do a sensitivity study on this phenomena,  
6 that the sensitivity is telling us the right thing,  
7 and ultimately it's an answer that we can rely on.

8 It will also depend in large measure on  
9 some qualitative arguments about how significant this  
10 entrainment -- You've heard argument yesterday. How  
11 significant really is this issue? We are still not  
12 sure, and that will be a source of continual  
13 discussion during the phase 3 review.

14 MEMBER WALLIS: Yes. Thank you very much.

15 MR. JENSEN: Okay. then the second one is  
16 the PRHR heat exchanger model, which is open, but we  
17 don't think it's going to have much effect.

18 Then finally, we have looked at --

19 MEMBER WALLIS: I'm sorry. Proposes to  
20 reduce the heat transfer area -- that's simply --  
21 That's in the numerics. They are going to say, well,  
22 if you don't like it, we'll just assume it's half as  
23 big, and that's conservative. Is that -- It's not  
24 actually physically reducing?

25 MR. JENSEN: Right. Hopefully.

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1 MR. CUMMINS: That's right.

2 MR. JENSEN: And they will look at the  
3 test data to see.

4 MEMBER WALLIS: Let's just cut it in half.

5 MR. JENSEN: Oh, I see what you mean.  
6 Excuse me. Well, us analysts, we don't deal with  
7 hardware very much. In fact, we sometimes forget  
8 about that it's actually a plant that's going to look  
9 like this. It's just a bunch of numbers.

10 All right. Then lastly, we've looked at  
11 one break size, the two inch cold leg break, and there  
12 was no core uncovering. But in the course of phase 3 we  
13 are going to be looking at the entrainment out of ADS-  
14 4, which will affect what is going on in the core, and  
15 we'll be looking at a lot of other break sizes.

16 So it's very likely that core uncovering  
17 will be calculated.

18 MEMBER WALLIS: So this statement, only a  
19 limited number of breaks have been analyzed -- that  
20 means by you or by Westinghouse?

21 MR. JENSEN: By Westinghouse.

22 MR. WERMIEL: By Westinghouse.

23 MEMBER WALLIS: Well, you said you are  
24 going to be looking at it. Does that mean you are  
25 going to be doing more analysis?

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1 MR. JENSEN: We will do more analysis. We  
2 have done -- looked at several break sizes already,  
3 and we got a small amount of core uncovering for one.

4 Westinghouse is going to look at some  
5 more, but I think the final runs are going to be --  
6 have to be after the ADS entrainment issue is solved.  
7 So will there be core uncovering? I don't know, but the  
8 SB LOCTA code and the NOTRUMP code really haven't been  
9 looked at for core uncovering in the passive plants.

10 There's a transition boiling model in  
11 NOTRUMP that we didn't look at for AP600, because no  
12 core uncovering was calculated, and the SB LOCTA code --  
13 I'll look back to see when that was reviewed last. I  
14 think we looked at it -- It was LOCTA4 back then, back  
15 in about 1972, back when the original ECCS model came  
16 through. So we will probably want to look at that  
17 again if there is any core uncovering predicted.

18 Let's see. I have one more slide, if you  
19 can bear with me.

20 (Slide change)

21 MR. JENSEN: This is what RELAP predicts  
22 for the flow in the hotleg when the ADS-4 is  
23 operating.

24 MEMBER WALLIS: Thirty meters a second?

25 MR. JENSEN: Thirty -- Yes, please, I left

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1 off the -- The top curve should say steam flow, and  
2 the bottom curve should say liquid flow.

3 MEMBER WALLIS: Ah. You liquid flow is  
4 actually catching up with the steam.

5 MR. JENSEN: The liquid is the bottom one,  
6 and it's just kind of bouncing around zero. It's  
7 fairly low. So ADS-4 opens at about 2900 seconds, and  
8 then the IRWST comes on at around 3500 seconds, which  
9 is this big water slug coming out. But I guess what  
10 I'm trying to show here is the steam velocity. It's  
11 pretty high in this hotleg.

12 RELAP predicted the flow was annular. It  
13 didn't think the flow -- based on its flow regime map,  
14 didn't think it had stratified flow at all. It  
15 thought it had annular flow. So it's carrying all  
16 this then out the ADS. So this is --

17 MEMBER WALLIS: What's happening in the  
18 vessel? Is the vessel level higher than the hotleg  
19 here?

20 MR. JENSEN: The vessel two phase level is  
21 up even with the hotleg, I think. It's carrying out  
22 two phase.

23 MEMBER WALLIS: Even?

24 MR. JENSEN: It's up in there, up in that  
25 region. Whatever is coming up is carrying it out.

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1           MEMBER WALLIS: I'm just saying the flow  
2 regime is going to depend very much on how the liquid  
3 gets in there at the end. It comes in as droplets.  
4 It's not going to be instant in the annular flow, for  
5 example.

6           MR. JENSEN: Right. So this is the kind  
7 of thing we can use RELAP for. Maybe we don't believe  
8 the flow regime, but we can say, well, we know what --  
9 it's telling us what the steam velocity is, and we  
10 want to be sure that the data that we are using, when  
11 we find some to benchmark WCOBRA/TRAC, is applicable  
12 for velocities of this magnitude.

13                   So we have a lot to do here.

14           MEMBER SCHROCK: These predictions were  
15 done with RELAP?

16           MR. JENSEN: Yes. This is RELAP. That's  
17 all I have to tell you about NOTRUMP. Entrainment is  
18 going to be a big problem.

19           CHAIRMAN KRESS: Okay. With that, we are  
20 at the point where we would like to hear what  
21 Westinghouse has to say about that.

22           MR. CORLETTI: I guess we can just  
23 summarize our plans going forward. We are doing our  
24 plant calculations with NOTRUMP. We also are  
25 preparing our topical report, which is our ADS --

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1 using COBRA/TRAC, looking at the ADS-4 IRWST  
2 transition phase.

3 We are validating that against the test  
4 data at OSU that was already performed for AP600. We  
5 are going to show that and also show plant  
6 calculations with that as part of this topical report  
7 we will be submitting with our application.

8 The purpose there we hope to show is that  
9 with such a code that NOTRUMP is still performing a  
10 conservative representation of the transient. That is  
11 going to be part of our phase 3 review.

12 MR. CUMMINS: This is Ed Cummins. To  
13 summarize our position, it's very similar to the  
14 staff's. In LOFTRAN their comment was we were  
15 sensitive to two phase events, if they are predicted.

16 Our current analysis doesn't predict two  
17 phase events for the steam line break, but the staff  
18 hasn't reviewed that, and it's intended to be reviewed  
19 in phase 3.

20 In NOTRUMP, basically, we discussed  
21 entrainment yesterday, and I think we wouldn't quite  
22 agree with this is a big problem. We think in some  
23 respects it is self-limiting, because H is cubed as  
24 well as steam flow. But this is something that we  
25 don't intend to resolve in phase 2. We intend to

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1 resolve in phase 3.

2 We agree that, if NOTRUMP shows core  
3 uncover, that that invokes this LOCTA code and that  
4 it was appropriate for the staff to review it.

5 Thirdly, we agree that the heat exchange  
6 model in NOTRUMP is applicable for less than 1.5 feet  
7 per second and, if it's greater, then it has to be  
8 adjusted downward to be conservative, and we intend to  
9 do that.

10 CHAIRMAN KRESS: Okay. At this point we  
11 are going to turn to WGOthic, but I wonder if the  
12 members would like a break first.

13 MEMBER WALLIS: I think, as we just have  
14 one more topic, we might take a break now and then --

15 CHAIRMAN KRESS: That's what I thought we  
16 might want to. So let's take a 15 minute break. Be  
17 back at ten o'clock.

18 (Whereupon, the foregoing matter went off  
19 the record at 9:47 a.m. and went back on the record at  
20 10:03 a.m.)

21 CHAIRMAN KRESS: Okay, let's turn now to  
22 the Gothic novel part of this thing. The word Gothic  
23 invokes visions of Frankenstein. No comment about the  
24 speaker, of course. Okay.

25 MR. THROM: Good morning. My name is

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1 Edward Throm, and I am currently in the Plant Systems  
2 Branch of NRR, and I'm in the new division called  
3 Design Review Section.

4 I'm going to be going over the WGOTHIC  
5 review for the AP100.

6 (Slide change)

7 MR. THROM: Since it always comes up, I  
8 did look it up again, and GOTHIC stands for Generation  
9 of Thermal-Hydraulic Information for Containment. So  
10 it's a word that has a meaning, and WGOTHIC is an  
11 extension of the numerical applications incorporating  
12 GOTHIC4.0 code.

13 The extension is the inclusion of the  
14 Kline model which is the Westinghouse model that  
15 addresses the passive containment cooling system,  
16 which is basically using condensation on the inside of  
17 the containment and evaporation of the water flow on  
18 the outside of the containment.

19 In the supplemental package I do have a  
20 caricature of the system. Water is basically poured  
21 onto a bucket on top of the containment. The bucket  
22 is not really on the containment. It's elevated from  
23 the containment, and then it is distributed through  
24 two sets of weirs such that there is uniform flow of  
25 the water down the shell of the containment.

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1 Air through buoyancy driven forces comes  
2 down the downcomer, up a riser section and out through  
3 the chimney, and the water is evaporated and the heat  
4 carried off through the chimney channel.

5 (Slide change)

6 MEMBER WALLIS: And the water evaporates  
7 before it reaches the ground or the bottom?

8 MR. THROM: Yes. Part of the modeling  
9 that is done in WGOthic is to make sure that the  
10 amount of water that is being evaporated is only the  
11 amount of water that can be evaporated.

12 What would normally happen is there is a  
13 drain line at this elevation, and any excess water  
14 would flow down that drain.

15 MEMBER SCHROCK: Is the aspect ratio  
16 realistic in this picture?

17 MR. THROM: No. That is just a  
18 caricature. I cut it out of another document.

19 MEMBER SCHROCK; It's much taller.

20 MR. THROM: Yes. There are -- I couldn't  
21 find any real good pictures, but it was just a sense  
22 to remind you again of what the passive containment  
23 cooling features are.

24 WGOthic is described in Westinghouse  
25 topical report, WCAP-14407, and the staff's safety

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1 evaluation was presented in NUREG-1512. So those two  
2 documents are the code.

3 Basically, the code approved in Part 52.  
4 Approval of the methodology is done as part of the  
5 design certification. So the approval of WGOTHIC for  
6 the AP600 is part of that design certification.

7 It's also necessary to point out that in  
8 developing and approving WGOTHIC we came up with what  
9 we called an evaluation model, not necessarily at the  
10 level of detail you see in an Appendix K model but,  
11 nevertheless, we needed a term to identify what we  
12 were talking about.

13 So the evaluation model conserved the  
14 aspects of using lumped parameter networks for the  
15 representation of the containment, issues concerning  
16 circulation and stratification, and issues concerning  
17 the use of the PCS flow and the mass and heat transfer  
18 models that were developed to model and conserve the  
19 passive containment cooling system.

20 (Slide change)

21 MR. THROM: As we are all aware, the large  
22 scale test facility which Westinghouse used was not  
23 well scaled for the blowdown portion of a transient.  
24 So the problem we had was not having a good scaled  
25 facility to assure ourselves that we really understood

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1 circulation, stratification, and some of the other  
2 issues that would be of importance if we were trying  
3 to do a quality calculation against a good set of  
4 data.

5 So during the development of the model, we  
6 looked at the international code databases.  
7 Specifically, if you want to read the information, you  
8 can look at Section, WCAP-14407 or Section 21.65 of  
9 the WCAP -- of the NUREG 1512.

10 In order to feel comfortable or justify  
11 the use of the lumped parameter approach, we went out  
12 into the international database, looking at the  
13 Battelle Model Containment and the HDR.

14 The HDR -- there were a couple of  
15 experiments that were done there where they sprayed  
16 water on the outside of the containment shell. What  
17 you see from the application of the GOTHIC code or  
18 tools like GOTHIC to the international database is the  
19 lumped parameter tends to homogenize the steam with  
20 the noncondensables, basically the air in the  
21 containment, and as a result, what's being condensed  
22 near condensing surfaces usually has a lower steam  
23 concentration that you might expect, and you generally  
24 always overpredict pressure, and pressure is one of  
25 the key markers for containment analysis.

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1                   When you apply regulatory requirements to  
2 these calculations, you really come up with a very  
3 conservative calculation for pressure.

4                   This basically -- We confirm  
5 Westinghouse's contention that the lumped parameter  
6 model is appropriate for use.

7                   (Slide change)

8                   MR. THROM: The other issues that you  
9 wound up with in not having a properly scaled facility  
10 were circulation and stratification. In order to  
11 address these concerns, Westinghouse presented, and we  
12 ultimately accepted, a very conservative approach.

13                   One approach is that after blowdown,  
14 Westinghouse turns off the heat sinks below the  
15 operating deck. So if they calculate steam going back  
16 down below deck, they don't take credit for the  
17 condensation.

18                   In order to address the issues with  
19 circulation and stratification, two things came up.  
20 One is the developing of a condensing surface on a  
21 floor. Westinghouse has elected not to take credit  
22 for that.

23                   The other big concern was potentially  
24 getting an air blanket on the operating deck as part  
25 of the stratification issue perhaps in the long term.

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1 So Westinghouse also takes no credit for condensation  
2 on the upper deck.

3 So that was the mechanism for addressing  
4 the uncertainties and saying we really know where the  
5 steam is, and we can take full credit for it. We've  
6 elected to be conservative in those particular  
7 aspects.

8 The heat and mass transfer correlations:  
9 There was a lot of separate effects tests done by  
10 Westinghouse. There is published data, and all of  
11 that information went into developing the correlations  
12 for mass and heat transfer used in the WGOETHIC code.

13 As we are all aware, there's a lot of  
14 scatter in data. You can draw a line. You can try to  
15 draw a 95 percent confidence line. What Westinghouse  
16 did was they put bounding multipliers on the mass and  
17 heat transfer correlations to basically bound the data  
18 when doing the calculation.

19 They also used the conservative mass and  
20 energy approaches that are prescribed in the standard  
21 review plan where, during either the LOCA or the steam  
22 line break, you maximize the energy release and the  
23 mass release to its ultimate almost. You look at a  
24 large double-ended break. You use Moody multipliers  
25 for the low -- You make sure all the stored heat is

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1 reduced quickly.

2 In the steam line break, similar  
3 conservative mass and energy methodologies are  
4 prescribed, and Westinghouse basically uses those in  
5 their evaluation model.

6 So overall, the model that has been  
7 developed and approved is a very conservative  
8 calculational tool.

9 (Slide change)

10 MR. THROM: You start looking at some of  
11 the differences between the AP600 and the AP1000, and  
12 it was pointed out yesterday, this is just simply a 76  
13 percent power uprate evaluation. Nonetheless, these  
14 differences aren't as marked as they might be.

15 Even though the initial inventories for  
16 both LOCA and main steam line break, the inventory and  
17 the energy stored in the primary or secondary system  
18 is larger. The pipings haven't changed. The coldleg  
19 where the break is going to be for the LOCA is the  
20 same size in the AP600 as the AP1000.

21 So your concern there is now the rate as  
22 being slightly different, not significantly different.  
23 Similarly, in the steam line break they have the flow  
24 restricter in the line, which again, even though you  
25 have the larger inventories and energies to release,

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1 the rates are not appreciably larger than you would  
2 expect for the AP600.

3 MEMBER WALLIS: Well, it's a race, because  
4 the total amount of energy is bigger.

5 MR. THROM: Yes.

6 MEMBER WALLIS: So that, if the rate is  
7 rapid, you are putting in an impulse of significantly  
8 more energy into the containment.

9 MR. THROM: Right.

10 MEMBER WALLIS: Large LOCA, for instance.

11 MR. THROM: Yes. But you see that there  
12 is the compensating factors within the containment are  
13 basically the free volume is increased so that  
14 compliance helps out a lot. The containment shell  
15 itself is a little thicker, and they do put more water  
16 on than they did previously with the AP600.

17 CHAIRMAN KRESS: For the question of the  
18 mixing in the containment, the lumped parameter node,  
19 have you given any thought to using a CFD code to look  
20 at that?

21 MR. THROM: Not at the staff level, no.  
22 We think that, in general, if you look at scaling of  
23 the break jet, you are going to see that it kind of  
24 supports the well mixed assumption. All the evidence  
25 out there does support it.

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1           Where you see some conservative in the  
2 evaluations, I think, for some of these real high  
3 energy jets, you would expect the steam to almost hit  
4 the ceiling or the dome of the containment where it's  
5 really cold due to this water, and get significant  
6 condensation.

7           Whereas, in the lumped parameter model, as  
8 I said earlier, you are going to be always mixing this  
9 with the air. So there's going to be a tendency to  
10 decrease the condensation rate and basically calculate  
11 a somewhat higher pressure.

12           CHAIRMAN KRESS: Well, I was worried about  
13 hydrogen stratification, which goes the other way, you  
14 know. You don't want to assume well mixed there. You  
15 want to know what you actually have.

16           MR. THROM: Right. And we don't believe  
17 we have that particular issue for the design base  
18 events.

19           CHAIRMAN KRESS: Because that's not enough  
20 hydrogen to deal with.

21           MR. THROM: That's dealt differently.  
22 There are other things that come into play when you  
23 look at hydrogen, when you look at equipment  
24 qualification, when you look at subcompartment loads.

25           GOTHIC is part of the tool, but there are

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1 other things that come into play when you look at  
2 those. So what we are really focusing on here right  
3 now is the Chapter 6 evaluation for the peak pressure  
4 response for the containment.

5 (Slide change)

6 MR. THROM: Westinghouse looked at these  
7 changes. First of all, there's nothing that changed  
8 in the PIRT. The rankings are basically the same.  
9 Actually, they are the same. The process has not  
10 changed. It's condensation on the inside of the  
11 shell, evaporation of water on the outside of the  
12 shell.

13 So we've not identified any new phenomena  
14 that need to be included in the models. However, we  
15 did feel quite concerned that the mass and heat  
16 transfer models still be used within applicable  
17 ranges, and the focus of the review was on that  
18 particular aspect, to go back and look at the mass and  
19 heat transfer correlations and look at the expected  
20 response of the AP600 to assure that the mass and heat  
21 transfer models and the tests that were run to develop  
22 those models covered the range of the AP600.

23 MEMBER WALLIS: These are natural  
24 convection models?

25 MR. THROM: Natural convection.

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1                   MEMBER WALLIS: High Rehle numbers beyond  
2 most of the database.

3                   MR. AUSTIN: This is Rick Austin from  
4 Westinghouse. The Rehle numbers are very high for  
5 AP1000 and AP600.

6                   CHAIRMAN KRESS:  $10^{10}$ ?

7                   MEMBER WALLIS: Are they beyond the  
8 database, the Rehle numbers?

9                   MR. AUSTIN: In the chimney they are.  
10 There's a table in WCAP-15613 that compares the heat  
11 and mass transfer correlation -- the dimensionalist  
12 groups for the heat and mass transfer correlations,  
13 with a test data range, the AP600 range and the AP1000  
14 range.

15                  MR. THROM: And what he is talking about  
16 is the chimney area, which is up here. And because  
17 there is insufficient data to cover those ranges,  
18 Westinghouse uses the Ichida correlation in that area,  
19 and that's deemed to be a conservative correlation.

20                  So that's kind of the one aspect where  
21 within the data that's the place where it wasn't  
22 adequately covered by any experiment. So Westinghouse  
23 in the evaluation model -- they elected to use Ichida  
24 correlation for that particular regime.

25                  Basically, what you see when you look at

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1 the dimensionalist numbers, the Grashof number,  
2 Reynolds number that you use in the correlations, for  
3 the most part, the AP1000 brings those numbers up into  
4 the higher range of the data, but they are covered.

5 That's covered in the WCAP that  
6 Westinghouse provided and verified by -- They have  
7 done scoping calculations and backed out the numbers  
8 and have shown that the peak numbers are within the  
9 range, and they are not really pushing the upper  
10 bounds of any of the ranges.

11 When they looked at the film flow, they  
12 found out that the lower end for the Reynolds number  
13 in the heat flux data that they have for film  
14 evaporation was still being covered.

15 The one concern that we did have was with  
16 the higher power, higher energy being reduced by a  
17 LOCA, we were somewhat concerned with the peak shell  
18 temperature before a credit would be taken for the  
19 PCS, and it was probably from a statement that was  
20 made in one of the topical reports that said, well, if you  
21 got really hot, you know, there might be a problem,  
22 but we didn't find any design basis events that would  
23 do that.

24 We challenged Westinghouse on that, and  
25 they did an evaluation that showed that the peak shell

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1 temperature prior to credit for the PCS water would be  
2 about 180 degrees. So the film model that's being  
3 used in WGOETHIC is applicable.

4 We were concerned that, if the shell  
5 temperature had gotten up into the 212 degree range  
6 where we might have to worry about a boiling front or  
7 potential breakup of the film, that that would be a  
8 concern. But calculations they have done and some  
9 preliminary calculations we have done indicate that  
10 that is not going to be a problem for the AP1000. A  
11 lot of that is due to the thicker shell.

12 MEMBER WALLIS: This run down the shell is  
13 -- Does it run as rivulets?

14 MR. THROM: It's a film.

15 MEMBER WALLIS: It's definitely a film?

16 MR. THROM: Yes.

17 MEMBER WALLIS: It's so much water that it  
18 really wets everything?

19 MR. THROM: Yes. Yes. It doesn't  
20 necessarily cover the full circumference of the shell.  
21 They have -- The water distribution tests were run by  
22 Westinghouse. These were basically full scale,  
23 partial height tests where they were done cold, but  
24 for different flow rates they came up with the  
25 coverage that you would have on the shell, and that's

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1 part of the model.

2 You would expect, actually, somewhat  
3 larger coverage in a heated environment, but we don't  
4 take any credit for that, because we don't have any  
5 data to really do that. So we look at, for example,  
6 early on about 90 percent of the shell being covered.

7  
8 Later on, as the water flow rates  
9 decrease, it drops off to like 50 percent, and then 25  
10 percent, but there's adequate --

11 CHAIRMAN KRESS: But they are using the  
12 same numbers for the AP1000?

13 MR. THROM: We think they are. It's one  
14 of those phase 3 things where we get to it -- I'll  
15 cover some of the issues that are going into phase 3.  
16 They basically parallel phase 2.

17 The thing is at this particular point the  
18 analyses that Westinghouse first presented back in  
19 December were with a one-node model, which we hadn't  
20 seen before. It gave us a lot of difficulty.

21 They came back in with a revised  
22 calculation in September which went back and used the  
23 109-node model that they used in the AP600. They  
24 couched those as unverified results. However, as  
25 scoping calculations, those were the numbers that --

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1 the calculations that they used to go back into the  
2 experimental database to assure themselves that they  
3 weren't creeping up on any ends of the data where,  
4 when the final calculations are done, you would expect  
5 to have an issue with needing more information.

6 That particular comment leads into one of  
7 the early concerns we had with the larger height of  
8 the containment and the potential for more complex  
9 mixing patterns that could influence the mixing and  
10 the buoyancy.

11 We expected less homogeneity of the  
12 environment and potentially higher temperatures in the  
13 dome, and with the one-node model we didn't see how  
14 they could address that issue.

15 They have gone back now, and they are  
16 using the multi-node approach. So we believe that the  
17 calculation they get will address these changes and  
18 also still lead to the conservative pressure  
19 calculation.

20 The scope -- As I said earlier, the  
21 scoping studies performed by Westinghouse show that  
22 the mass and heat transfer correlations are being used  
23 within their acceptable ranges. We don't -- other  
24 than the issue with the Rehle number and the chimney.  
25 That's already addressed through the Ichida. But when

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1 you look at the mix convection or the assisted  
2 convection correlations that are being applied, the  
3 data is applicable to the scale of the AP1000.

4 Well, in summary, the phase 2 review,  
5 we've not identified any new phenomena that we think  
6 need to be incorporated in the models. The current  
7 rankings remain unchanged, and they have some heat  
8 transfer correlations that are being used within their  
9 applicable range.

10 Using the approved model and methodology,  
11 we believe that the WGOETHIC is applicable for the  
12 AP1000.

13 As I pointed out earlier, when we get into  
14 phase 3, we need to confirm most of these findings.  
15 The calculations we have seen today still have not  
16 applied the evaporated flow model, and this is an  
17 iterative process that Westinghouse uses to assure  
18 that they don't have numerical instabilities in the  
19 code.

20 That basically is a methodology for only  
21 applying as much water as you can basically evaporate,  
22 and that was approved as part of the original  
23 calculation, but using the evaporated flow model in  
24 combination with the Chun and Seban correlation, one  
25 of the restrictions we put on the evaluation model to

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1 address wavy flow.

2           The standard review plan mass and energy  
3 release is one thing that is not yet done in the  
4 scoping analysis. In the standard review plan, for a  
5 pressurized water reactor after blowdown, there is a  
6 30, 90, two minute period of time called refill at  
7 which time the accumulators are basically condensing  
8 the steam that is in the reactor vessel, and there's  
9 no real release into containment, although in the real  
10 world you would expect that the heat structures would  
11 be condensing the blowdown steam, in the standard  
12 review plan the expectation is that you collapse that  
13 region.

14           So you don't get any credit for heat  
15 removal while there is no mass and energy going into  
16 containment. The calculations they have done haven't  
17 included that, but they should not be any significant  
18 impact on the application of the mass and heat  
19 transfer models. It's just that we haven't really got  
20 the committed to design basis action evaluation done  
21 in accordance with the standard review plan, which is  
22 the expectation.

23           Also the calculations we have seen to date  
24 for the AP1000 are still using basically the ADS-4,  
25 IRWST and sump injection and mass flow rates that

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1 were developed during the AP600. If you remember,  
2 it's the ADS-4 counteracted by the IRWST that leads to  
3 and turns around the second peak.

4 So, you know, those numbers need to be  
5 developed in the final analysis. While we don't  
6 expect that any of this will lead to exercising the  
7 mass and heat transfer correlations outside their  
8 range, we want to look at it again, particularly.

9 We have them in the safety evaluation, a  
10 requirement that when the mass fluxes on a containment  
11 shell get much larger than the AP600, Westinghouse has  
12 to revisit the Kline numerics to make sure that there  
13 aren't any instabilities in that. So that's part of  
14 the final review.

15 At this particular time -- In the  
16 background package there's two pages of all of the  
17 conservatisms that are in the evaluation model.  
18 There's a lot of them, almost point by point. The  
19 input is taken to be conservative.

20 MEMBER WALLIS: Your design pressures are  
21 psia in the way it's put here?

22 MR. THROM: Yes.

23 MEMBER WALLIS: So you've added 14.7 or  
24 something?

25 MR. THROM: Yes.

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1                   MEMBER WALLIS:    Can't really use the  
2 correlate psig. Atmospheric pressure goes up and down  
3 a bit. There's a difference.

4                   MR. THROM:    Well, yes, but when you -- If  
5 you want to use a percented ranking, you really should  
6 use absolute. That's the only -- I guess in today's  
7 environment we should be using some type of Pascal  
8 anyway

9                   MEMBER WALLIS: Do you have predictions --  
10 they have predictions yet for the AP1000 max pressure  
11 in the containment?

12                  MR. THROM:    Yes, we have two sets of  
13 calculations from Westinghouse. We have the scoping  
14 calculations which were not done with the model we  
15 expected to see, but for the main steam line break  
16 they were calculating on the order of 70.7 psia.

17                  MEMBER WALLIS: So it's pretty close.

18                  MR. THROM:    Close, yes.        And in  
19 containment you will basically see that it is always  
20 very close, but understand that the calculation is  
21 extremely conservative.

22                  For the LOCA, in the scoping calculations  
23 that were presented to us back in December of 2000,  
24 those again didn't really comport with the standard  
25 review plan methodology. What they used there was a

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1 five-hour time period to remove the sensible heat from  
2 the primary system, where in the SRP methodology you  
3 basically do that over an hour.

4 So that calculation showed that the peak  
5 pressure was about 60.7 psia, but that's not a fair  
6 marker. In the calculations they provided in  
7 September where they went back in and started going to  
8 the detailed model, they went back in and used the  
9 one-hour time period, and I believe they are  
10 calculating just about the same number now for the  
11 LOCA, about 70, in that ballpark.

12 So there is a chance that things might  
13 change a little bit, once all of the final boundary  
14 conditions are input into the code.

15 MR. BOEHNERT: What's the design limit?

16 MR. THROM: Excuse me?

17 MR. BOEHNERT: The design limit, Ed?

18 MR. THROM: 73.7. That's along about  
19 slide 3. There is margin. I mean, in the AP600 we  
20 cut even a lot closer than that.

21 (Slide change)

22 MR. THROM: We have developed a contain-2  
23 model. I've got a picture of it up here for those who  
24 are interested. It's got 26 nodes in it. What's not  
25 shown is the environmental node that's node 26.

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1           It's similar in nature to the WGOthic  
2 model, but we don't have as much detail in the model.  
3 The progression of Westinghouse's development of the  
4 AP600 model into more nodding than they probably really  
5 needed, because they were looking at a different  
6 approach early on.

7           We have done calculations using the  
8 scoping data, which is not final data, and for the  
9 main steam line break we calculated 69.4 psia as  
10 compared to the 70.7 that Westinghouse got.

11           In the contain model that we developed it  
12 was an offshoot from the AP600 model, which was  
13 developed very early in the process. In the model we  
14 have modeled all of the heat structures. We've  
15 modeled the heat structure for the upper deck.

16           So when we did the scoping evaluation, we  
17 calculated 54 psia as a comparison to the 60.7 that  
18 Westinghouse got for the same type of calculation.  
19 What we did do -- and the problem with contain is it  
20 meets everybody's expectation that there are no dials  
21 in the code that make the analyst's job easy to turn  
22 things on and off.

23           What we were able to do was mimic the mass  
24 and heat transfer penalties. When you apply that to  
25 the calculation, you see a 2 to 3 psi increase. So

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1 the calculations are fairly comparable. The main  
2 steam line break is showing to be the one, I think,  
3 from the pressure point. We are getting about the  
4 same calculation in most of the PCS characteristics.

5 The heat structure characteristics are  
6 really not impacted by the main steam line break,  
7 basically because of where you release the steam in  
8 the model. You release it at an elevated location.  
9 The lumped parameter model has a difficult time of  
10 getting the steam back down into the areas where you  
11 have the concern about how you address potential  
12 stratification and mixing.

13 So we expect that WGOTHIC is applicable to  
14 the AP1000, basically, within the context of the  
15 evaluation model and the conservativeness of the input  
16 and the look at the international database and the use  
17 of the lumped parameter model.

18 What we've seen to date suggests that,  
19 when the design calculations are done, the mass and  
20 heat transfer correlations are going to be used within  
21 their applicable ranges, and there is no need to  
22 broaden the database.

23 That's all I have.

24 CHAIRMAN KRESS: Are there any comments or  
25 questions from the members before we hear from

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1 Westinghouse response on this. Seeing none, I guess  
2 we will see if you have any comments you would like to  
3 make.

4 MR. CUMMINS: This is Ed Cummins. We are  
5 in basic agreement with the staff's conclusion. We  
6 would like to respond to an earlier ACRS question  
7 relative to CFD modeling, and show you what we have  
8 calculated. Rick Austin is going to do that.

9 CHAIRMAN KRESS: Great.

10 MR. CUMMINS: Thank you.

11 MR. AUSTIN: Okay. My name is Rick Austin  
12 from Westinghouse Electric. I was asked to present  
13 some work that we did to qualitatively compare the  
14 mixing in AP600 to AP1000. We did this when we were  
15 looking at the PIRT and the scaling issues, and it's  
16 contained in the WCAP-15163.

17 (Slide change)

18 MR. AUSTIN: We looked at -- WE built  
19 models of the AP600 and AP1000 above deck operating  
20 region in two dimensional CFD code. Star 3-D it's  
21 called. Those results, as I said, are presented in  
22 15613. We showed those results to the NRC in, I  
23 think, the Thermal-Hydraulics -- ACRS Thermal-  
24 Hydraulics Subcommittee.

25 Dr. Wallis asked us if we could look at

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1 that in 3-D. So Dr. Milorad Dzodzo -- he's our CFD  
2 code expert -- put together a 3-D pie slide model with  
3 the same CFD code.

4 MEMBER WALLIS: A 1.5 degree pie?

5 MR. AUSTIN: 1.5 degree --

6 MEMBER WALLIS: Pretty thin sliver of pie.

7 MR. AUSTIN: -- pie slice. The 1.5 degree  
8 pie slide model we built has approximately a million  
9 cells. So the computing time was excessive, and I  
10 think it took him a week to generate the results that  
11 I'm going to show here. I think he might have had a  
12 dual processor type computer, too.

13 MEMBER WALLIS: Now you said you had --  
14 Well, you don't have a steam plume in there?

15 MR. AUSTIN: Yes. This is air only. We  
16 couldn't model the condensation of the steam.

17 MEMBER WALLIS: This is air only?

18 MR. AUSTIN: Right.

19 MEMBER WALLIS: But there is a heated --

20 MR. AUSTIN: There's a heated plate at the  
21 bottom. It simulates a hot wall at the bottom on  
22 here, and there's a cold wall here and a cold wall on  
23 top.

24 MEMBER WALLIS: In reality, you are  
25 injecting steam rather than having all plate.

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1 MR. AUSTIN: That's correct.

2 MEMBER WALLIS; Why didn't you inject --  
3 Oh, but you couldn't remove mass, I guess. In the CFD  
4 model, you didn't know how to remove the mass.

5 MR. AUSTIN: That's right. Couldn't  
6 condense the steam.

7 I guess when Dr. Dzodzo looked at that, he  
8 suggested that the steam, because it was lighter than  
9 the air, would have probably provided even a little  
10 better mixing --

11 MEMBER WALLIS: Because of more buoyancy,  
12 it tends to go up more.

13 MR. AUSTIN: Right. A little better  
14 mixing than what we would see with the CFD analysis.

15 So this first slide just shows the basic  
16 model that we put together. I don't know if this is  
17 going to come out very well. That's --

18 MEMBER WALLIS: I think it's just the  
19 noding. The whole thing is full of nodes.

20 MR. AUSTIN: That's the noding structure  
21 in the corners of the pie slide. It's highly detailed  
22 on the edges. I think he was trying to resolve the  
23 boundary layer. Those are like one millimeter size  
24 width cells there.

25 (Slide change)

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1 MR. AUSTIN: This is a 2-D model  
2 prediction for the temperature distribution for  
3 AP1000, and I'll put up -- I probably could use two  
4 projectors.

5 (Slide change)

6 MR. AUSTIN: This is the 3-D model that  
7 results. I guess you can imagine both sides of that.

8 MEMBER WALLIS: You're going to have to  
9 tell us something. Everything looks a kind of uniform  
10 blue here. So I'm not quite sure. The other one  
11 showed more --

12 MR. AUSTIN: The colors are --

13 MEMBER WALLIS: The other one showed more  
14 clearly a circulation pattern. The other one shows a  
15 transition on the wall in color, which I don't see in  
16 the 1000. It may be just the way that the --

17 MR. AUSTIN: Yes, it's very thin -- a very  
18 thin boundary layer on this one. This one, you can  
19 see. It just may be the way the colors came out here.

20 MEMBER WALLIS: Well, the plume is more  
21 evident in that one, and the wall boundary is more  
22 evident in the righthand one.

23 MR. AUSTIN: Right.

24 MEMBER WALLIS: So does this say it's well  
25 mixed or does it show that it is a sort of circulating

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1 pattern with a not very well mixed region in between?

2 MR. AUSTIN: It shows a circulating  
3 pattern with a hot plume rising up the center and the  
4 colder plumes falling down along the outer walls. In  
5 the center portion -- There is a velocity profile plot  
6 here. The center portion or that little donut region  
7 -- this is what the 2-D predicted, and here's the 3-D  
8 prediction, same type of behavior.

9 The donut region around the middle there  
10 is -- That is somewhat stagnant. It doesn't have much  
11 velocity.

12 MEMBER WALLIS: So it indicates that you  
13 don't have a well mixed -- So then you are going to  
14 argue the well mixed is conservative, I guess. That's  
15 the Westinghouse position, isn't it?

16 MR. AUSTIN: Yes.

17 MEMBER WALLIS: This is not well mixed,  
18 but the well mixed assumption in the code is  
19 conservative?

20 MR. AUSTIN: Yes.

21 CHAIRMAN KRESS: I would have called this  
22 well mixed.

23 MEMBER WALLIS: Well, that blue region  
24 isn't particularly well mixed.

25 MR. AUSTIN: The blue region doesn't

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1 circulate as much. There's very little circulation in  
2 that region.

3 MEMBER WALLIS: You have this sort of  
4 mixing in your breadmaker, you would get lousy bread.  
5 I don't know how to describe it to you.

6 CHAIRMAN KRESS: Does the CFD model have  
7 a turbulent term in it?

8 MR. AUSTIN: Dr. Dzodzo would be the  
9 expert on that. I'm not a --

10 MR. BROWN: Bill Brown from Westinghouse.  
11 I think it does, but I think you have to look at the  
12 range of numbers here, too, before you get carried  
13 away with making -- I think --

14 CHAIRMAN KRESS: That's what I was looking  
15 at.

16 MR. BROWN: Yes. The differences are very  
17 small, Dr. Wallis. They are very small.

18 MR. AUSTIN: The temperatures are real  
19 small.

20 MR. SIEBER: Ten degrees or so.

21 MR. BROWN: You are only talking a few  
22 degrees. So over the type of height -- we're talking  
23 about, you know, hundred feet plus.

24 MEMBER WALLIS: I think we have to look at  
25 the change in temperature of that blue annular

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1 region, whatever you call, Taurus sort of region. Did  
2 that actually warm up during the transient or not  
3 much?

4 MR. AUSTIN: Yes, this one shows -- Well,  
5 the temperature there is probably on the order of 370  
6 degrees.

7 MEMBER WALLIS: So even the coldest bit  
8 warmed up a lot. Is that what we conclude? I can't  
9 really tell. What was the initial temperature  
10 compared with the temperatures we are seeing here?

11 MR. AUSTIN: The initial temperature --  
12 The cold all is at 366k, and the hot wall is at 394k.

13  
14 MEMBER WALLIS: And the initial  
15 temperature of everything was?

16 MR. AUSTIN: 385k. It's the average. We  
17 use an average temperature.

18 MEMBER WALLIS: When you use k, it's  
19 difficult to see the differences. I guess what I  
20 would want to know is how much did that cold region,  
21 the one affected region, change its temperature. You  
22 can't tell just looking at it. That dark blue blob,  
23 that elongated donut thing -- it doesn't mix very  
24 much.

25 CHAIRMAN KRESS: I think this is safe

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1 calculation.

2 MEMBER WALLIS: Does it go up in the  
3 middle and down the wall in that thing?

4 CHAIRMAN KRESS: This is steady state  
5 calculation?

6 MR. BROWN; Yes. Bill Brown. This is  
7 steady state. This is after many, many iterations.  
8 That's why it took a week to get here.

9 MEMBER WALLIS: So now you have to do the  
10 transient.

11 CHAIRMAN KRESS: What this indicates to me  
12 is that with those kind of temperature differences  
13 inside the containment that you are very likely to  
14 have a well mixed containment.

15 MEMBER WALLIS: I think what we have to  
16 look at is the velocities here and see how rapidly a  
17 chunk of fluid goes around compared with how rapidly  
18 things are changing with time.

19 CHAIRMAN KRESS: Yes, that would be  
20 something --

21 MEMBER WALLIS: How close are we to  
22 Fauske's steady state? This is useful.

23 MR. BROWN: Bill Brown again. Don't  
24 forget that one of the original intentions you had  
25 here was just some interest in the 2-D versus 3-D

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1 result. So that was originally.

2 MEMBER WALLIS: Also 600 versus 1000, too.

3 MR. BROWN: Yes. That was originally why  
4 we did it, was to address the L/D type of aspect ratio  
5 difference. One thing we also notice that Rick may  
6 not have mentioned is that in the 3-D -- I believe,  
7 Dr. Kress, maybe you said this at one of the last  
8 meetings, that you expected maybe a little improvement  
9 perhaps in the results.

10 What we noticed is that, if you look on  
11 the picture on the left, that the plume actually  
12 wasn't quite -- from what we could tell in the details  
13 and looking at all the iterations, wasn't quite  
14 actually hitting the top of the containment, but now  
15 in the 3-D it actually is hitting the top of the  
16 containment. So we actually get a little improvement.

17 MEMBER WALLIS: First I will also tell  
18 you, heat transfer coefficients on the wall. Now this  
19 isn't condensation, but there's probably a way to go  
20 from the heat transfer coefficients you get here to  
21 what they should be with condensation in some way that  
22 you can sort of verify that heat transfer behavior is  
23 conservative or whatever you want to show. You should  
24 be able to get some heat transfer information on the  
25 wall from this sort --

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1 MR. BROWN: We can get dry heat transfer,  
2 right.

3 MEMBER WALLIS: Yes, but then there's  
4 probably a way you can show, you know, by analogy or  
5 something. You can scale it.

6 CHAIRMAN KRESS: I'm pretty sure the CFD  
7 code has it modeled in it for the heat transfer. With  
8 that many nodes that small, it probably uses the  
9 conduction equation.

10 MEMBER WALLIS: Then you can compare it  
11 with some-- Well, you presumably used some kind of  
12 Rehle number correlation or something for the heat  
13 transfer coefficient?

14 MR. AUSTIN: Inside containment, yes. We  
15 used free conduction correlations.

16 MEMBER WALLIS: It would be interesting.  
17 This isn't just free convection on the wall. It's a  
18 driven circulation pattern. So it's somewhat  
19 different from just free convection on the wall. It  
20 would be useful for you to compare the two. You could  
21 probably show that neglecting the circulation is quite  
22 conservative.

23 Just use free convection on the wall. You  
24 may get a heat transfer coefficient, say, half as much  
25 as you predict here for the air case. That might help

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1 you. I don't want to do your work for you.

2 It would be useful if you could show,  
3 because of circulation, there is really more heat  
4 transfer, say, in air than you would predict using the  
5 kind of assumptions you use for your heat transfer  
6 calculation.

7 MR. AUSTIN: And we agree.

8 MEMBER WALLIS: And then that would be  
9 reassuring.

10 MR. AUSTIN: That's all I had.

11 CHAIRMAN KRESS: We appreciate that. That  
12 was very useful, I think.

13 MR. BOEHNERT: A question for  
14 Westinghouse. Those slides are labeled proprietary.  
15 Do you really mean that?

16 MR. AUSTIN: No.

17 MR. BOEHNERT: We can cross that off.

18 MR. BROWN: That was from my proprietary  
19 presentation. Those slides there aren't proprietary.  
20 Sorry about that.

21 CHAIRMAN KRESS: In the full Committee  
22 meeting in March we only have two hours to cover all  
23 the stuff we covered in a day and a half -- well, I  
24 guess one day, counting both of them. So we need to  
25 have some idea of how to condense all this.

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1 My feeling is on yesterday's presentations  
2 on the DAC and the exemptions, I think you can just  
3 use one slide to tell what the exemptions were. I  
4 think everybody is in full agreement on those almost.

5 For the DAC, I think the comment that  
6 Westinghouse is going to request for the seismic  
7 structure a hard rock side makes things a lot easier  
8 in terms of what we say, because that sort of takes  
9 those out of DAC space.

10 So given that, I think you just clarify  
11 what Westinghouse intentions are there, and then that  
12 means we focus the issues of DAC on the piping. I  
13 think that may be one you want to really focus on,  
14 because I think that's one the Committee would have to  
15 make some sort of judgment on, if we want to give our  
16 take on it, our thing sort of.

17 I would focus most of the talk on the  
18 piping DAC. Now you have to do something about the  
19 codes, how to get all this -- I like the thought of  
20 the staff showing -- giving us an impression of what  
21 the depth of their review was.

22 You had a couple of slides that -- for  
23 talking about the code applicability and the data  
24 applicability. So if you could just give the full  
25 Committee an impression of the depth of your review

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1 and the basis for your conclusions on that.

2 With Westinghouse, I particularly liked  
3 that stuff you did to show from the entrainment that  
4 it's self-limiting, and I think that would be useful.

5 A lot of this on the code and the data, I  
6 think, is going to come down to the entrainment issue.  
7 So I would focus on that as much as I could during the  
8 two hours we have. This is the thing that I think is  
9 going to give us problems.

10 I think with the containment and GOTHIC,  
11 just a very quick overview on that. I didn't see very  
12 much contentious. Everybody seems to be in agreement  
13 on that. So I wouldn't do a lot with that. I would  
14 just point out what it is.

15 So if the members have some other thoughts  
16 on what the two hours might consist of, I would  
17 welcome comments at this point.

18 MEMBER WALLIS: Well, I'd like to see the  
19 scaling of the summary applied to the scaling that  
20 showed some of the inserts for red indicating the few  
21 areas where scaling needed to be investigated further.

22 CHAIRMAN KRESS: Oh, yes, definitely I'd  
23 like to see that, too.

24 MEMBER WALLIS: I think we need the  
25 picture showing entrainment in the two locations. I

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1 think we need sort of the summary picture of is there  
2 or is there not a possible issue with entrainment. I  
3 mean, the numbers, actually Jg\*, and there's just one  
4 slide. I think there was a clear message there.

5 MEMBER SIEBER: I think you probably don't  
6 want to go through all the math and logic in the  
7 scaling.

8 MEMBER WALLIS: No. I don't think we need  
9 all Marino's equations.

10 CHAIRMAN KRESS: Although that was good  
11 stuff.

12 MEMBER WALLIS: I think there's a bottom  
13 line for Marino, is that if you make different  
14 assumptions about the void fraction, you get different  
15 rates of loss of inventory. That's sort of the bottom  
16 line. Maybe that can be done in five minutes.

17 CHAIRMAN KRESS: Yes.

18 MEMBER WALLIS: That sort of ties in with  
19 what Steve is saying. I think also in the RELAP you  
20 don't need anything like as much as we had this  
21 morning. What's sort of the bottom line with RELAP?  
22 What are you doing with it? Where is it going, maybe  
23 a couple of slides there.

24 MEMBER POWERS: Tom, may I make a  
25 suggestion, that for the staff presentation you invert

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1 the order and begin with Mr. Throm's presentation so  
2 that he can remind the members who are not here about  
3 AP600, because most of those members that are not here  
4 were not part of the AP600 review.

5 CHAIRMAN KRESS: That would be a good  
6 suggestion.

7 MEMBER POWERS: And he has a caricature  
8 that I think would allow him to point out some of the  
9 -- He used it to point out some of the key containment  
10 features, and I would encourage him to go ahead and do  
11 that.

12 He might just also note a few of the  
13 critical features for the discussion of the in-vessel  
14 phenomena.

15 CHAIRMAN KRESS: There was a -- in the  
16 chart with the table on it, comparing notes. That  
17 would be a good thing to have up there.

18 MEMBER POWERS: I would use a picture.

19 CHAIRMAN KRESS: Well, a picture is going  
20 to look just like AP600.

21 MEMBER WALLIS: A realistic picture, not  
22 with a lot of content.

23 MEMBER POWERS: Well, I mean, sort of the  
24 plant.

25 CHAIRMAN KRESS: But that chart showing

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1 the --

2 MEMBER POWERS: What I'm thinking of is  
3 those members that are not here -- I mean, nearly all  
4 of them are --

5 CHAIRMAN KRESS: It would be a good idea  
6 to have a picture.

7 MEMBER POWERS: -- relatively new.

8 CHAIRMAN KRESS: Yes, and then the chart  
9 showing the differences between AP600 and AP1000.

10 MEMBER WALLIS: When words like CMT are  
11 used, there needs to be, you know, a very quick  
12 tutorial.

13 CHAIRMAN KRESS: Re-explain what those  
14 devices -- where they come into play and when they are  
15 used. That would be easy.

16 MR. CORLETTI: Would you like Westinghouse  
17 to do just a comparison, a five minute comparison of  
18 those two plans?

19 CHAIRMAN KRESS: Yes, I think that would  
20 be a good idea. Let Westinghouse do that.

21 MEMBER POWERS: The members that are not  
22 here, almost none --

23 CHAIRMAN KRESS: Yes, they are all new and  
24 weren't here for AP600.

25 MEMBER POWERS: -- were present for the

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1 AP600, and nearly all of them are thermal-  
2 hydraulically averse. I like these guys a lot, by the  
3 way.

4 CHAIRMAN KRESS: Yes. What would be good  
5 would be a little short tutorial on the philosophy of  
6 the passive systems, where they come into play, and  
7 why, and that would be useful for those members, I  
8 think. A good comment, Dana.

9 Any other thoughts?

10 MEMBER WALLIS: Now we are supposed to  
11 write a letter on this?

12 CHAIRMAN KRESS: We have in mind a letter,  
13 because I think the staff plans to go to the  
14 Commission at the end of March with their feelings on  
15 both the DAC and the exemptions and the code  
16 applicability.

17 So I guess the Commission would appreciate  
18 our thoughts on those.

19 MEMBER WALLIS: So we would be both sort  
20 of endorsing some of the preliminary conclusions or  
21 something or saying that they are on the right track?  
22 There's no real conclusion yet, is there? So we got  
23 to be careful about it.

24 CHAIRMAN KRESS: Well, we'll be careful.

25 MEMBER WALLIS: Saying they are on the

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1 right track.

2 MR. CUMMINS: Maybe I could make a  
3 comment, add comments. What we asked the staff to  
4 conclude was that the AP600 tests were valid for the  
5 AP1000, that the AP600 codes were applicable to the  
6 AP1000, and their position on DACs and exemptions.

7 So we didn't ask them to conclude the  
8 safety of the AP1000 plant, but we did -- There are  
9 some conclusions for which we would like to achieve.

10 MR. WILSON: This is Jerry Wilson. So  
11 what we are going to do is send a letter eventually to  
12 Westinghouse answering those questions that Mr.  
13 Cummins just summarized, but prior to sending the  
14 letter, decided we wanted to run it by the Commission.

15  
16 So as you say, I'm sure the Commission  
17 will want to hear your views on it as they consider  
18 that.

19 CHAIRMAN KRESS: We'll comment on those  
20 four issues, I think.

21 MR. DZODZO: And if I may add a couple of  
22 comments, first I'd like to thank you for very  
23 insightful questions, and if there were any  
24 shortcomings in answering those questions, it was  
25 because a project limited to the otherwise unbounded

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1 curiosity of reviewers into a scope of phase 3.

2 My second comment is also that the  
3 reviewers also limited to design basis here. The  
4 applicability of some codes may resurface when I go  
5 into severe accidents, and in particular into source  
6 the calculations, since thermal-hydraulic conservatism  
7 sometimes is counterproductive to source the  
8 calculations.

9 As we know, the position mechanism are  
10 sensitive to local thermal-dynamic conditions.

11 CHAIRMAN KRESS: And we will look forward  
12 to reviewing those during the phase 3 part of the  
13 thing.

14 MEMBER POWERS: It strikes me, Tom, that  
15 we are going -- One of the central issues arises in  
16 connection with the DAC is the rule in Part 52  
17 concerning the completeness of the design information.

18 CHAIRMAN KRESS: I think you're exactly  
19 right. That is the issue.

20 MEMBER POWERS: And the Commission that  
21 endorsed that rule is different than the Commission we  
22 have now, and we are going to have to discuss for them  
23 a little bit on why anyone would put such a silly rule  
24 in.

25 CHAIRMAN KRESS: I think you are exactly

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1 right. In fact, in mentally thinking what might be in  
2 our letter, that was one of the things I had in mind  
3 discussing. I think you're exactly right. That's the  
4 central issue.

5 MEMBER SIEBER: Yes, it is.

6 CHAIRMAN KRESS: And particularly those  
7 two criteria, you know. So that, I think, will  
8 definitely end up in our letter, some discussion on  
9 that, and how it impacts on the question of the DAC  
10 for the piping. I think you're exactly right.

11 That's one reason I wanted a bit of  
12 concentration on the piping DAC issue.

13 MEMBER POWERS: It's a good object lesson.  
14 The other object lesson, of course, is the  
15 instrumentation and control, because that's a case  
16 where nearly everybody says, yeah, that's a good idea.

17 CHAIRMAN KRESS: Everybody agrees on that.  
18 Yes.

19 MEMBER POWERS: Yes, and so you got two to  
20 compare, and you need to compare up sides and down  
21 sides.

22 CHAIRMAN KRESS: Yes. I think that should  
23 be part of our discussions on the full Committee.

24 MEMBER POWERS: So this is going to be a  
25 difficult letter, isn't it? I mean, it's a lengthy

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1 letter.

2 CHAIRMAN KRESS: I don't think so. I've  
3 already got it written in my head. But maybe it will  
4 be.

5 MEMBER POWERS: The challenge that we face  
6 is translating from Tennessee to English.

7 CHAIRMAN KRESS: Oh, that will be  
8 difficult.

9 MEMBER SIEBER: I can't be any harder than  
10 New York.

11 MEMBER WALLIS: Well, I'm glad to hear  
12 that you folks understand what's going on with the  
13 DAC. I mean, you said there was a problem with new  
14 members understanding.

15 CHAIRMAN KRESS: Oh, that's right. You  
16 weren't part of the DAC.

17 MEMBER WALLIS: I haven't a clue what this  
18 DAC business is about. So you guys better understand  
19 it well.

20 CHAIRMAN KRESS: Yes, we think we know  
21 what DAC and ITAACs are, and Tier 1s and Tier 2s.

22 MEMBER POWERS: But we have to translate  
23 from English from Tennessee to English and then to  
24 academe use.

25 CHAIRMAN KRESS: Yes. You're right, it's

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1 going to be difficult.

2 Okay. With this comment, have we given  
3 you enough guidance? Are there any closing comments  
4 anybody wishes to make?

5 Seeing none, I am going to declare this  
6 Joint Subcommittee adjourned.

7 (Whereupon, the foregoing matter went off  
8 the record at 10:58 a.m.)

9

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Phenomena and Future Plant  
Designs Meeting

Docket Number: (Not Applicable)

Location: Rockville, Maryland

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## 3-D CFD Air Mixing Evaluation

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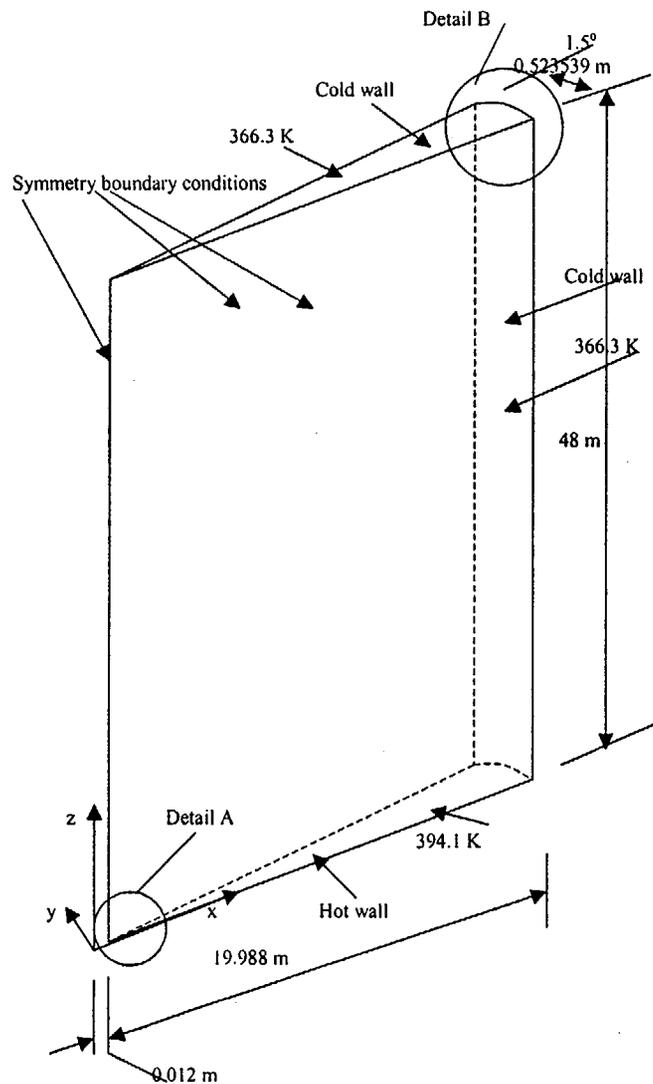
- Westinghouse presented a 2-D mixing evaluation comparing the AP600 to AP1000 in WCAP-15613 to determine the impact of increased height
  - 2-D vertical slice representing the volume above the operating deck
  - Both coarse and fine grid modeling used
  - Heated floor, cold ceiling and walls, air only
  - Models predicted a rising warm air plume in center, falling cold air plumes along the walls, and fairly stagnant air in between.

## 3-D CFD Air Mixing Evaluation

---

- Dr. Wallis asked us to perform a 3-D mixing evaluation for AP1000
  - Built a 3-D pie slice (1.5°) representing the volume from the center of containment out to the shell
  - Heated floor, cold ceiling and wall, air only
  - Model predicted a rising warm air plume in center, falling cold air plumes along the walls, and fairly stagnant air in between.
  - Warm plume reaches the ceiling in the 3-D model

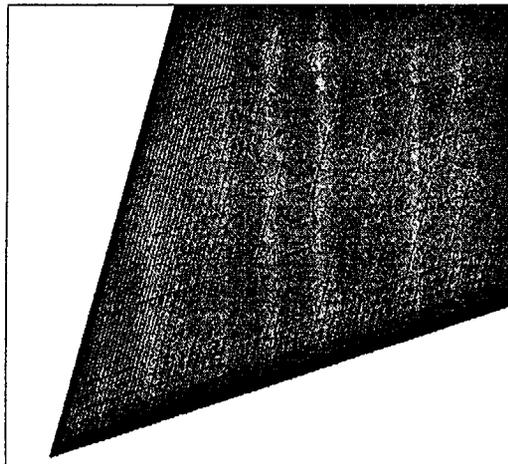
# 3-D CFD Air Mixing Evaluation



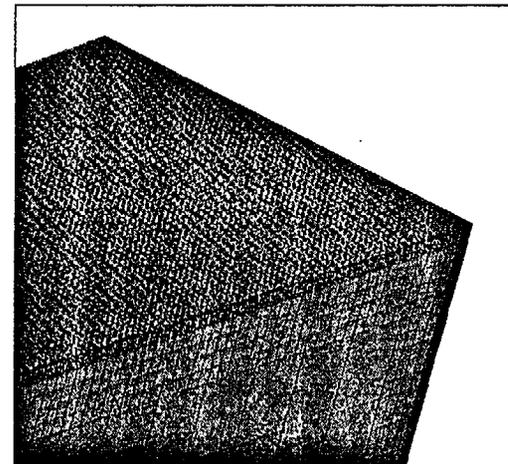
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# 3-D CFD Air Mixing Evaluation

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STAR  
PROSTAR 3.10  
11-JUN-01  
VIEW  
-1.000  
-0.558  
0.455  
ANGLE  
63.061  
DISTANCE  
0.332  
CENTER  
0.207  
-0.107  
0.328  
EHIDDEN PLOT

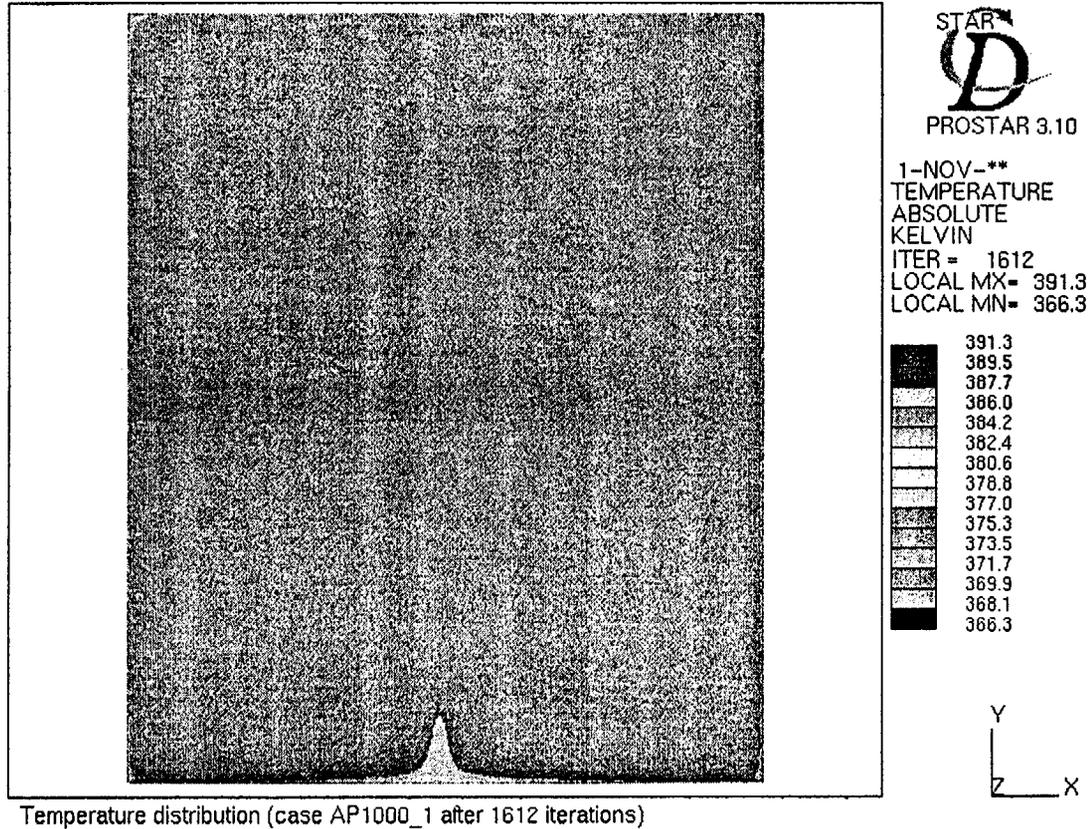


STAR  
PROSTAR 3.10  
11-JUN-01  
VIEW  
-1.000  
-0.558  
0.455  
ANGLE  
63.061  
DISTANCE  
0.231  
CENTER  
20.569  
0.567  
47.610  
EHIDDEN PLOT



Detailed Noding Structure at Center and Outer Edge

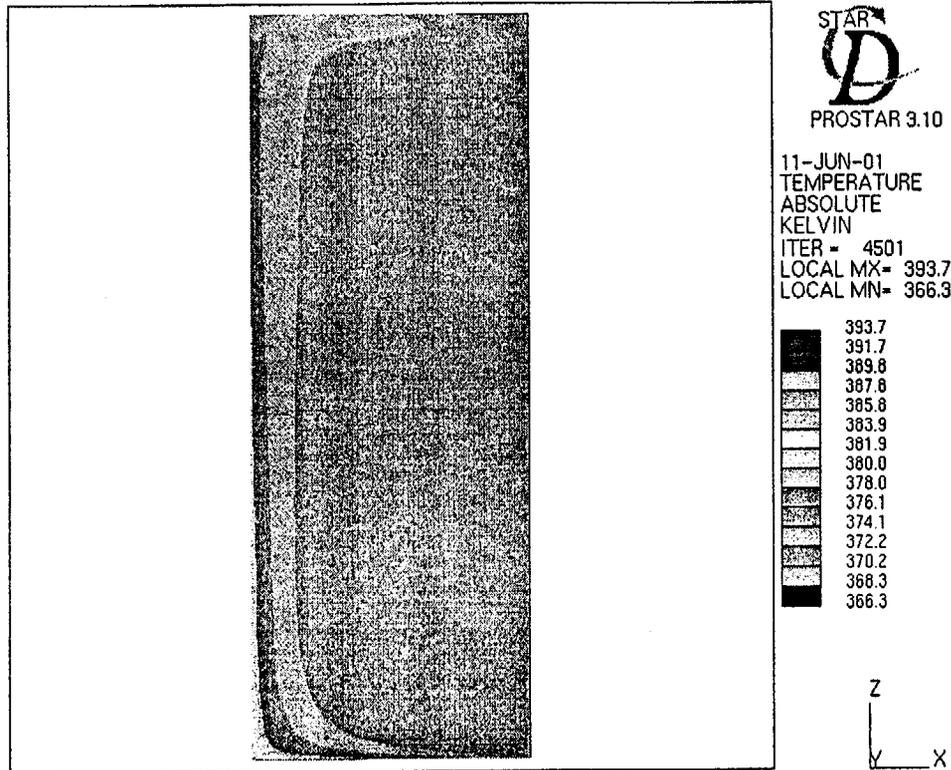
# 3-D CFD Air Mixing Evaluation



## 2-D Model Predicted Temperature Distribution

0001mmc29.ppt

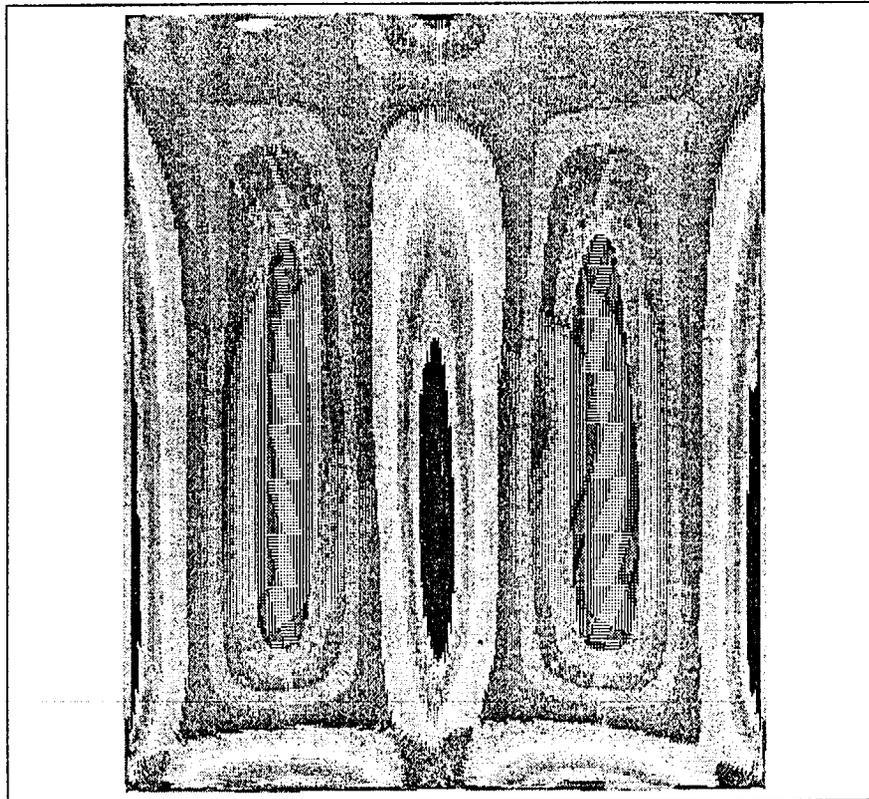
# 3-D CFD Air Mixing Evaluation



## 3-D Model Predicted Temperature Distribution

0001mmc30.ppt

# 3-D CFD Air Mixing Evaluation



PROSTAR 3.10

1-NOV-\*\*  
VELOCITY MAGNITUDE  
M/S  
ITER = 1612  
LOCAL MX = 1.149  
LOCAL MN = .4881E-04

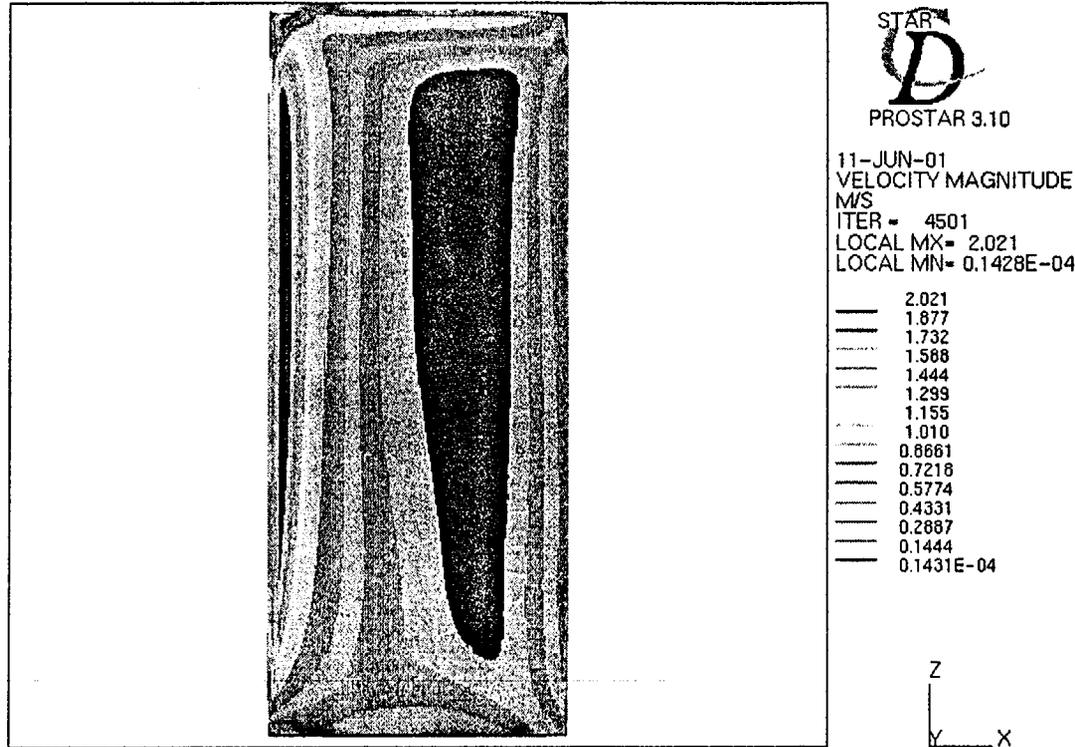
- 1.149
- 1.067
- .9849
- .9029
- .8208
- .7387
- .6566
- .5746
- .4925
- .4104
- .3283
- .2463
- .1642
- .8212E-01
- .4876E-04



Velocity distribution (case AP1000\_1 after 1612 iterations)

## 2-D Model Predicted Velocity Distribution

# 3-D CFD Air Mixing Evaluation



3-D Model Predicted Velocity Distribution

**Supplementary Figures**

**NRC Staff Review of NOTRUMP and LOFTRAN for AP1000**

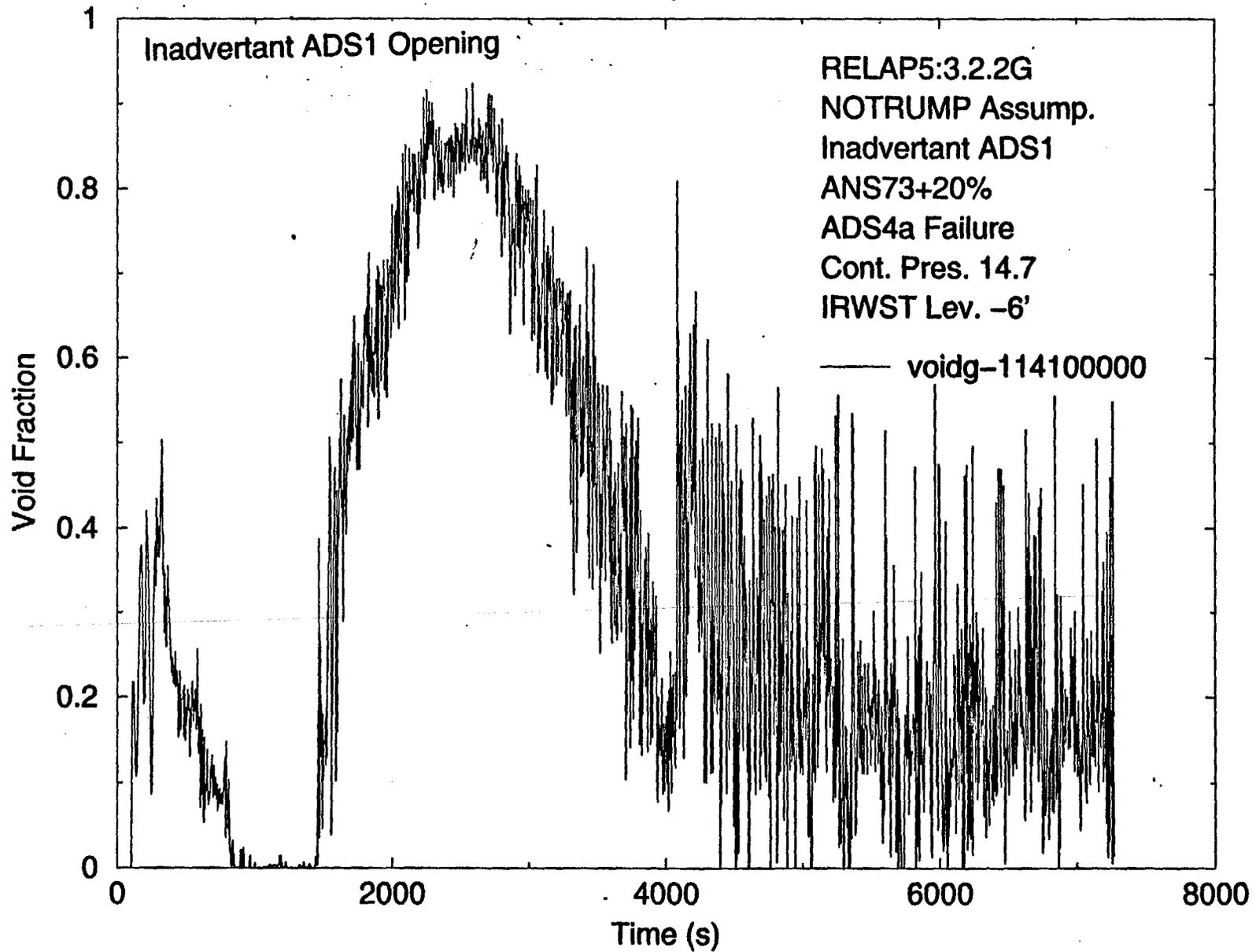
**ACRS Thermal/Hydraulic Subcommittee Meeting  
February 15, 2002**



**Walton L. Jensen  
NRC Staff**

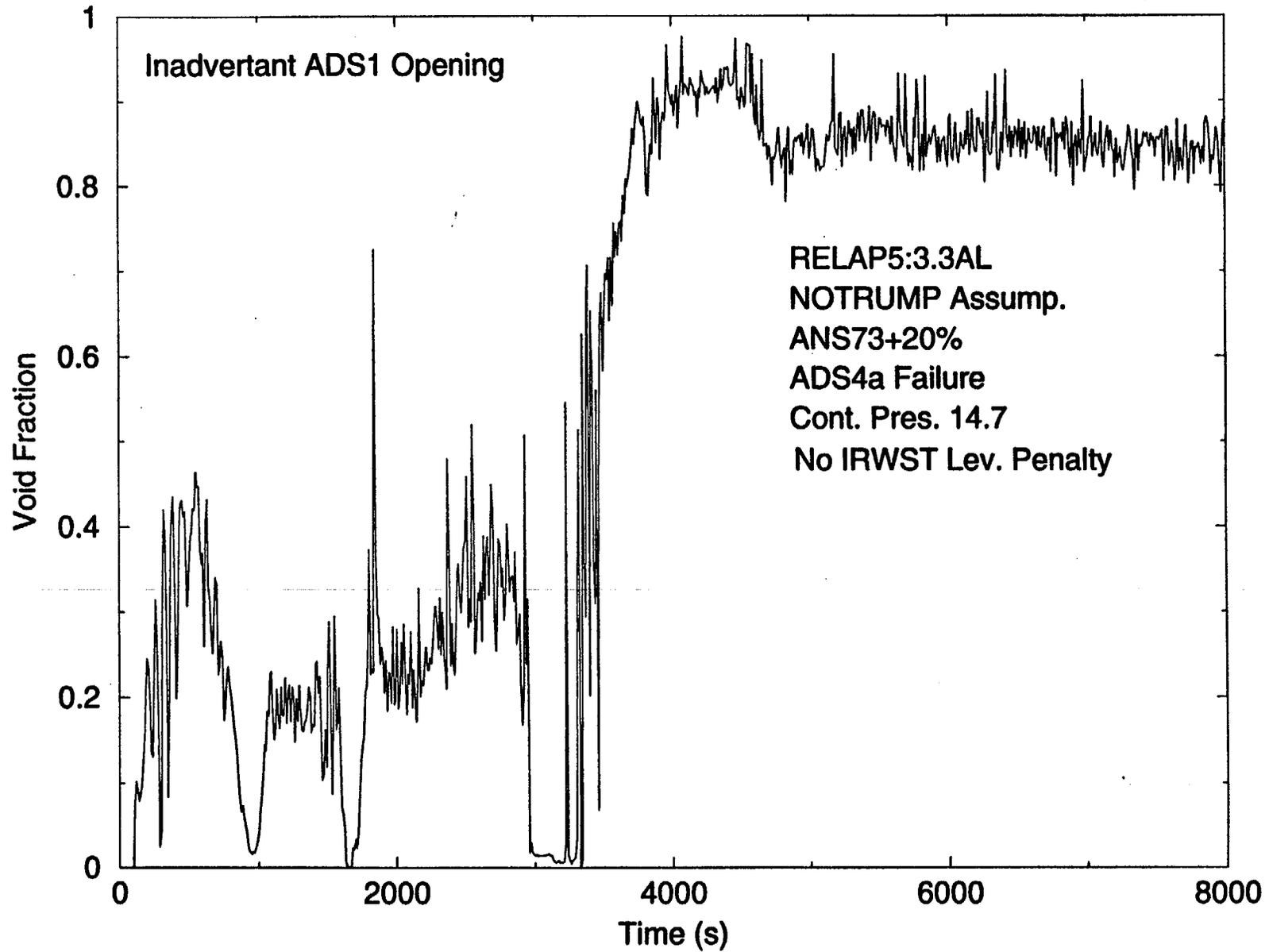
# AP600

Void in Top of Core



# AP1000

## Void in Top of Core



## RELAP5 - NOTRUMP Comparison

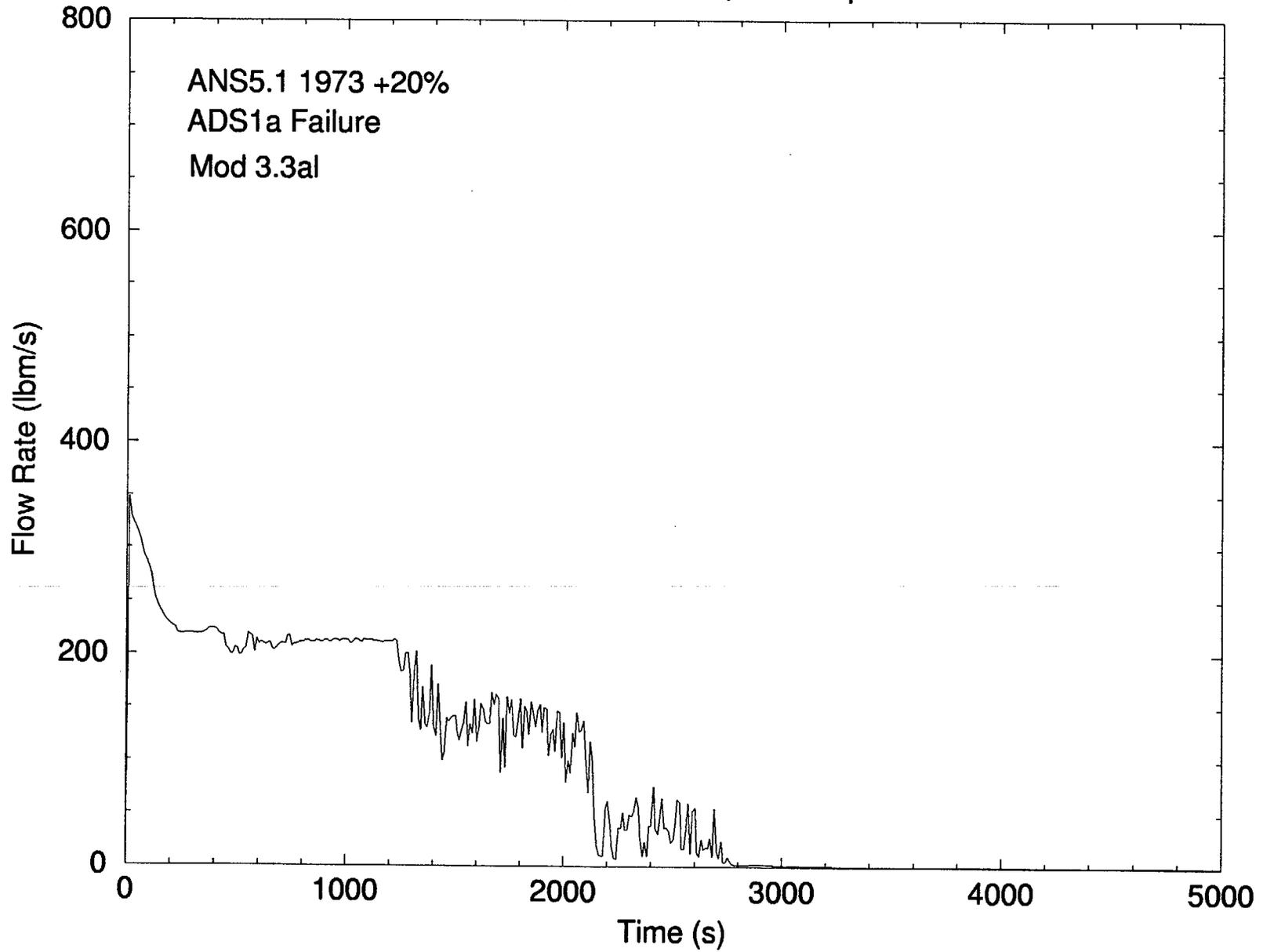
### Two-Inch Cold Leg Break

Event	Time (seconds)	
	RELAP5	NOTRUMP Nov. 2001
Break Initiates	0.0	0.0
Reactor Trip Signal	9.4 OPΔT	55.5
"S" Signal	52.4	62
Reactor Coolant Pump Trip	67.5	67.2
CMTs begin to Drain	1280	1000
Accumulator Injection Begins	1642	1447
ADS-1 Actuates	2097	1337.1
ADS-2 Actuates	2177	1467.1
ADS-3 Actuates	2297	1587.1
ADS-4 Actuates	2906	2490.1
Accumulators Empty	3020	1983
Voids above core > 90%	3156	
CMTs Empty	3580	2890
IRWST Injection Begins	3621	3300
Max. voids above core ~95%	3660	

# Break Flow Rate vs. Time

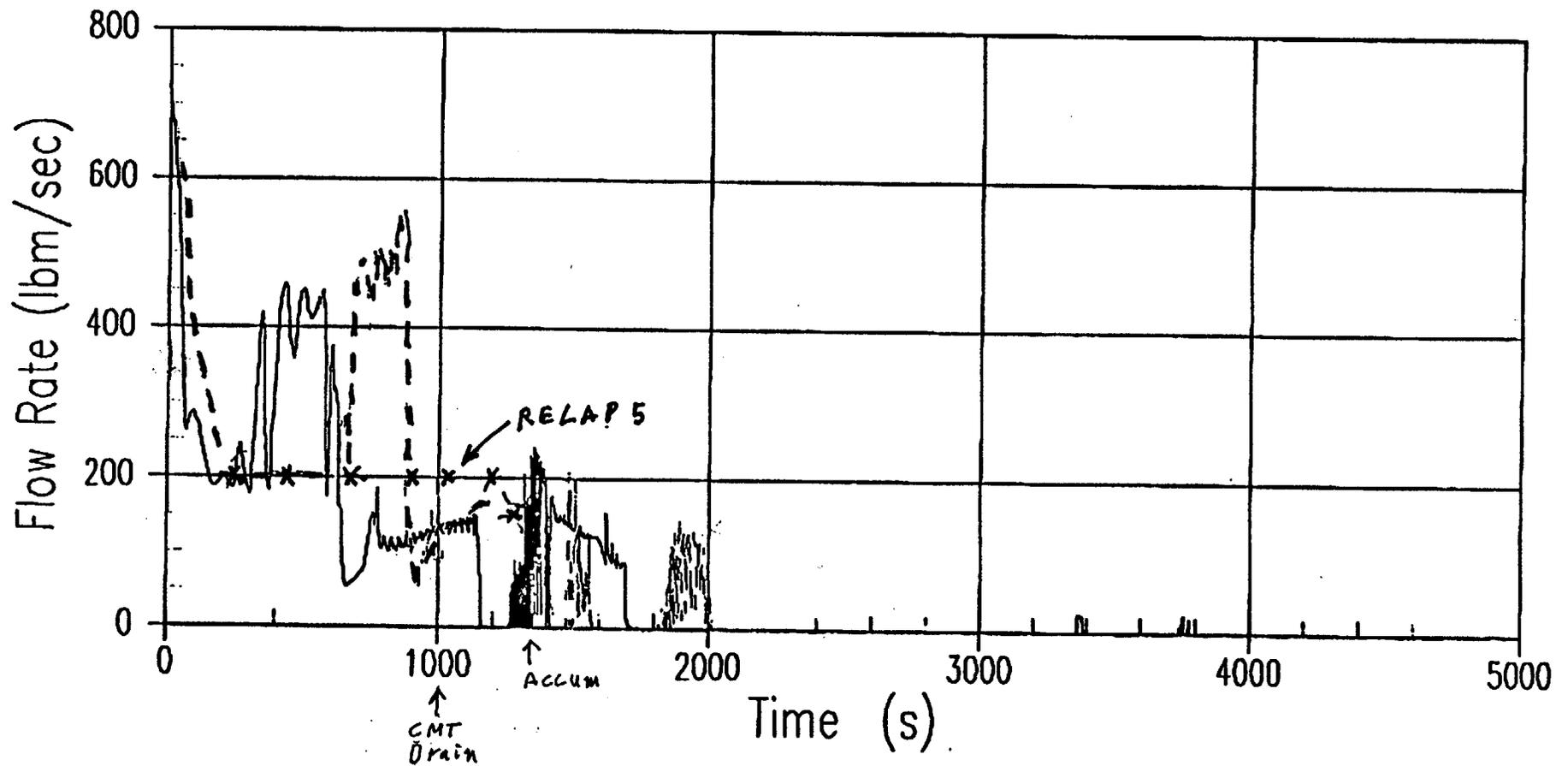
AP1000, 2 Inch CLB, DEC-Alpha

— mflowj-376000000



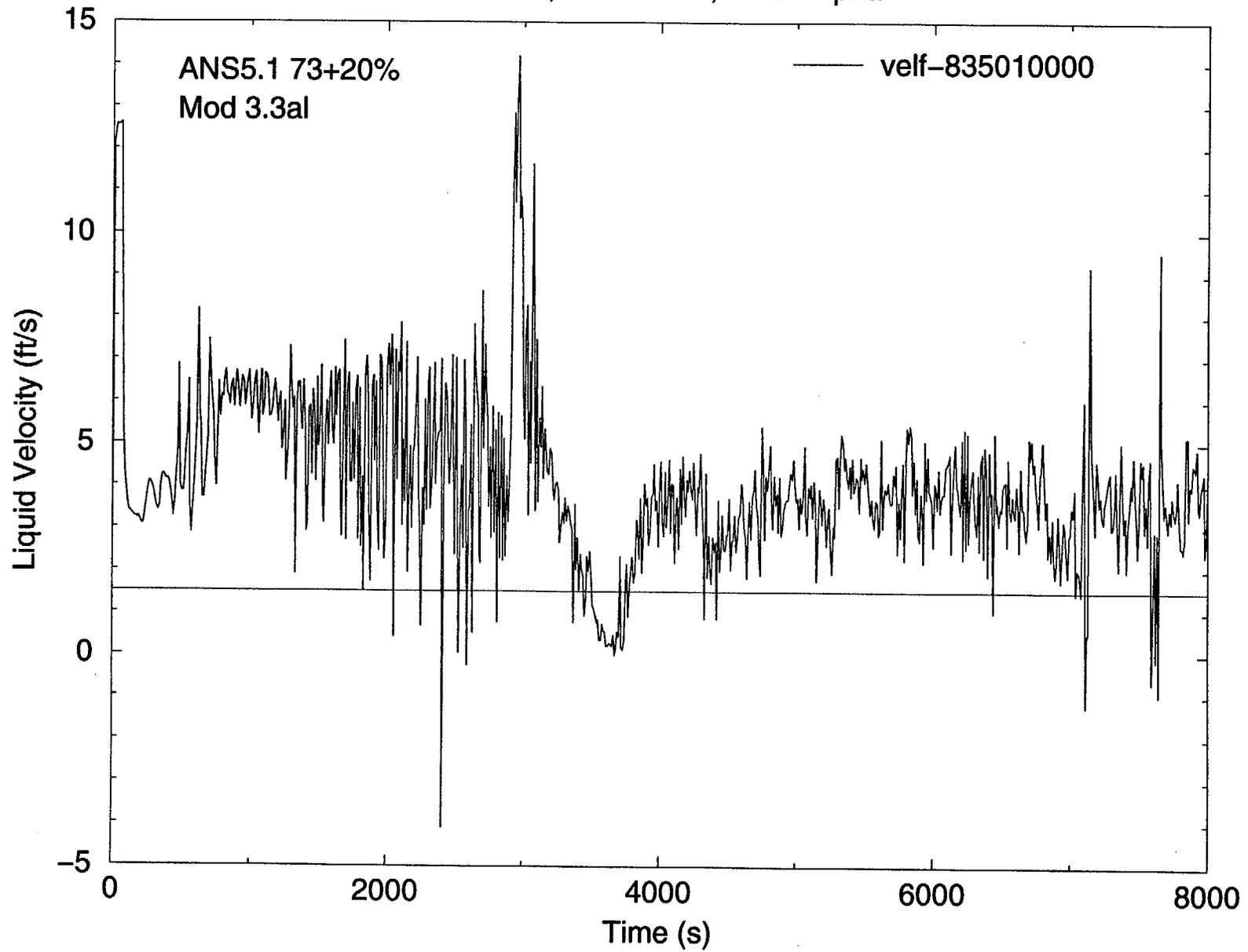
# AP600 vs. AP1000 2in49 Break Liquid Break Flow Rate

— AP600  
- - - AP1000 - 11/2001 Version



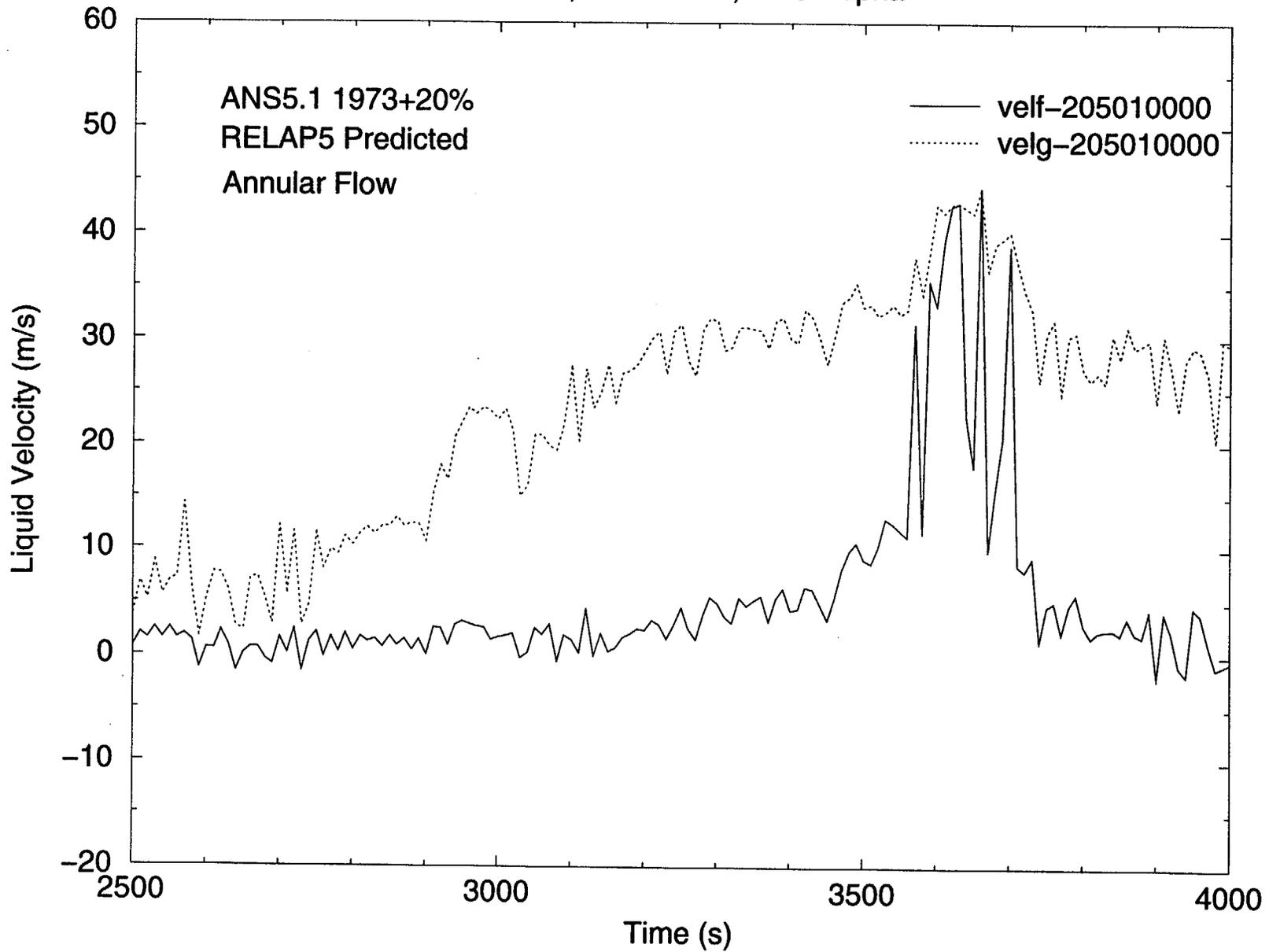
# PRHR Exit Flow Velocity

AP1000, 2 inch CLB, DEC-Alpha



# Hot Leg Velocity vs. Time

AP1000, 2 Inch CLB, DEC-Alpha



**NRC Staff Review of NOTRUMP and LOFTRAN for AP1000**

**ACRS Thermal/Hydraulic Subcommittee Meeting  
February 15, 2002**



**Walton L. Jensen  
NRC Staff**

BY L.W. Ward DATE \_\_\_\_\_ SHEET 3 OF 4 REV. \_\_\_\_\_  
 CHECKED \_\_\_\_\_ DATE \_\_\_\_\_ FILE \_\_\_\_\_  
 TITLE Development of the AP-1000 RELAP5 Input Model

**TABLE 1.0-2  
Passive Safety System Design Features**

System	AP600	AP1000	Comment
<b>Core Makeup Tanks</b>			
Number	2	2	Core makeup tank volume and flow rate is increased to provide additional injection flow. CMT elevations are maintained at the AP600 level.
Volume, ft <sup>3</sup>	2000	2500	
Line Resistance, %	100%	64%	
Design Flow rate, %	100%	125%	
<b>Accumulators</b>			
Number	2	2	The accumulators remain the same as AP600
Volume, ft <sup>3</sup>	2000	2000	
Pressure, psig	700	700	
<b>IRWST</b>			
Volume, gallons	557,000	590,000	The IRWST level has been increased by using more accurate level instruments. This permits a higher operating level.
Water Level, in	130.00	131.58	
Line Resistance, %	100%	32%	
Design Flow Rate, %	100%	184%	
<b>Automatic Depressurization</b>			
Stages 1-3			The first three stages of ADS are the same in AP1000.
Location	Top Pzr	Top Pzr	
Configuration	6 paths	6 paths	
Vent Area, %	100%	100%	
Stage-4			The ADS-4 vent area is increased more than the ratio of the core power. The ADS-4 venting is designed to allow for stable IRWST/sump injection during long term cooling
Location	Hot Leg	Hot Leg	
Configuration	4 paths	4 paths	
Line Size, nominal	10-inch	14-inch	
Vent Area, %	100%	176%	
Line Resistance, %	100%	28%	
Capacity, %	100%	189%	

BY L.W. Ward DATE \_\_\_\_\_ SHEET 4 OF 4 REV. \_\_\_\_\_  
 CHECKED \_\_\_\_\_ DATE \_\_\_\_\_ FILE \_\_\_\_\_  
 TITLE Development of the AP-1000 RELAP5 Input Model

**TABLE 1.0-2**  
**Passive Safety System Design Features**  
**(con't)**

System	AP600	AP1000	Comment
<b>Passive RHR Heat Exchanger</b>			
Type	C-Tube		The AP1000PRHR HX retains the AP600 configuration. The heat transfer area was increased by extending the length of the heat exchanger. The inlet and outlet piping have been increased resulting in higher flow rates.
Surface Area, %	100%	C-Tube	
Design Flow Rate, %	100%	122%	
Design Heat Transfer, %	100%	174%	
		172%	
<b>Containment</b>			
Diameter, ft	130	130	The AP1000 containment volume and design pressure were increased to accommodate higher mass and energy releases.
Overall Height, ft	189.83	215.33	
Shell Thickness, 1A	1.625	1.75	
Design Pressure, psig	45	59	
Net Free Volume, ft <sup>3</sup>	1.73x10 <sup>6</sup>	2.07 x10 <sup>6</sup>	
<b>Passive Containment Cooling System Water Storage Tank</b>			
Volume (Top of Overflow), gallons	580,000	800,000	The PCS water storage tank was increased to accommodate higher flow rates. The PCS flow rates have been increased based on the increase in core power.

## **LOFTRAN**

- **Used to evaluate non-LOCA transients and accidents including SGTR in conjunction with other codes. (RCS pressure, fuel temperature, DNBR)**
- **Approved for operating plants 1985 and for AP600 1998.**
- **Entire reactor system is modeled but two phase conditions are only allowed in the pressurizer and upper head.**

## **AP1000 Considerations**

- **ADS actuation only for a limited period to assess DNBR following a spurious opening.  
No RCS void formation.**
- **PRHR heat transfer based on correlation of PRHR test data.  
Test conditions extend to those of AP1000.**
- **LOFTRAN cannot evaluate asymmetrical flow conditions in split cold legs.  
(Single RCP trip, locked rotor/sheared shaft)  
The external cold leg flow model developed for AP600 should still apply.**
- **CMT draining is not expected.  
No void formation expected in the pressure balance lines.**
- **Larger steam generators of AP1000 increase the likelihood that significant voiding may occur during MSLB.**

**NRC Staff Conclusion:**

**LOFTRAN is acceptable for analysis of non-LOCA transients and accidents for AP1000 including SGTR with the excepting one outstanding open issue.**

**Open Issue:**

**Westinghouse has not performed the analysis of a main steam line break to evaluate reactor system voiding. Voids might form in the reactor vessel head, CMT pressure balance line and intact steam generator tubes. The analysis and NRC review is deferred to Phase 3.**

## **NOTRUMP**

- **Used to evaluate small break LOCA. NOTRUMP is used in conjunction with the SBLOCTA code to calculate peak cladding temperature.**
- **Approved for operating plants in 1985 and for AP600 in 1998.**
- **Five conservation equations and a drift flux model are used to calculate liquid and vapor flows and thermodynamic states.**
- **Momentum flux from area and density changes in the flow links is not included in the present model.**

## **RELAP5 Comparisons**

- **NRC RELAP5 input deck produced based on an existing AP600 input and information supplied by Westinghouse.**
- **Single failure, decay heat and containment back pressure same as NOTRUMP**
- **Higher core void fractions than for AP600**
- **Results similar to NOTRUMP**
  - **Differences in break flow and depressurization rate because of segmented downcomer modeling in RELAP5 vs. single stack in NOTRUMP**
  - **Slightly higher core void fractions than NOTRUMP**
  - **Slight core uncover for DVI line break**
- **NRC approval of AP1000 to be based on Westinghouse calculations**

## **AP1000 Considerations**

- **Accumulators same size as AP600.**
- **ADS1/2/3 are the same size.**
- **CMTs are the same height but with 24% more volume than AP600.**
- **PRHRHX is 22% larger but removes 72% more heat.  
NOTRUMP has a high heat flow limit (tube flow  $\leq 1.5$  ft/sec )**
- **ADS4 is 76% larger and is designed for 89% more capacity. Entrainment of liquid including upper plenum and hot leg leading to the ADS4 is an open issue.**

## **NRC Staff Conclusions:**

**NOTRUMP is acceptable for analysis of small break LOCA for AP1000 with exception to the following outstanding issues.**

- 1. Liquid entrainment from upper plenum, through hot legs and ADS4. Westinghouse proposes to benchmark NOTRUMP ADS4 against a modified WCOBRA/TRAC. Experimental verification remains an issue.**
- 2. The conservatism of the PRHRHX model needs to be justified for high heat flows. Westinghouse proposes to reduce the heat transfer area by 50%. This penalty needs to be justified in a data comparison.**
- 3. Only a limited number of breaks have been analyzed. The results will be affected by resolution of the entrainment issues. If core uncover is calculated, Westinghouse must seek approval for methodology used to calculate peak clad temperatures for AP1000 small break LOCA.**

**WGOTHIC Computer Program**  
**Presentation to the Advisory Committee**  
**on Reactor Safeguards Subcommittees**  
**on Thermal-Hydraulic Phenomena**  
**and on Future Plant Designs**

**February 14-15, 2002**

**Edward D. Throm**  
**Senior Reactor Engineer**  
**Plant Systems Branch**  
**Division of Systems Safety and Analysis**  
**Office of Nuclear Reactor Regulation**  
**U.S. Nuclear Regulatory Commission**  
**Telephone: (301) 415-3153**

## **WGOTHIC Computer Program**

**Evaluation of lumped-parameter network and circulation and stratification issues are discussed in**

- **WCAP-14407, Section 9**
- **NUREG-1512, Section 21.6.5.7.8**

**Application of GOTHIC program to international test problems, including the Battelle Model Containment (BMC) and the HDR (Heissdampfreaktor) experiments, demonstrated the conservative aspects of the lumped-parameter network.**

**Modeling conservatism to address uncertainties in circulation and stratification, and conservatism in the PCS flow and mass and heat transfer models resulted in the approval of an Evaluation Model for using WGOTHIC for design-basis accident analyses.**

## **WGOTHIC Computer Program**

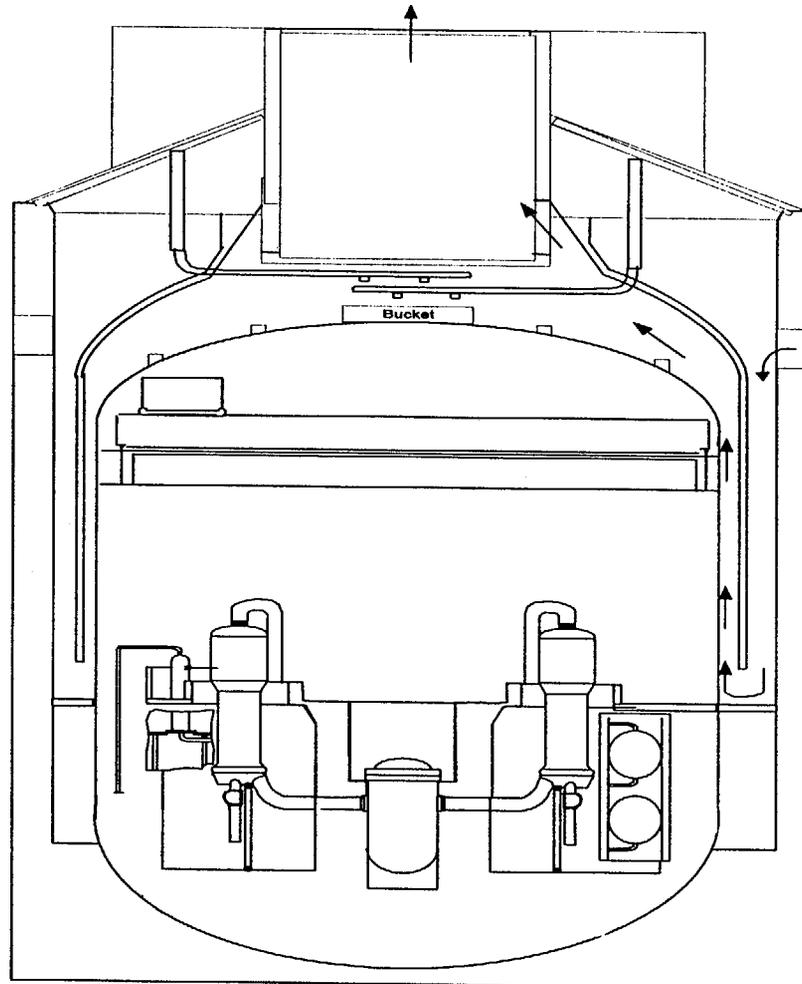
### **AP600 versus AP1000**

**Larger height could cause more complex recirculation patterns and influence mixing and increase the buoyancy driven flow rate. Less homogeneity of the containment atmosphere above the operating deck could result, with higher temperatures in the upper dome.**

**Westinghouse should conservatively predict any decreased homogeneity using the lumped-parameter model.**

**Scoping studied performed by Westinghouse indicate that the mass and heat transfer correlations are being used within acceptable ranges.**

Figure 21.6-22. AP600 Containment



- The loss coefficient in the external annulus should include a 30 percent increase over the value derived from the test program.
- Condensation and convection on heat sinks in the dead-ended compartments, below the operating deck, should not be credited after the blowdown period. This conservative assumption should also be employed for MSLB analyses.
- Heat transfer to horizontal, upwards facing surfaces which may become covered with a condensation film is not credited. In particular, the operating deck itself, which becomes covered with an air rich layer, should not be credited.

For each calculation with significant energy transfer to the PCS through the shell, the stability of the "clime" heat and mass transfer solution must be examined by the COL applicant (for example by plotting heat transfer rates vs time for both the wet and dry "climes") to confirm that the calculation has not violated the time step stability.

In the "Evaporation Limited" flow model, Westinghouse neglects PCS runoff sensible heat which is conservative and offsets the nonconservatism introduced by the simultaneous use of the Chun and Seban and the "Evaporated Limited" flow model. Therefore, these two assumptions must be employed together, for the staff to consider this model to be acceptable for licensing analyses.

The 2-D enhancement to the "Evaporation Limited" flow may not be used to credit leakage reduction for siting evaluations.