Official Transcript of Proceedings ACRST-3148

NUCLEAR REGULATORY COMMISSION

ORIGINAL

Title: Advisory Committee on Reactor Safeguards
Thermal-Hydraulic Phenomena Subcommittee

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

Docket Number: (not applicable)

Location: Rockville, Maryland

Date: Thursday, March 15, 2001

Work Order No.: NRC-112 Pages 1-136

CLOSED SESSION: pages 1-60

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

TR04

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE

+ + + + +

WESTINGHOUSE PROPOSED APPROACH TO ADDRESS

AP1000 T/H ISSUES

+ + + + +

OPEN SESSION

+ + + + +

THURSDAY

MARCH 15, 2001

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 1:00 p.m., Dr. Graham B. Wallis, Chairman, presiding.

SUBCOMMITTEE MEMBERS:

GRAHAM B. WALLIS, Chairman

THOMAS S. KRESS

WILLIAM J. SHACK

I N D E X

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

(1:00 p.m.)

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

The other ACRS Members in attendance are Thomas Kress and William Shack, and we expect Mario Bonaca to be present within about an hour and we also may have a consultant, Dr. Novak Zuber present.

The purpose of this meeting is for the Subcommittee to review the Westinghouse Electric Company's proposed approach to address thermal-hydraulic issues pertaining to its AP1000 passive plant design.

The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate for deliberation by the full Committee. Paul Boehnert is the cognizant ACRS staff engineer for this meeting.

Portions of this meeting will be closed to the public to discuss Westinghouse Electric Company proprietary information. I'd ask Westinghouse to let us know when the meeting should be closed.

The rules for participation in today's

meeting have been announced as part of the notice of this meeting previously published in the Federal Register on March 1, 2001.

A transcript of the meeting is being kept. And the open portions of the transcript will be made available as stated in the Federal Register notice.

It is requested that the speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

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

I'd like to say that it's a pleasure to welcome Westinghouse back. We haven't seen you in a while. We've spent some time with your competitors in the last couple of years, but we're glad to have you here again and we look forward to your presentation.

MR. CORLETTI: Good afternoon. On behalf of Westinghouse, my name is Mike Corletti. Thanks for the warm welcome.

Today, we're going to be talking about the precertification review of the AP1000 and I'd like to start with the purpose of today's meeting and the agenda.

Today's meeting is going to be an

informational meeting. It's really the first time we've been able to present this to the ACRS and we wanted to concentrate on the thermal-hydraulic -- the two major issues that this Subcommittee would be most interested in. We're going to really outline what the objectives of the AP1000 precertification review are and review our proposed approach to resolution of the two key issues.

Those two key issues we'll talk a lot about later, but really they are whether our desire to use the AP600 test data in support of Design Certification for AP1000 and the applicability of the AP600 analysis codes.

Throughout the meeting we would be looking for feedback on our approach. I understand you've just received our deliverables probably last week, so we have no expectations that you have reviewed it completely and thoroughly.

CHAIRMAN WALLIS: We found all the mistakes.

(Laughter.)

MR. CORLETTI: If you found them all, that would be good, so we can correct them very quickly and resolve them.

But really, we'd like to get the feedback on our general approach to these two key issues and then talk about the expectations for our future meetings.

You see the agenda that's up there. We're going to have myself speaking about the objectives of the review and some of the plant description overview. We're going to have Terry Schultz talk about the AP1000 passive safety systems, the design that we've done in some of the analyses that are included in our plant description, an analysis report. That's the first report that we've sent in.

Then we're going to have Bill Brown talk about our approach to scaling. We've just recently last week sent in the PIRT and scaling assessment report and Bill is going to talk you through his approach to scaling and what the conclusions that we've drawn from that report. And then Jim Gresham is going to speak to our plan for the use of the approved AP600 analysis codes and how we would plan to apply those. He's going to be talking about a future report that we're still working on.

We went to the staff last year to talk about AP1000 and really introduce the staff to the AP1000 and what our major design objectives were. Really, we're taking the AP600 design that went through very extensive design and analysis and starting with that, but trying to increase the capacity of selected systems to increase the power output. To have a plant that would have an overnight capital cost in the range of $900 to $1000 per kilowatt.

CHAIRMAN WALLIS: Now isn't the AP1000 designed to compete in the U.S.? What was the AP600 for?

MR. CORLETTI: The AP600 was also designed to compete in the U.S. and at the time that it began which was in 1988, the target economic goals were something on the order of $1500 a kilowatt. AP600 meets those goals, meets the original design, the goals that were set forth.

What's happened since 12 years passed, I think the deregulated market has come upon us and basically AP1000 is in response to that.

CHAIRMAN WALLIS: So there wasn't some physical reason why it was smaller? There wasn't some sort of design constraint?

MR. CORLETTI: It was not a design constraint, but it really was a sampling of the industry and of the utilities and it was a size selected that they felt would be what they'd like to see.

CHAIRMAN WALLIS: It seemed sort of a strange economic decision where most others are thousands --anyway, we should move on.

MR. CORLETTI: So the realities of the AP600, we had invested quite a bit of money both in the design and licensing of AP600, some upwards of $400 million had been invested by Westinghouse and the industry as a whole.

We knew that going forward we would not be able to start with a clean sheet of paper, but we did want to -- but if we could design the AP600 with -- the AP1000 within the space constraints of AP600, we would be able to have a plant design that would meet the economic targets that were necessary.

When we say the space constraints, this is what we mean here. Basically, the AP600 and AP1000 side by side, the structural design, the --

CHAIRMAN WALLIS: Looks like one of those things you have in high school or something, to spot the differences.

MR. CORLETTI: There are a few.

CHAIRMAN WALLIS: There are a few --

MR. CORLETTI: That's true and the structure -- you can lay them on top and they'd be exactly the same.

You'll see some of the differences, the much larger steam generators that we have there. And that is -- besides that, it's probably tough to see.

But we also wanted to retain credibility of proven components. We don't want to redesign all the components that -- our design approach is being still using proven components to the extent possible. This gives us the advantage then that we can retain the cost basis of the AP600 which we have a very good handle on and by doing the changes, only those necessary to increase the power up of the plant --

CHAIRMAN WALLIS: You say proven components, you mean components previously accepted by the NRC? They haven't been built.

MR. CORLETTI: We're going to get to that, but like the steam generators are based on the ANO steam generators that we just --

CHAIRMAN WALLIS: Okay, some of them have been really proven.

MR. CORLETTI: Yes, that's right.

CHAIRMAN WALLIS: Thank you.

MR. CORLETTI: I think you're going to find that most all of them been actually.

But also we set out to retain the AP600

licensing basis. What did that mean? Well, AP600 met the regulatory requirements with large margins, large safety margins. We knew it would be unacceptable to come in with a plant design that did not meet those large safety margins.

Except all the policy issues that we fought so long and hard with you and us and the staff and we came to resolution, we basically want to accept all those policy issues for AP1000.

So when we went to the staff, we explained that based on our -- the available resources that we saw that we thought we could pursue a Design Certification under certain conditions and basically we had -- those conditions were such that the staff thought it was a good idea that we review those first and get an agreement on those first before both the staff and us invest a large amount of resources in the whole Design Certification effort, that while we're improving the efficiency process, and basically, we're trying to leverage AP600 Design Certification. The NRC, we just completed that review, not but two years ago it was at the time and we felt that staff had a good understanding of the design and why it was acceptable as did we and now is the best time to go forward with getting into some of these tough issues.

The issues that we are trying to -- we actually identified six issues. ACRS also provided their insights and guidance. I think the insights and guidance that you gave us are really not necessarily focused just on this Phase 2 review, but really for the Phase 2 and the Design Certification.

Two of the items that were identified, we did defer to Design Certification. We will do them at that time, that being what percentage of the SAR we could retain from the AP600 for AP1000 and also the issues with regards to the AP600 PRA. Those have totally been deferred to Design Cert.

The four issues that this phase will be dealing with, as I said, the sufficiency of the AP600 test program to meet the requirements of 10 CFR Part 52. We had a very extensive, I think most of you were familiar with the AP600 test program. We're going through a systematic review of that and in our report we've tried to show how we would plan -- how that test data, we believe is applicable to AP1000 and really what it means and I think that will be the subject of Bill's presentation.

The second item is the applicability of the NRC approved analysis codes, how we can use the approved codes for AP1000, what were the major issues that we had to resolve for AP600 and the way we resolved them, is that still applicable to the AP1000?

The two other issues are probably -- they're not the subject of today's meeting, but in the third one is how we would use design acceptance criteria in lieu of detail design engineering in some of the selected areas such as piping, structural and seismic. And the fourth issue was the applicability of the exemptions that were granted on AP600 and how we'd be able to use for AP1000.

Just to give you a status of the review, we submitted the Plant Description and Analysis Report. In that report it gives a comparable description of the AP1000 design features and compares them to AP600. We include a safety systems margins assessment which Terry is going to be talking about today. Really, it's the first principles comparison of the key passive safety features.

And then we did safety analysis assessment. We basically took the AP600 analysis codes and revised them all to reflect the AP1000 and ran those codes, really as a way to characterize the performance of the AP1000, not as the final Chapter 15 safety analysis, but just to give everyone an understanding of the phenomena that we would be --

that the AP1000 would exhibit compared to AP600.

CHAIRMAN WALLIS: Now when you made the design choices, I noticed that you retained nearly the same -- some things are the same, right, and some things are different.

Some things are scaled up a little bit and some of the pipes are bigger --

MR. CORLETTI: Right.

CHAIRMAN WALLIS: But the reasons given in this blue document here are very simple sort of reasons. It would seem you would have to actually run some codes to figure out if they're really the right choices.

MR. CORLETTI: And those codes are in the first report that we did. We ran -- and Terry will be speaking of those in the colored -- it's the book that accompanied that.

CHAIRMAN WALLIS: It was something like the -- I guess the accumulators are the same.

MR. CORLETTI: Right.

CHAIRMAN WALLIS: Those are some of the things that are the same.

And one would think that the optimum accumulator for a bigger reactor would be different.

MR. CORLETTI: Terry's going to specifically --

CHAIRMAN WALLIS: He's going to address that question?

MR. CORLETTI: That's right and I think that takes us really to the next part which is the Plant Description and Analysis Report.

MR. BOEHNERT: Mike, before you get off that last slide, when is the Analysis Report, the Code Applicability Report going to be available?

MR. CORLETTI: We're working on that and our schedule is to submit that in April.

Our approach is really -- you can't decide on the code -- where the contents of the Code Applicability Report until you really resolve the test data that you used to validate those codes is still appropriate for AP1000. That's been our approach and that's really the reason we've performed them in the order that we have.

The first slide is the comparison of some of the key selected parameters.

CHAIRMAN WALLIS: The thing that strikes one the most, to me anyway, is the heat rating has been upgraded considerably?

MR. CORLETTI: Yes, it has.

CHAIRMAN WALLIS: So you're going to have to convince someone that that's okay?

MR. CORLETTI: Right.

CHAIRMAN WALLIS: You're making quite a demand on cooling, both in normal operation and in --

MEMBER KRESS: That was accomplished by increasing the enrichment.

MR. CORLETTI: Yes. The focus of the -- I'll get into the basis for the fuel, but it's -- we haven't brought our fuel people with us today because it's really going to be part of the Design Certification and the review of the fuel design at that point. This meeting is really the test and analysis, but I can give you a little basis of the fuel design and I don't want to go too deep into it, if that would be okay.

The reactor power is 3400 megawatts compared to the 1933 of the AP600, so as you said, we've increased the number of fuel assemblies from 145 to 157.

MEMBER KRESS: See, that's a change of --

MR. CORLETTI: Twelve fuel assemblies.

MEMBER KRESS: That's a change of what, 74 percent in power?

MR. CORLETTI: Yes. We did it in two

ways, increasing the number of fuel assemblies and in lengthening the fuel rods.

Our three loop course, our three loop plants typically have 157 fuel assemblies. In fact, our 3XL which has the same fuel, 14-foot core, are operating Doel 4 Tihange 3 in Belgium, so really the fuel assembly design, the reactor vessel design is essentially the same as those units.

CHAIRMAN WALLIS: So you bring it into line with something that already exists?

MR. CORLETTI: Yes. And the core power density has been increased over those units. Those units are 3,000 megawatt units. We've increased the core power density to be the same as our operating three loop plants that have 12 foot fuel.

MEMBER KRESS: Does this give you any problem though of too much fluence on the reactor vessel?

MR. CORLETTI: No, it really doesn't. With the materials that are selected today, you can essentially radiate them --

MEMBER KRESS: You can almost get away by selecting materials?

MR. CORLETTI: Yes. With good materials, you really can almost show infinite irradiation and you can still meet the 60 year design life.

MEMBER KRESS: This is for 60 years?

MR. CORLETTI: Yes. This is 60 year design life.

CHAIRMAN WALLIS: Infinite irradiation?

MR. CORLETTI: Not exactly.

(Laughter.)

MR. CORLETTI: Very long and essentially--

CHAIRMAN WALLIS: The fluence did go up?

MR. CORLETTI: Absolutely.

MEMBER KRESS: But with the right materials you can stand it?

MR. CORLETTI: Right, that's right. The hot leg temperature, you'll notice, has increased from 600 to 615, but again, it's still well within the operating range of most of our plants.

MEMBER KRESS: Your RCS materials are all the same?

MR. CORLETTI: Yes. Again, the 17 by 17 fuel assemblies. The number of control rods has increased. We've got 8 control rods, really filled up the available space.

MEMBER KRESS: Now with the increased length of the fuel by two feet, does that mean you have to increase the length of the control rods also?

MR. CORLETTI: Yes sir.

MEMBER KRESS: By the same amount?

MR. CORLETTI: By the same amount and then it's really the same as what we have in the South Texas Unit also which is also 14 foot.

MEMBER KRESS: You already have experience?

MR. CORLETTI: Yes, we do, yes.

MEMBER KRESS: Okay.

MR. CORLETTI: Both in South Texas and in Doel and Tihange.

MEMBER KRESS: Okay.

CHAIRMAN WALLIS: Which are fairly old plants.

MR. CORLETTI: They've been around. Yeah. I don't thing -- South Texas is one of our newer old plants.

(Laughter.)

CHAIRMAN WALLIS: But the Belgium plant --

MR. CORLETTI: I think they're the same vintage as the South Texas plants.

The reactor vessel did not change and basically it's the same -- the AP600 we started with a larger vessel to begin with. We started with our three loop configuration vessels.

The steam generator, you'll see a big change in the surface area there. We have some slides to show you the relative size of the two.

MEMBER KRESS: Did you put in more tubes or longer tubes?

MR. CORLETTI: More tubes and we wanted to have a low pressure drop steam generator so that we could minimize the impact on the reactor coolant pump, so we have many tubes.

It's similar, I guess, it's not -- the last -- what happened when we started AP600, Delta 75 was our replacement generators for our Model Fs. So that was the generator we picked when we began AP600.

Since that time we've been supplying replacement steam generators and at the time we started AP1000, we were just finishing the design and we were actually finishing the construction of the ANO replacement steam generators which are about the same megawatt rating as this unit.

Now subsequent to that we have merged with Combustion Engineering and they have even more experience with large steam generators like this. We really have had a collaborative effort on the Delta 125. They've been working, the two design teams have worked together to get the design of this --

MEMBER SHACK: Do you use egg crates?

MR. CORLETTI: No.

(Laughter.)

The reactor coolant pump is another that I'll talk some more about. Reactor coolant pump flow rate was increased to accommodate the higher core power, the inertia is increased to accommodate longer flow coast down to meet the DNB requirements.

MEMBER KRESS: You just make them bigger with a bigger motor on them?

MR. CORLETTI: Well, you'll see it is a higher capacity. It is a bigger motor. Didn't get that much bigger. The hydraulics are different and I'll show you a little sketch of that.

CHAIRMAN WALLIS: It's interesting you have a table of these parameters, whereas the other parameters that are really the key, the passive like the CMTs and all of that, you really ought to compare those. I don't see a table of that comparison.

MR. CORLETTI: That will be in Terry's on the passive -- I was just trying to set the stage for the main reactor coolant system.

CHAIRMAN WALLIS: The message I get from this is that you've been there before with other reactors and there's nothing unique about AP1000.

MR. CORLETTI: I can move on then.

(Laughter.)

MEMBER KRESS: With the exception of that last one on there --

MR. CORLETTI: Which one is that, sir?

MEMBER KRESS: Containment height.

MR. CORLETTI: Containment height. We have increased the containment height. I don't believe it's taller than the AP600, but I don't believe it's taller than -- I don't have a good comparison with operating plants.

MEMBER KRESS: I mind the aspect ratio, it seems like it's unusual compared to containments I'm used to, the lift diameter.

CHAIRMAN WALLIS: It's nowhere near in proportion to the power, is it? It's gone up a little bit, 10 percent.

MR. CORLETTI: We've done a couple of things. We've increased the design pressure. We've made the wall thicker. And we've increased the height.

CHAIRMAN WALLIS: But the height is 10 percent, the volume is 10 percent bigger and the diameter is the same.

MR. CORLETTI: I think it's about 20

percent actually. I have -- Terry has a slide that gives the percentage of change.

It's 12 percent.

(Pause.)

MEMBER KRESS: So you got about that much more surface area to take out 74 percent more heat?

MR. CORLETTI: The mass and energy aren't -- yeah, I think Terry has -- Terry is going to get there, yeah.

MEMBER SHACK: You really kicked up the design pressures.

MR. CORLETTI: We increased the design pressures.

MEMBER KRESS: Which makes a substantial difference in terms of heat transfer.

MR. CORLETTI: Again, I think we've covered most of this. When we did this upright, we basically started with a proven fuel design, again fuel core that we've had experienced with before. Core power density has been increased.

We then went about -- the reactor vessel was similar to Doel 4 and Tihange 3. Basically, we fixed the elevation of the hot leg and cold leg pipings and we let the bottom of the vessel drop to accommodate the longer fuel.

I think the steam generator, we talked about that. Reactor coolant pump, I have a slide on that.

Again, you'll see, this is a comparison. We've added three fuel assemblies on the periphery. That's the main difference. Again, that looks -- that is basically the same as our three loop operating plants.

This shows a comparison of the overall length and as you were saying not only does the vessel get longer, but the integrated head package, to be able to pull the control rods out gets longer also.

And this shows the relative dimensions of the steam generator.

One of the items -- I know the steam generator is a lot bigger, the mass energy is larger, but the flow restricter is the same diameter, so really the rate of the discharge from a steam line break, for instance, is the same.

The reactor coolant pump, AP600 was based on a proven motor design at the time that we began. But due to the higher power density of AP1000 we required really a longer flow coastdown, which means we had to increase the inertia. We also had to increase the pump head and flow to get sufficient flow through the core, to accommodate the core power.

MEMBER SHACK: People used depleted uranium before for that?

MR. CORLETTI: As part of AP600, we did for the AP600 pump. And we ran a test, we built one of the flywheels to demonstrate that we could. I'm not sure, no one uses them -- the Navy doesn't use them in these kind of pumps and we typically use shaft steel pumps, so that was a new feature of AP600.

CHAIRMAN WALLIS: Just to make sure, if it flies apart, it's unstoppable?

MR. CORLETTI: Right, that was part of -- that was a lot of what the review on AP600 was, was the flywheel integrity.

One of the things we did to minimize the impact on the pump motor size is we have added a variable speed controller that allows the pump to operate at low speed during cold conditions in the reactor coolant. So as you're heating up the reactor coolant system, they typically heat up the loops on pump heat, until the system has come up to operating temperature, then we basically disengage the variable controller and it's really locked out. So it's really only operating at shutdown condition.

Another difference is the hydraulics.

It's really -- hydraulics, different hydraulics. It's one that we've designed and actually built for the Saruga plant that we're working on. We built a test model.

Here, you see some of the operating conditions. The pump flow, the head has been increased and the inertia has been increased from 5,000 to roughly 15,000.

MEMBER KRESS: Your test model, is it a full-size prototype?

MR. CORLETTI: Of the hydraulics, yes.

MEMBER KRESS: Of the hydraulics.

MR. CORLETTI: And you see, we've increased the motor rating. It still is significantly --

CHAIRMAN WALLIS: The megawatts is 6000?

MR. CORLETTI: 6000 horsepower. Our AP600 pumps were roughly 6 megawatts for the four of them.

CHAIRMAN WALLIS: So this is maybe 11 or 12 or something?

MR. CORLETTI: Yeah, that's right, 12 megawatts.

CHAIRMAN WALLIS: Energy efficiency.

MR. CORLETTI: Yes. The thing with these hydraulics are slightly more efficient than the AP600, but yes.

As you see, the interesting thing, the overall size is not increased that much which is important to us because we had to make sure we could take the pump out for pump replacement which was one of the key limiting design criterias that we placed on EMD, our pump designers as we have been doing this is make sure you can replace, pull the pump out.

CHAIRMAN WALLIS: Presumably things are a big tighter, things are bigger in the same containment and it's tighter.

MR. CORLETTI: Yes, it is. Things are tighter.

We did in the Safety Analysis Report, we performed a loss of flow analysis. The same way we did AP600 really.

MEMBER KRESS: Is that a pump coastdown?

MR. CORLETTI: Basically, you lose all four pumps simultaneously.

MEMBER KRESS: Yes, but they coast down?

MR. CORLETTI: And they coast down, that's right.

And the next slide here really shows the analysis results for that. And you'll see with the higher efficiency AP1000, at the time of minimum DNB, it's a significantly higher flow than we had for AP600. You need that to meet the DNB requirements for the higher power core.

This is presented in the first report, the Plant Description and Analysis Report.

My final slide is one that really just shows the increase in the pressurizer. Again, we did not increase the diameter. We did increase the volume by raising the height, so it can fit in the same pressurizer compartment. We didn't want to change the structures around the pressurizer. It's larger to accommodate pressure transients associated with the higher power.

CHAIRMAN WALLIS: What's the major criterion for pressurizer design?

MR. CORLETTI: It's really for loss of load, you want to prevent --

CHAIRMAN WALLIS: In-surges?

MR. CORLETTI: Yeah, in-surges and minimize pressure -- basically, you want to limit design -- the pressure to 110 percent of design pressure -- and you don't want to over-pressure above 110 percent of design pressure. So it works in combination with the safety valves to really accept the pressure transients. There's many different ones, but that tends to be the limiting one.

With that I'm going to move to the passive safety systems and Terry is going to talk about that.

MEMBER KRESS: Now that volume is changed. It's not the same ratio as --

MR. CORLETTI: No, but basically you look at the in-surge and really the pressure outside. It's dependent not only on the power, but really on the overall reactor coolant system volume and the changes in temperature.

MEMBER KRESS: You didn't change it.

MR. CORLETTI: That's exactly right. We didn't change that 70 percent.

CHAIRMAN WALLIS: So it's just thermal expansion of the water?

MR. CORLETTI: That is -- yes. So basically you would have a -- the real sizing they do a trip without inserting the rods and you have the expansion of the water and you see whether prevent filling it up.

MEMBER KRESS: To anticipate a transient without a scram is --

CHAIRMAN WALLIS: Just like losing a fan belt on a car.

MR. CORLETTI: That's how we do our design calculations, yes. Okay. Thank you very much.

CHAIRMAN WALLIS: We are ahead of time, aren't we?

MEMBER KRESS: We'll be challenged on that later.

(Pause.)

MR. SCHULZ: Thanks, Mike. As Mike said, there are several items that I am going to try to talk about here related to the passive safety systems design for AP1000.

I would like to talk about the design changes that we've made and try to give you some insights and understanding as to how we went about it and how we arrived at the sort of curious some things are bigger, some things aren't.

MEMBER KRESS: What's an Advisory Engineer?

CHAIRMAN WALLIS: A smart one.

(Laughter.)

MR. SCHULZ: It's an official category of engineering at Westinghouse.

MEMBER KRESS: It's one of their official categories.

CHAIRMAN WALLIS: It's like an Advisory Committee.

(Laughter.)

MR. SCHULZ: I wouldn't --

MEMBER SHACK: He's eligible to become a first principal.

MEMBER KRESS: Where I went to school we never had a category called Advisory Engineer.

MR. SCHULZ: The second thing that I'm going to talk about is a margins assessment that we've done. These are very simple --

CHAIRMAN WALLIS: I was very struck by the simplicity. They're extraordinary simple. I would think a thing as expensive as this and as important as this would be something a little more sophisticated. I mean it seems to be very, very crude --

MEMBER KRESS: Actually, I was quite pleased with that approach myself.

CHAIRMAN WALLIS: You liked that. It's very good for a start.

MEMBER KRESS: What's why --

MEMBER SHACK: That's what the designer really did and then he went off and did the analysis after he had it.

MEMBER KRESS: Yes.

CHAIRMAN WALLIS: I would have thought you'd optimize it or something -- computer codes and say is this really the best we can do?

MR. SCHULZ: It is an iterative process. We already in this short time that we've been working on AP1000, we've gone around several times on should we make the accumulators bigger or not? What happens if we run them faster? What happens if we try to make them bigger? What are the costs of making them bigger in terms of the plant impact? We've been doing that. What you see here is more of the end result of the iterations we've made.

There is a role. The margins assessment is -- a lot of this comes out of the design process. What you see in the report is more of an end assessment of where we ended up.

In addition, as Mike mentioned, as I already showed you some, we've used the AP600 SSAR safety analysis codes and we've made some analysis on AP1000 for the purpose of assessing where we think we are in terms of the design changes and do we think the design is adequate.

MEMBER KRESS: Now if Hal Lewis were here, he would point out to you that principals run schools.

MR. SCHULZ: Yes.

MEMBER KRESS: But I'll refrain from doing that.

(Laughter.)

MR. SCHULZ: Thank you. Mike has already talked about the design approach on the plant level and of course it's very important for us in terms of the economic viability of what we end up with and the resources it takes to get there that we minimize the changes to the plant. But at the same time we need to make the plant safe and have adequate margins and in doing that margin thinking, we've been looking at both deterministic, which I'm going to talk about mainly today and also the probabilistic area.

Now when I'm talking about probabilistic-wise is more the T & H success criteria, how many ADS valves do we need to prevent core melt kind of thing. And we have done some looking at that already in our process in trying to check whether the systems are adequately sized for AP1000.

And also keeping in mind as we did in AP600, where there is uncertainty in testing and analysis, we're providing margin in the systems design.

CHAIRMAN WALLIS: Your hand calculations struck me as being sort of independent. You assessed each part independently, but as I remember an analysis of AP600's behavior, it's the interaction between these systems which is pretty key in an accident and the balance between them as hydrostatic heads and Novak Zuber's bathtubs and things and you cannot really look at one by itself and say well, just look at how that performs because it affects the whole transient which changes when the next one comes on and how they interact and all that.

I think you'd have to run computer programs quite a bit in order to iterate to a good design. I was very surprised that the hand calculations seemed to work out or they did work out. That was your real basis --

MR. SCHULZ: I think we are not making these hand calculations in a vacuum. We have done a lot of analysis on AP600, a lot of testing and from that we've gained insights into what are the limiting points in a transient? What are the limiting events?

And then with that understanding we say okay, if we take a snapshot in time when the RWST is just starting to inject, this is the delta P we have and if we take that same delta P which is an assumption, a critical one, and apply it to AP1000, how much more flow do we get and does that seem to make sense? So yes, it is very much separate effect on a system, but we're using our experience and judgments on what we learned on AP600 analysis and testing to try to focus in on what we think will be the limiting situation for AP1000.

Now it's not enough to just do that. That's why we've already exercised a computer code as a good check on the integrated effects.

MEMBER KRESS: Are you going to give us details on the sub-bullets, the deterministic criteria and this PRA success criteria later?

MR. SCHULZ: As I go through each feature, I will mention what we've looked at. I won't really be presenting any analysis. We have done some map analysis which is what -- what we would do to at least initially assess what the success criteria is. In fact, I don't think we've reported any in that report that we gave you that we did mention that we had done that. I will mention a couple of features where that -- where we did some work in that area.

So if I don't say enough about that, I'm sure you'll remind me.

So what I intend to do now is go through feature by feature and talk about what's different, what's the same and then go through the margins assessment and some safety analysis for each.

So in the passive RHR, the configuration is identical in terms of where it connects to the RCS, where the heat exchange is located, where the water returns to the steam generator, the valving arrangement is all identical. The elevation of the heat exchanger is the same.

The changes that we made were increase the pipe through the system from 10 inch to 14 inch, so we made a significant increase in the pipe size. Now originally, when we started AP1000, that's all we did. We left the heat exchanger alone.

But then through some of our iteration process, into a computer analysis, that wasn't enough, so then we looked at making the heat exchanger a little bit bigger. And so the other change that we made to the design is to increase the surface area of the heat exchanger about 20 percent.

When we did that by adding a few tubes, it turned out on AP600 on the tube sheet there were about 9 tubes on the top and bottom rows that were left out. We left them out because we just didn't need that surface area.

So on AP1000 we said well, that's an easy way of getting a little bit more surface area, so we filled in the tube sheet on the top and bottom rows and we also extended horizontal portion of the heat exchanger 3 feet. Of course, on the top and the bottom. And the total effect of that was to give us about 22 more percent more surface area.

CHAIRMAN WALLIS: Now are the flow patterns in this heat exchanger are important, I mean the stratification and that sort of stuff in the pool and everything, does that make a difference to the performance?

MR. SCHULZ: One of the things that we got out of the testing that we've done in both the passive RHR, especially the passive RHR testing, we investigated and tried to quantify the mixing in the tank and what we learned from that is the tank does mix well horizontally. The heat exchanger is kind of like a pump and it pumps water and keeps the tank relatively uniform.

The tank is not getting bigger, but we are adding a little bit more water on top by adding, putting in some more accurate low instrumentations, so we're gaining a foot or so of water level in the tank, but the tank is not getting significantly larger. So it will heat up a little faster and it will start boiling a little sooner, but that doesn't seem to be--

CHAIRMAN WALLIS: That's a well-mixed tank in both cases?

MR. SCHULZ: Yes, it's a well-mixed tank. So early on when you're trying -- worried about mitigating the design transient or loss of flow of feedline break, the tank is going to be subcooled. Bulk-wise anyways.

MEMBER KRESS: This tank is half moon shaped?

MR. SCHULZ: Yes.

MEMBER KRESS: The heat exchanger is on the flat side?

MR. SCHULZ: It's on one end. I don't know that I have a slide.

(Pause.)

I've got one that shows --

MR. CORLETTI: Page 42 of the slides.

MEMBER KRESS: I see where it is.

MR. SCHULZ: This is the tank here.

CHAIRMAN WALLIS: Where is the tank though?

MEMBER KRESS: It's that solid line.

MR. SCHULZ: This is actually the operating deck so you can't really see the tank, but it's under this part here. The heat exchanger is actually under this hatch.

CHAIRMAN WALLIS: That sets up currents

which mix the whole tank?

MR. SCHULZ: Mix the whole tank, yes.

MEMBER KRESS: That's why I was --

CHAIRMAN WALLIS: That doesn't change --

SPECIAL AGENT WHITE: That's the reason I was asking. Over there in the corner. You ran a test on a model of this with 3 or 4 tubes?

MR. SCHULZ: Yes, yes. And those tubes were baffled off from the rest of the tank to try to give us a way of assessing the mixing.

This is the corner -- this is where the pressurizer is, so it comes up through here and the tank wraps around.

CHAIRMAN WALLIS: Do you get boiling from these tubes to empower the transient?

MR. SCHULZ: As the transient goes on, you do. Early on, you get essentially no boiling.

CHAIRMAN WALLIS: And it's the same kind of scenario, I mean the boiling progresses and is there anything different about the two power levels in terms of boiling?

MR. SCHULZ: We don't think so in the short term. In the longer term, the AP1000 tank will heat up quicker, but in both cases, we're talking about more than an hour before you start boiling in the tank, before the tank really reaches saturation. We'll get some local boiling a little before that, but until you get really vigorous boiling around the heat exchanger will be well beyond an hour.

MEMBER KRESS: Now how did you know this tank was pretty well mixed? Is this a calculation that you did?

MR. SCHULZ: Well, it's based on this testing, primarily.

MEMBER KRESS: Based on that testing?

MR. SCHULZ: Yes. We took temperature measures around the tank and could see that -- I mean the top of the tank heats up a little faster than the bottom of the tank, but there is this, around this heat exchanger there's a strong circulating current driven by the heat that you're putting in there, so it keeps putting the colder water from the bottom of the tank.

CHAIRMAN WALLIS: Is steam being involved eventually?

MR. SCHULZ: Eventually, yes.

CHAIRMAN WALLIS: Presumably, there's more steam being involved in an AP1000?

MR. SCHULZ: Be more and it would happen a little sooner, yes. And that gets vented to the containment when that starts occurring the passive containment cooling comes into play.

CHAIRMAN WALLIS: How is this formed? Is there sort of a great evolution of steam and level swell in this corner of this tank and --

MR. SCHULZ: Yes. I think that fluid to the heat exchanger --

CHAIRMAN WALLIS: Will be some kind of bubbling and frothing and swelling.

MR. BROWN: Dr. Wallis, Bill Brown here. We noticed that's really more -- the real level swell we saw in the test was really more associated when the automatic pressurization system goes off. So if you're thinking about swelling and things in the tank the real challenge to that is when the ADS 123 discharges in here. This is more of a bulk boiling situation. So level swell is really associated with the ADS.

CHAIRMAN WALLIS: Now this pipe goes into the bottom of the steam generator, it's a different steam generator?

MR. SCHULZ: Yes.

CHAIRMAN WALLIS: I think there's something about mixing in the bottom of the steam generator which they used a stratification in the cold leg or didn't we go through that with APU 600?

Didn't we worry at one stage about mixing it in the -- where your pipe comes out of the steam generator?

MR. SCHULZ: I believe there was some notice of that, especially in OSU. When the heat exchanger starts working, there's still steam being released from the steam generator which means that there's still a flow going through that, through the loop, through the tubes of the steam generator and it's not just flow through the passive RHR circuit.

As long as that continues and it will continue for some time, depending on the particular transient, it may be half an hour or it may be an hour before the steaming is terminated in that steam generator and passive RHR has -- its capacity matches the decay heat. Now after that point in time there will tend to be more of a stratification in the loop than before them when there is still circulation flow through the steam generator.

CHAIRMAN WALLIS: Is this the same as in 600 or do you run into some new phenomenon of stratification that's different.

MR. SCHULZ: I don't think it's the same phenomenon. Things may occur in a little bit different timings and because the flow through the passive RHR is a little bit greater. The temperatures are not lower coming out of the heat exchanger or are not significantly different, so and the flow is a little bit greater because of the bigger pipes through the system.

But I think the phenomenon is the same that there would be colder water running around the bottom of the pipe, primarily after you get to the point where you match decay heat.

The margins assessment again as we mentioned to start with, I had mentioned to start with tends to be a simple first principles calculation. In this case, we tried to calculate the natural circulation heat removal from the heat exchanger.

Now this is not quite as simple as some of the other calculations so actually you're exercising the same correlations, heat transfer correlations that we use in our safety analysis codes that in a stand alone spreadsheet type of program which gives fairly close agreement with the safety analysis code.

So by putting some boundary conditions in terms of the RCS temperature and the temperatures we picked were based on the steam generator safety valve setpoints which are a little bit higher in AP1000 than

AP600. In exercising that code, we end up calculating did we get about 170 so percent more decay heat removal which is not quite equal to the increase in power, but very close to it. So that's a comforting factor.

Another thing that we checked in this is--

CHAIRMAN WALLIS: In thinking about this, isn't the limiting heat transfer resistance until you get boiling, it's only RWST side, it's a natural convection in the RWST which is much less effective than this stuff that's whipping around your 14-inch pipe and going around.

MR. SCHULZ: Yes.

CHAIRMAN WALLIS: So that's the limit and that isn't going to be increased much by increasing the velocity or decreasing the flow path resistance.

MR. SCHULZ: In terms of heat transfer coefficients, yes, but by having more surface area and --

CHAIRMAN WALLIS: There isn't 72 percent more --

MR. SCHULZ: No, there isn't. There's 22 percent more surface area, but by reducing the resistance on the primary side, we can allow more water to flow with a given density difference and you can go through that using the same correlations which are more limiting on the tank side, but you still can't improve that heat transfer by reducing the resistance on the primary site. Not so much from a heat transfer effectiveness point of view, but by giving a certain density difference, you can get more flow to circulate and of course, there is interaction there between how much flow is circulating and what the delta T is on the heat exchanger.

CHAIRMAN WALLIS: So you've increased your heat flux by 30 percent, I see.

MR. SCHULZ: Yes. But we think we're still comfortable versus critical heat flux in the heat exchanger.

The other thing that is an important consideration here is as I mentioned when you first turn the heat exchanger on it can't match decay heat.

CHAIRMAN WALLIS: I don't know why you worry about heat flux anyway because it's going to get cooled somewhere else eventually. It's not that critical, is it if you get critical heat flux? It's not as if it's called a heat source which kind of -- any type of heat aspersion --

MR. SCHULZ: Right, it's not critical from that point of view, no, no.

MEMBER KRESS: That's why the design basis?

MR. SCHULZ: It's just that if you got less heat transfer than you thought you were getting from a portion of the heat exchanger, the overall heat transfer of the heat exchanger might be a little less than you thought, but what tends to happen if you ever got into critical heat fluxes the hot part of the tubes gets a little less heat temperature reduction and the heat moves on to the heat exchanger and these tubes are relatively long so eventually you get most of that heat out, but it would affect the overall heat transfer somewhat, so it's something that we look at and try to keep in mind in the design.

The other factor is how much of the steam generator secondary side water you boil off in an event and these percentages are a little confusing, but basically if you look at the amount of water in a steam generator per megawatt of core power. The AP1000 has 36 percent more mass at the time of trip than AP600 does per megawatt.

And that when I say final water this is when you would calculate that you terminate steaming with the passive RHR. So you've decreased the water level some, but in AP1000 basically you end up with twice as much water in the steam generator at the end of a transient than AP600.

CHAIRMAN WALLIS: Does this make up for some of your other capacities not being increased in your accumulators at the same CMTs aren't that much bigger, but you have steam generators with a lot more water in them.

MR. SCHULZ: It doesn't help accumulators of core make up tanks very much. It helps the passive RHR a little bit. Initially, we had a passive RHR that was maybe 25, 30 percent more capacity than the AP600 and this story on secondary site mass was more important than it is now because we've almost got parity with power in passive RHR. So this is not so important as it was once when we were playing around with smaller passive RHRs.

CHAIRMAN WALLIS: I guess it's only energy balance you care about in this phase?

MR. SCHULZ: Yes.

CHAIRMAN WALLIS: It's not mass --

MR. SCHULZ: In fact, this -- we've toyed with, is it good to have more, is it good to have less? When you get to the containment, having more mass here challenges the containment mass energy input, so it's not so good from that point of view, but it is better from say a transient mitigation point of view.

So that's the margin story. We've also done some safety analysis, transients again to assess the AP1000 and the selection of the passive RHR heat exchanger changes. Same methods as we used on AP600, conservative inputs and models. We selected several limiting transients. We've looked at all four of these events for AP1000.

Due to time limitations we chose to show you what the loss, feedline rupture looks like and the curves are a little confusing here, but basically the criteria is subcooling and maintaining subcooling and if you look at this dotted line versus the solid line, the dotted line is saturation temperature and the solid line is the hot leg temperature, so you see the hot leg temperature is dropping down to a comfortable level below the saturation temperature.

In both cases, the transients look a little different. AP1000 doesn't cool down quite as much, as fast. So in both cases there's a comfortable margin. If you actually look at one of these transients for an operating plant, you would see the subcooling become much less in time, it tends to drop down, but then come back up and the margin is a lot less. So AP600 and AP1000 both have a lot higher subcooling margins than most operating plants.

And so our conclusions from that is that from our assessment of these computer calculations is that the AP1000 has comparable behavior and margins to AP600 and so we're -- we feel comfortable with the sizing of the passive RHR.

CHAIRMAN WALLIS: Margin, what do you mean, your measure of margin?

MR. SCHULZ: In this case, like subcooling.

CHAIRMAN WALLIS: Like subcooling. Yeah. It's not a direct measure of some sort of safety margin. It's an indirect measure -- it's better to have more subcooling therefore as an indication. But it's not a very quantitative measure.

MR. SCHULZ: You can go through this transient side about so many degrees minimum.

CHAIRMAN WALLIS: Yeah, but I'm not quite sure what that means in terms of --

MR. SCHULZ: Real safety?

CHAIRMAN WALLIS: More definite measure of safety.

MR. SCHULZ: The acceptance criteria for feedline break is keeping the reactor subcooled. Now does something real bad happens when it becomes saturated? Not necessarily.

So it's more of a licensing criteria than a safety criteria.

I'd like to now move on to the passive safety injection. And again, the configuration of the AP1000 in terms of numbers of tanks, the valving arrangement is identical with the AP600. The accumulators are the same size and we'll be talking about each of these features in a few minutes. The core makeup tank is 25 percent bigger and we increased the orifice that controls the CMT flow so that's flow rate is also 25 percent bigger. We've increased the pipe sizes from the IWST to the direct vessel injection line. We've also increased the recirculation piping and we've also increased the stage 4 ADS piping and valving. The other piping has not been changed.

CHAIRMAN WALLIS: On the ADS 1, 2 and 3 are still the same?

MR. SCHULZ: Exactly the same.

CHAIRMAN WALLIS: Which I found a little surprising, but maybe there's a good reason for it.

MR. SCHULZ: There is a reason. We think so.

CHAIRMAN WALLIS: You have less mass of water per megawatt?

MR. SCHULZ: Yes.

CHAIRMAN WALLIS: But your hand calculations emphasize flow rate. You have bigger pipes and all that, so you try and duplicate the flow rate, but there's less mass. So in terms of a mass balance you might think there's a less margin, less water to cool to use the RWST?

MR. SCHULZ: You could say that. We think that when you look at a bit more mechanistic in terms of specific situations that we have sufficient margin and I think if we try to go through in our discussion here, you can see what you think.

CHAIRMAN WALLIS: Okay.

MR. SCHULZ: In some cases yes.

MEMBER SHACK: You have adequate margin, but by and large, it does it smaller, for things like peak clad temperature.

MR. SCHULZ: For large LOCA yes. That's not necessarily true, we don't think it's true for like long-term cooling. We think we're at the same or better margin because we've increased things much more than we did in other areas. In other words, we were rather selective in where we increased things and how much.

CHAIRMAN WALLIS: But you haven't decided that you want to stay with the same PCT as AP600, for instance. You're going to get closer to the requirement, the regulatory limit.

MR. SCHULZ: That's right. Again --

CHAIRMAN WALLIS: So you're going to see how far the staff will let you go in terms of raising PCT.

MR. SCHULZ: I wouldn't put it that way. We're not playing a --

MEMBER SHACK: There's a known regulatory limit.

MR. SCHULZ: That's right.

CHAIRMAN WALLIS: Yeah, but presumably somebody came in here several years ago and said 1644 was great, now you're going to tell us 1940 is great.

MR. SCHULZ: When we originally selected the accumulator sizes for AP600, we had no idea what the PCT was going to be.

CHAIRMAN WALLIS: It seems very strange to me. I think it worked backwards. So you have a design criteria and worked back to whether cumulative size needs to be to meet it.

MR. SCHULZ: I'm sorry?

CHAIRMAN WALLIS: You seem to have picked an accumulator and then see what you get the PCT and then said that's okay. I think it worked backwards. You designed the accumulator to achieve or the PCT you wanted.

MR. SCHULZ: In this case, we realize what we're starting from a design, the AP600 equipment and we're saying how big does it need to be to provide adequate margin for AP1000. So it's a little bit different than starting with a clean sheet of paper.

CHAIRMAN WALLIS: But the adequate margin apparently is a higher PCT?

MR. SCHULZ: In this case, yes.

CHAIRMAN WALLIS: Why is that so? Why is it now acceptable to have a higher PCT than before?

MR. SCHULZ: It always was acceptable. We didn't design to a particular PCT.

CHAIRMAN WALLIS: But some designers decided 1940 is now okay as opposed to 1644. These are much more important numbers than choosing the accumulator as the same as before or something. If you had twice as big an accumulator, maybe you could bring that down to 1644, I don't know.

Someone has decided that these are okay numbers?

MR. SCHULZ: Basically, all the operating plants in the United States have temperatures that are this --

CHAIRMAN WALLIS: So you decided to be a little less conservative than you are with 600?

MR. SCHULZ: That's right.

MEMBER KRESS: If that number had been 2100 would you have felt "iffy" about it?

MR. SCHULZ: Yes, I would have felt iffy. If we had gotten to the point where these numbers were higher than most operating plants and were getting close to the limit --

MEMBER KRESS: How do you know how close that is to 2100?

MR. SCHULZ: 2200.

MEMBER KRESS: Well, I said 21 because I didn't want to get all the way up to 22.

MR. SCHULZ: Okay.

MEMBER KRESS: Because I was seeing the uncertainty on the number.

CHAIRMAN WALLIS: It's with uncertainty.

MR. SCHULZ: With uncertainty.

MEMBER KRESS: That's with uncertainty?

MR. SCHULZ: With uncertainty. We're down at 1670 without, approximately.

MEMBER KRESS: What's that, two sigma of n?

MR. SCHULZ: This is the -- I don't know what -- maybe Bob Kemper can help me out, but these are the uncertainties that were calculated basically for AP600 for both co-retract and the PCT uncertainty. So the plant parameters and the models both are accounted for in here.

MR. KEMPER: Bob Kemper here. What Terry is showing as the reflood PCT with uncertainty would be our assessment of the 95th percentile value as obtained with our large break LOCA EE methodology. And that's the assessment we have at this time for this.

MEMBER KRESS: So 99 percentile might have been about 2200? Why is 95 percentile acceptable is my question?

MR. KEMPER: That is the basis for the large break LOCA methodology with best --

MEMBER KRESS: Using best estimate.

MR. KEMPER: COBRA track best estimate.

MEMBER KRESS: So this was a best estimate calculation rather than Appendix K?

MR. KEMPER: The AP600 was done with the approved methodology for large break LOCA.

MEMBER KRESS: Which was Appendix K?

MR. KEMPER: No. It uses the uncertainty determination and that would be essentially best estimate decay heat and then the decay heat uncertainty is rolled in with the other uncertainties in CSAU type methodology to obtain the result.

MEMBER KRESS: Okay. That's very helpful.

CHAIRMAN WALLIS: So it looks as if somebody said let's go with the same accumulator and see what we get for PCT?

MR. SCHULZ: Yes, and there are several considerations here. One, we actually studied taking the same accumulator and readjusting the flow orifice to get more flow. And by doing that we can reduce the large break LOCA PCT.

However, there are other events that the accumulator plays a role in, small break LOCAs and in particular small LOCAs that are involved in multiple failure PRA-type events where say the accumulator -- not accumulator, the core makeup tanks have been failed due to some common mode failure that would be considered in the PRA. And having accumulators empty quicker in those kind of events is not good, so it's not safer.

So we in the balance between those two

events, the large break LOCA which is a very low probability event and in fact some day maybe eliminated from consideration, we felt that the safety was better balanced by maintaining the small break LOCA-type performance where the accumulator runs a little bit longer.

Now we also could have made the accumulator bigger. However, it's buried in concrete, basically, surrounded by concrete. It's already a sphere, so we've maximized the volume in the space available. So it would have been rather disruptive to the plant design and structures to make the accumulator bigger.

CHAIRMAN WALLIS: So now you've got a sensible argument. It seems from a spherical perspective, it's not a very expensive thing comparatively speaking. The obvious thing would be to make the accumulator bigger, but if they've got some good reason for space constraints, then that makes some sense, but in terms of thermal-hydraulics, it seems to be very arbitrary to say well, choose the same size.

MR. SCHULZ: Yes, yes.

CHAIRMAN WALLIS: So there is some reason for it.

MR. SCHULZ: The tank itself is not that expensive, so we have had space to make it easily bigger, that would have been a different story.

In the core makeup tanks, we actually did choose to make the tank bigger. This tank does have constraints vertically. It's located on a concrete floor so we can't go down very easily. The operating deck is fairly close to above the tank so we can't really make it bigger. We did choose to make it a little fatter, 25 percent increase in volume.

This is a very expensive tank. It's a full system design pressure, Class I vessels. It's a very expensive tank, so it's something that we have to keep in mind. Now the cost of the tank is not so significant relative to the cost of the plant. I want to imply that, but it is an expensive tank.

Why 25 percent? That's kind of a curious number. Let me try to explain what we did.

MEMBER KRESS: You knew we would ask that, didn't you?

MR. SCHULZ: Yes. We asked ourselves too. In our looking at the range of accidents that the core makeup tank deals with, we think one of the more limiting events is a direct vessel injection line break which eliminates one of the tanks, in fact, half of the injection system.

And at the point in time where the accumulator is empty which of course happens first in a transient, the accumulators start running and when they run fast as the plant depressurization occurs, the core makeup tanks don't inject because of the way the systems interact, the tanks interact and when the accumulator empties then the core makeup tank is basically relied upon to maintain core cooling. That occurs in about 10 minutes after the accident.

Now if you look at that period of time and take decay heat and some instrument of sensible heat coming out of the fuel in the reactor vessel, you can estimate a heat that you should be removing and back calculate a safety injection flow.

Now it turns out that when you do that AP600 had a significant margin relative to that flow requirement, basically 38 percent margin.

MEMBER KRESS: And you want to remove that amount of heat over some time period? There's a window in there, I seem to remember --

MR. SCHULZ: I'm looking at an instant in time.

SPECIAL AGENT WHITE: You were looking at an instant in time.

MR. SCHULZ: I'm looking at an instant.

MEMBER KRESS: But you want to continue that removal, have enough water to continue that removal --

CHAIRMAN WALLIS: That is why the flow capability and the volume are up by 25 percent?

MR. SCHULZ: Right. There's two questions here. I'm addressing right now the flow rate question and then I should speak separately about the volume and duration question because we actually separately looked at those two.

In thinking about the flow rate question, it turns out that if you take the AP600 core makeup tank, it would just about match the AP1000 calculated requirement, but it would have very little margin to it. And we were uncomfortable with that. So that's part of where the 25 percent increase in flow rate comes from.

The other place where that comes from is looking at some multiple failure scenarios where we don't have any accumulators and in that case having some more flow rate out of the core makeup tanks is also beneficial.

CHAIRMAN WALLIS: Now these numbers, this requirement per flow is based on an energy balance, do you know the core, the decay heat --

MR. SCHULZ: Decay heat --

CHAIRMAN WALLIS: There are very few uncertainties in those numbers?

MR. SCHULZ: Decay heat there's very little uncertainty. There's a little more uncertainty maybe in the sensible heat that's also --

CHAIRMAN WALLIS: Those are pretty hard numbers, not much uncertainty, so you don't need a huge margin. You need some margin.

MR. SCHULZ: That's right. I would agree with that.

CHAIRMAN WALLIS: So the rationale thing probably would be to match your margin to your uncertainties in some logical way so it would be explainable to a committee like this one?

(Laughter.)

MEMBER KRESS: Where have I heard that before?

CHAIRMAN WALLIS: That is to make Dr. Kress happy.

MEMBER KRESS: Yes. I would be ecstatic, wouldn't I?

MR. SCHULZ: I am not sure I could do

that.

The other thing that we factored in here in terms of volume is that we did not want the tank to have a shorter duration of injection. That plays into ADS sizing and RWST injection capability which we feel that that is an area where we really want to keep margin and not reduce margin versus AP600 and by -- with the power increase that we already need to deal with, shortening the CMT injection would add to the burden that ADS and RWST injection would have to overcome.

So one of our sort of internal guidelines was not to shorten that initial cut in requirement for when RWST injection should start. And by maintaining CMT duration of injection that helped us in that mission. That's kind of a soft requirement, but that's the way we kind of approached it and why we kept the CMT, increased its volume when we increased the flow rate.

What I'm going to go through is the ADS margin assessment and then RWST margin assessment and then show you a small break LOCA which kind of looks at the integrated effects of those three elements.

In ADS we increased the size of the four stage and again the ADS four stage is obviously one of the most important features in getting to the low pressure where you can get RWST injection. So we feel that that is a very important feature. It's important to have this adequate capacity.

CHAIRMAN WALLIS: But did you increase it because you didn't want to change 1, 2, 3 -- 1, 2 and 3 are the same so you're getting less depressurization from 1, 2, 3 proportionally or the bigger system? In order to catch up, then you have a bigger ADS fall? Is that the way that I should think about it?

MR. SCHULZ: There's a couple of reasons why we didn't change stages 1, 2 and 3. One of them is 1, 2 and 3 is not very useful at the RWST cut in point because you end up, according to the testing and analysis with water in the pressurizer which severely limits the amount of flow that you get through the pressurizer. And so making 1, 2 and 3 bigger we didn't think would help very much. So it was much more effective and probably necessary to increase four stage --

CHAIRMAN WALLIS: What about 1, 2, 3 and 4?

MR. SCHULZ: To basically get you to --

CHAIRMAN WALLIS: To depressurize and to depressurize along the same sort of curve, you presumably need a bigger 1, 2 and 3 for a bigger reactor.

MR. SCHULZ: If you wanted to depressurize along the same curve.

CHAIRMAN WALLIS: Do you depressurize a little slower at the beginning and faster later on, is that what you --

MR. SCHULZ: Yes, and where you notice it is at the lower pressures. At the higher pressures, it doesn't make a lot of difference because you depressurize fairly rapidly when you're say above 100 psi or something.

CHAIRMAN WALLIS: This doesn't quite follow the same scenario time-wise as an AP600. You would have actually increased the size of 1, 2 and 3 and 4.

MR. SCHULZ: If you wanted to scale it up, yes.

CHAIRMAN WALLIS: Right.

MR. SCHULZ: Exactly.

CHAIRMAN WALLIS: So you've changed the sequencing of things a bit, presumably, with this choice?

MR. SCHULZ: A little bit, yes. And we have even thought, if we started with a clean sheet of paper, which we aren't, that maybe we'd even take out the third stage because it's not so useful. One of the things we've learned in all our testing and analysis is it's much more effective in terms of getting to the lower pressures to have hot leg venting than pressurizer venting because there's things that happen in the pressurizer that interfere with its effectiveness at low pressures, not high pressures, but low pressures.

MEMBER KRESS: I would have thought when you depressurize this vessel that the most important thing was the stored energy in the water and how much water is in there and the volume and not the power. So the 76 percent, various size, bothers me a little because I don't think the total volume of water in the primary system changed that much and I think don't it's internal energy at the start changed that much.

So it seems to me like -- I'm disagreeing with what Graham said because I would have thought the thing would have just depressurized about the same as the AP600 with the 1, 2, 3 as it's sized. And even with the 4 as it's sized. I may be wrong there --

CHAIRMAN WALLIS: It's a bit bigger, but it's not bigger proportionately.

MEMBER KRESS: No, it's not 76 percent

bigger internal energy. So I'm still not quite sure of the choice.

MR. SCHULZ: I think there's an element, if you think about large LOCAs, I think that's much more true, when you're blowing down the system very rapidly, how much you're starting with is very important.

Our EDS is sequenced and blows -- it's a more protracted blow down.

MEMBER KRESS: If you're right -- you're right.

MR. SCHULZ: Probably more important.

MEMBER KRESS: Yes.

CHAIRMAN WALLIS: Anyway, it's all going to be clarified by some computer runs of how they really work, not just the hand calculations.

So you have a new ADS 4 valve that you're going to test at full scale?

MR. SCHULZ: We need a new ADS stage 4 valve yes.

CHAIRMAN WALLIS: Are you going to test it at full scale?

MR. SCHULZ: When we build the plant we'll -- when we build the valve, we will test the valve.

CHAIRMAN WALLIS: Yes.

MR. SCHULZ: In a test facility.

CHAIRMAN WALLIS: You don't need the plant to test the valve.

MR. SCHULZ: Right, in fact, it's a little difficult to do that. Right.

MR. GAGNON: What I provided Terry is basically the depressurization response. I'm Andy Gagnon from Westinghouse.

That's just a depressurization response for an inadvertent ADS small break LOCA situation. As you can see, the depressurization characteristics are very similar with the common ADS 1 to 3.

MR. SCHULZ: And you're right, it does come down a little slower, but still, this is pretty rapid depressurization. I think is this where the fourth stage opens up?

MR. GAGNON: Yes.

MR. SCHULZ: So we come down here and hold until the fourth stage finally opens up near the end -- later in the transient.

CHAIRMAN WALLIS: Now do you put on there things like CMT training, would they occur about the same time?

MR. SCHULZ: I think so, as I recall.

MR. GAGNON: For the inadvertent ADS, yes, it's approximately the same time.

MR. SCHULZ: And about the same duration as it was designed to do.

The other assessment that I wanted to talk about before we showed the small break analysis was the IRWST. And we basically did two things here to improve the injection capability. One is to raise the initial water level. Now we didn't raise the maximum water level. What we did is compress the operating band and a lot of that operating band was given up to errors in level measurement because we only had a wide range level measurement in the tank and it's like 30 feet. So that ended up giving us some significant possible errors in measuring the level and what we are doing at AP1000 is putting in a narrow range level instrument that will cut that error down quite a bit and end up giving us one and a half more feet initial water level.

The more significant thing was increasing the line size, basically that's the injection line size from the IRWST from 6 to 8 inches which significantly reduces the line resistance and if you run through the numbers, assuming some RCS pressure, containment pressure and with the initial hit of water in the tank, you'll get like an 84 percent more injection flow which is a little bit more than decay heat. So again, this is an area where we think it's important to maintain AP600 margins without reducing them, and in fact, increasing them slightly.

CHAIRMAN WALLIS: Now again you're talking about flow rate and not just the overall capacity. The IRWST is not much bigger?

MR. SCHULZ: It's not much --

CHAIRMAN WALLIS: Same amount of water.

MR. SCHULZ: Well, you get a little bit more water.

CHAIRMAN WALLIS: Little bit.

MR. SCHULZ: But not much.

CHAIRMAN WALLIS: And it's going in faster, it's going in much faster.

MR. SCHULZ: Right, now that will affect when you get to recirculation --

CHAIRMAN WALLIS: Yes.

MR. SCHULZ: Which is long term cooling which I'll get to in just a little bit.

Now if you take those effects and then look at a small break LOCA transient and then again using for assessing purposes the AP600 SAR analysis and this is NO TRUMP, Appendix K type approach, we looked at several different events, a 2-inch curve leg break which is sort of a reference one we look at. DVI break which tends to be challenging from accumulator core makeup tank early injection capability and inadvertent ADS which tends to be more challenging in terms of ADS and IRWST cut in a little bit later.

This shows you the core mixture level and tries to compare AP600 to AP1000 for DVI line break. You see initially AP600 has a dip and AP1000 doesn't. And the main reason for that is this is the same break size in both plants and it's limited by a Venturi in the nozzle to about 4 inches ID and so since AP1000 is a better plant with the same break, it has a little bit less of a blow down effect early on. So that's the main reason why AP1000 actually doesn't have this dip.

Later on, the trends are pretty similar. There's some minor variations of AP1000. This is when IRWST is starting to inject and shut off and inject and shut off until out in the 2800, 2900 seconds RWST comes on and stays on and the level goes up a little bit.

CHAIRMAN WALLIS: What's the top of the core on this?

MR. SCHULZ: This dotted line.

CHAIRMAN WALLIS: That's the top of the core?

MR. GAGNON: The vast line is the top of active fuel and they've been offset to represent the difference in vessel lengths.

CHAIRMAN WALLIS: So the zero for the level is different than the two?

MR. GAGNON: Yes, that's correct.

MR. SCHULZ: And from this, we basically conclude that from the three basic transients that we looked at, we didn't see any core uncovery, the behavior of the plants were similar. We didn't see any phenomenon that was different.

CHAIRMAN WALLIS: Now this is a mixture level?

MR. SCHULZ: Yes.

CHAIRMAN WALLIS: The collapsed level is somewhere else, so there's some kind of a two-phased flow level which says how much the expansion due to the presence of the vapor is that we can rely on?

MR. SCHULZ: Of course.

MR. GAGNON: That's the core fraction model.

MEMBER KRESS: The collapsed level would be a lot level for --

CHAIRMAN WALLIS: There's a good verification of this, whatever the model is for the level swell, whatever you call it? Because some of the models they use are not very good, over rise glossing or whatever it is that governs the level swell. Maybe yours is.

MR. GAGNON: It's the same model as in our approved valuation model.

CHAIRMAN WALLIS: That's for AP600.

MR. GAGNON: Yes.

MR. BOEHNERT: Is this calculated using NO TRUMP?

MR. GAGNON: Yes.

MR. BOEHNERT: Both of these?

MR. GAGNON: Yes. Same methodology.

CHAIRMAN WALLIS: The staff has this code?

MR. GAGNON: The staff does not have this code at this point.

CHAIRMAN WALLIS: Is the staff going to get the code?

MR. GAGNON: Uh --

MR. SCHULZ: Mr. Gresham will address that later.

CHAIRMAN WALLIS: It's interesting, I think, for people to run sensitivity studies on these sorts of questions about how is the collapse level related to the mixture level and so on, what's the sort of certainty with which you can make these predictions and what are the uncertainties and what's the sensitivity to some assumption of its own.

MEMBER KRESS: Particularly with respect to this item here, because that's one of the things that gave us comfort was that the level never got down below the top of the core, except in one little period there it was, but --

MR. BOEHNERT: There was also a problem using NO TRUMP from the standpoint the staff said, I think, said you could only use it on AP600 and there was an issue there about applicability to AP1000.

CHAIRMAN WALLIS: All the more reasonable why it needs to be tested in some way.

MR. BOEHNERT: I would think.

CHAIRMAN WALLIS: Does the staff have any intention to get this code and run it and then look at the kind of sensitivity questions?

MR. WILSON: Jerry Wilson, NRR. We made a request of Westinghouse to have the codes as part of our review. And we expect -- you'll notice earlier there was a discussion about an additional report to be submitted and that's the code report and we expect to discuss this issue when that report is submitted.

CHAIRMAN WALLIS: It's just going to be something you insist upon? Just discussing it doesn't give me a good feeling. Are you going to insist upon getting this code?

MR. WILSON: I don't want to prejudge it. As I said, we made a request and we'll see that Westinghouse has to say.

CHAIRMAN WALLIS: Would it help if the ACRS said that you should insist upon it?

MR. WILSON: It always helps to hear from ACRS.

(Laughter.)

MEMBER KRESS: Do they teach you guys diplomacy?

MR. WILSON: It's part of the job.

(Laughter.)

CHAIRMAN WALLIS: Okay.

MR. SCHULZ: The last part of the safety injection system that I want to talk about is that involving the long term cooling or the containment recirculation part. And so what we have here is again a margins assessment looking at this aspect. The line resistance has been significantly reduced by again making pipe sizes bigger.

Another factor in that that is important is when do you get to recirculation? And we have, as you noticed, kept the RWST about the same volume. We've increased the injection lines which is helpful in terms of getting water into the reactor, but it also increases the spill rate, if you have a direct vessel injection line. So if you look, for example, this DVI case without the RNS as the pumped RHR system which can interact in this event, so we have to keep account of whether it's operating or not. But if you look at the case without RNS, this is just with the gravity passive systems working, in AP600 you would get to recirculation in 4.7 hours. With that same event for AP1000, you get there soon, 2.6 hours and the main reason for that is that you've got a bigger line that's spilling so it helps drag down the level and get you to recirculation sooner.

CHAIRMAN WALLIS: And you've got more decay heat then because it's sooner.

MR. SCHULZ: And you've got more decay heat then, so we have to deal with that.

Now it turns out on AP600 that the limiting case was not the gravity case. It was, in fact, the case where these RHR pumps were running. The operators in the plant are instructed that if you have a LOCA and the ADS goes off, turn on these RHR pumps, even though they're not safety, they can help you. Well, if you have a DVI line break, it actually can hurt you in some respects and that is instead of having recirculation occur in four some hours, it's 2.1 hours.

What we analyzed in AP600 SAR is the limiting recirculation cut in or initiation time was the 2.1 hours.

Now if we take that same event for AP1000, it would even be short than 2.1 hours. And we didn't want that to occur. So what we ended up doing is changing the RHR pump design so that initially it will not take water out of the RWST. It takes water from outside of containment, like a more conventional reactor.

MEMBER KRESS: There's another tank out there somewhere?

MR. SCHULZ: Yes. We're going to take water out of the spent fuel, CAS loading pit or something. We will not take water out of the RWST.

MEMBER KRESS: So you've essentially added another source of water to your system?

MR. SCHULZ: Yes, so if the nonsafety system works, it cannot make the event worse. And in fact, will make it better because it will put extra water in the containment.

So now for this event, the limiting case is, in fact, without the RNS working because that adds extra water and we end up with additional margin, in fact, more than twice as much flow as AP600.

MEMBER SHACK: Isn't there something where you change that alignment in some situation?

MR. SCHULZ: Yes. What would happen as this event would continue is the event that's talked about here is you run the RNS at pump until you get to recirculation and then it magically fails. That's the worse design basis deterministic type assumption. So this case here is not what the RNS pump continuing to run indefinitely, it runs until recirc. and then it stops.

Now in the AP600, once you get the system lined up and you start it running, it just -- it just keeps going in the same mode of operation. You don't have to realign it.

For AP1000 when the outside water supply gets depleted, we have to switch to the inside water supply of the RWST. We'll have valves to do that and it will be manual operation, but it's again, not a safety. It doesn't have to be done to make the plant safe. It's an extra level of defense.

So we've done some things to increase the water level in terms of the initial water level in the tank and avoiding flooding of the refueling cavity.

We've changed RNS alignment so it takes water from outside. We've increase the line resistance. So we've done a number of things that significantly improve the situation.

We've also done the long-term cooling calculation again using the SAR methodology which is COBRA/TRAC in this case.

CHAIRMAN WALLIS: Your ultimate heat sink is --

MR. SCHULZ: The passive containment cooling and the air.

CHAIRMAN WALLIS: Containment.

MR. SCHULZ: Yes. Just like in the AP600.

Now if the RNS pumps were running, which they may be, they have big heat exchangers and if the CCW is running that's where the heat will go, or most of it. But again, that's not safety. We don't really on that to work, but it is another level of defense.

So in this case we've looked at this limiting DVI break case for AP1000, running the same methodology as we did with AP600.

CHAIRMAN WALLIS: This nonsafety system that's pumping water in from outside, it's not recirculating, it's just pumping it in?

MR. SCHULZ: Initially, pumping it in. When the outside water supply gets depleted, we'll realign it to inside containment, much like you do in today's plants.

CHAIRMAN WALLIS: But you're not taking another path for taking contaminated water out with this system?

MR. SCHULZ: If you continue to run the system, you will.

One of the restrictions on running this system in terms of the operating procedures is that the activity levels are not very high in containment. If you get to a situation where you've really damaged fuel and you have high activity in containment, you would normally not run the RNS unless you're in a core melt scenario or you're in one of those kind of situations.

The first guideline would be turn it on, but if the activity goes up, turn it off or don't run it. And that's the same situation as AP600. In fact, AP600, when you initially start the RNS, it's pulling water from inside containment to inject it back in.

So when we look at the results of the COBRA/TRAC we see similar behavior, no core uncovery relative to AP600. So looking at the COBRA/TRAC results, they look like we were successful in sizing ADS and recirculation.

CHAIRMAN WALLIS: How close does it come to uncovery? It always could be within a micron or something?

MR. SCHULZ: No. I think feet.

CHAIRMAN WALLIS: More reassuring than AP600?

MR. SCHULZ: I don't know -- do we know the comparison?

CHAIRMAN WALLIS: Maybe we could see that later.

MR. GAGNON: The behavior is comparable as I recall in terms of margin.

CHAIRMAN WALLIS: So when we see the details it will look just like AP600?

MR. SCHULZ: Or better. In summary, for the passive core cooling system, we've retained the configuration of the design. We selectively increased features in terms of the capabilities. We've done these independent hand calculation margins assessments which are actually part of the design process to give us a feeling for how much we've increased the capacities and where we've done that and we've done some checks using the SAR codes to look at the integrated effects.

I'd like to now move on to containment. Mike showed you a little bit of containment and talked a little bit about what we've done to the pressure vessel. The shell thickness gets a little bit thicker, the 1-3/4s is the limit to avoid post-weld heat treatment which we don't want to do, so we've gone up to that limit.

The total free volume is actually increased 20 percent or so. The total volume has not increased that much, but there's a lot of structures in there and we've accounted for those. And so most of the increase that we made goes to free volume, although we do have bigger steam generators in there.

The design pressure has gone up. In order to account for that design pressure --

CHAIRMAN WALLIS: How much does it grow when it gets to 59 psig?

MR. SCHULZ: How much does the --

CHAIRMAN WALLIS: How much does it grow in terms of inches?

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

MR. CUMMINGS: Ed Cummings. On AP600 it was about an inch and a half. I guess this would be just a little bit larger than that.

MEMBER SHACK: When I went to my friendly ASTM handbook, I couldn't see where you'd get a whole lot more design strength under the SA738. You have to put a code case together for that.

MR. SCHULZ: Yes. We have to put a code case together for that. I don't remember. I thought it was significant, but not -- the other thing that we've done in the containment cooling area is we made the water storage tank bigger and this is the maximum water at the overflow point that we're using as a reference point here. And we increased it from 540,000 gallons to 800,000 gallons. We also increased the water flow rate.

Now the initial water flow rate didn't increase very much. We run 400 or so gallons for about 3 hours to cover the containment shell, to form the film quickly, relatively quickly. And since the containment dome is the same shape in diameter and it's just a little bit taller, we've maintained that flow rate, increased it a little bit, but not very much.

After that three hours, the flow rate increases more proportional to the power increase. So it's 70 some percent.

CHAIRMAN WALLIS: Your concrete wall is thicker, is it?

MR. SCHULZ: It's not thicker. It may have or probably will have more rebar.

CHAIRMAN WALLIS: More rebar, has something in it to hold up that water at a higher level.

MR. SCHULZ: Yes, it's higher and it's a little bit heavier.

CHAIRMAN WALLIS: Do we get into seismic considerations, the whole thing shakes?

MR. SCHULZ: We will have to demonstrate that. I think this is one of the issues with the staff is how much demonstration we will be doing and I believe we'll be doing one site, one calculation for --

MR. CUMMINGS: This is Ed Cummings. We're providing hard rock seismic analysis case and we have done an assessment of the roof structure to show feasibility.

MR. SCHULZ: We have also again, as we've done in the other features, taken the SAR analysis codes and methods which is GOTHIC in this case and analyzed the containment. One thing that was a little different than -- at least the SAR reference case, was using a more realistic large LOCA steam generator energy input. We had used a very conservative arbitrary input forcing the generator energy to go into the reactor coolant system very quickly which gave us a second peak in pressure that was kind of unrealistic. So we're using this as what we think is a more realistic scenario. But otherwise, the codes and methods and conservatisms in the code is the same.

We looked at two limiting cases, the double ended large LOCA and a large steam line break.

MEMBER KRESS: Now when you're transferring heat condensing steam on the wall of your containment, I recall there was some question about the model we had in there on how it dealt with the surface area. It might be covered by liquid and the part might not be -- did that ever get resolved, Graham?

MR. SCHULZ: In terms of the outside of the containment, the water coverage for AP1000 should actually be a little better at least around the dome and the upper part of the shell because the geometry is the same in terms of the diameter and the shape of the head and we're in the longer time, anyways, we're putting more water flow on.

MEMBER KRESS: That was one of the issues. The one I was recalling though was all on the inside.

MR. SCHULZ: Okay.

MEMBER KRESS: That's a different --

CHAIRMAN WALLIS: Doesn't etching, surface behavior, if it gets dirty and it doesn't wet so well or what's better and things --

MR. SCHULZ: That's important on the outside, not so much on the inside.

CHAIRMAN WALLIS: On the outside.

MR. SCHULZ: The wetting and the spreading of the film.

CHAIRMAN WALLIS: This thing is going to rush, isn't it?

MR. SCHULZ: No.

CHAIRMAN WALLIS: Things happen to it.

MR. SCHULZ: Well, it's got a coating on it that is -- has a safety function and it will be inspected during the life of the plant and in fact, we'll be running some tests, running water already outside periodically which will have a couple of purposes. It will tend to wash the outside and it also will demonstrate the fact that the water film forms. So we can test that part of it, in fact.

CHAIRMAN WALLIS: Do you have any wetting agent you add to the water to help it spread?

MR. SCHULZ: No, we don't. The coding is an important factor that we do take credit for and that's why it has some safety function, btu we don't add anything to the water.

MEMBER SHACK: But you did up the rate as well as the total volume of water, as I recall.

MR. SCHULZ: Yes, yes. And I think the issues with curbage were more in the lower flow rate regimes, not so much in that initial 400 GPM flow rate. When we slowed down later in time and there's where we'll have some more water flow.

MEMBER KRESS: We had some questions about the GOTHIC assumption of well-mixed flow inside the containment. And now you've got a slightly worse case for mixing, maybe, I don't know, because you've got more heat but how have you dealt with that issue of whether or not it's well mixed in there?

MR. SCHULZ: I think it's something that Bill Brown will probably get to, maybe, maybe not. Would you like to address that now?

MR. BROWN: Bill Brown. If you remember

the last time we went through this, one of the things that was suggested by the Committee was to do some CFD and included in this report you'll see a comparison between AP600 and AP1000. We took a little 2-D slice through the hull of containment and the results that we see from it is that it looked similarly mixed to AP600.

MEMBER KRESS: Good move.

CHAIRMAN WALLIS: Do we get to talk to you about that later on today?

MR. BROWN: Yes, if you feel good about that.

(Laughter.)

CHAIRMAN WALLIS: Well, the obvious question is why you take a slice instead of a -- whatever the cylindrical symmetry, a slice really isn't very typical of a cylinder, but we'll get to that later on, perhaps when you are standing up there.

MR. BROWN: Yes.

MEMBER KRESS: I thought the slice was vertical?

MR. SCHULZ: It is.

MEMBER KRESS: That seems to me like it's appropriate.

CHAIRMAN WALLIS: Well, we'll talk about

that.

MEMBER KRESS: Okay.

MR. SCHULZ: The large break LOCA transient looks like this for AP1000. You see the higher design pressure. The actual margins in terms of PSI and even percentage are even greater on AP1000 than they are on AP600.

CHAIRMAN WALLIS: This is with conservative assumptions?

MR. SCHULZ: This is with conservative assumptions, AP600 methodology margins. The only difference is in the rate of steam generator energy input which affects the second peak there.

The other event which we looked at which is actually limiting is the main steam line break. And it does with the large steam generators that we have in AP1000, it is understandable why this is limiting.

CHAIRMAN WALLIS: Well, you need some uncertainty analysis.

MR. SCHULZ: Well, I'm not so sure. Passive containment cooling is not very important here.

In fact, we've run the same transient without passive containment cooling and the peak is barely larger --

CHAIRMAN WALLIS: No, I mean I just wonder how certain -- do you have conservative assumptions in this?

MR. SCHULZ: Yes.

CHAIRMAN WALLIS: So the real thing should be less than that?

MR. SCHULZ: Yes. That is correct. So our conclusion on the containment is that we expect margins to increase, to be better on AP1000. We've increased the capacity of the containment.

CHAIRMAN WALLIS: It's a very funny code, that one. It goes up linearly and just before it reaches disaster it stops.

(Laughter.)

MR. SCHULZ: That's not too surprising.

(Laughter.)

CHAIRMAN WALLIS: That's what I always suspected.

(Laughter.)

MR. SCHULZ: This is what happens when you get designers working with the analysis, you figure out how big you have to make the containment and this was really limiting.

The other thing is that design pressure is not a disaster either.

CHAIRMAN WALLIS: No.

MR. SCHULZ: You can go above that --

DR. WALLIS: But you'd expect something which would have a gentler approach to the maximum or something instead of going up linearly and coming down linearly.

MEMBER KRESS: That's probably just an artifact of the plotting routine.

At some point up there is where you empty out the steam generator, I guess.

MR. OFSTUN: This is Rick Ofstun. That's correct. The time that the steam generator empties or SVIs are closed at 600 seconds, that's when the break release --

CHAIRMAN WALLIS: So if something happens --

MR. OFSTUN: After the break release stops then the containment heat sinks continue to soak up heat.

CHAIRMAN WALLIS: So it does turnaround for a good reason.

MR. OFSTUN: Right.

MR. BOEHNERT: What's the peak pressure you calculate?

MR. OFSTUN: It looks like around 70 or 70.5 psi. I think we're about 2 or 3 psi from the design limit.

MR. SCHULZ: Three and a half or four.

MR. OFSTUN: Okay.

MR. SCHULZ: Again, we didn't see anything that was really different form AP600 in terms of the phenomenon involved. The margins look larger. Main steam line break is the limiting event and the performance of the PCS is not very important in that event.

CHAIRMAN WALLIS: When we look at this 2.5 psi between design pressure, this is where stratification might be important. It may be well mixed but not that well mixed. It makes a difference to the pressure.

MEMBER KRESS: Yeah, but in the worse case, it's well mixed.

CHAIRMAN WALLIS: Well, maybe if that's the case you can reassure us.

MEMBER KRESS: If you're stratified or not well mixed, you actually get to a lower pressure.

CHAIRMAN WALLIS: I don't, but the containment does.

MEMBER KRESS: The containment.

MR. BROWN: Bill Brown, Dr. Wallis. We would love it if all the steam could go up and get with that nice cold water up there and we've actually taken the worse case and actually assume it would be well mixed.

CHAIRMAN WALLIS: Are you finished now?

MR. SCHULZ: Yes sir. That was our last slide.

CHAIRMAN WALLIS: We're a little bit behind in time, I think.

I'm wondering -- we're going to take a break now, but when we come back probably we'll accept fairly briefly the reports are going to look about the same?

MR. SCHULZ: Yes.

CHAIRMAN WALLIS: I noticed that some of your advisors recommended such phenomena be upgraded in the PIRT. You might want to mention one or two of those if they're important, but then we should really move on to the scaling approach, but we're going to take a break and I think we should have at least 10 minutes. Let's same come back at 5 after.

(Off the record.)

CHAIRMAN WALLIS: Let's come back in session. We're looking forward to hear some more.

MR. BROWN: PIRT and scaling assessment. To give you an idea of the outline here, I want to briefly go over the PIRT assessment, not the PIRT itself, there really wasn't much changes. And I want to spend most of my time in the scaling assessment which will consist a little bit of trying to identify the things in which we really assessed relative to actually did an analysis, I guess.

And a little bit on our approach and then I want to get into some of the major areas, the ADS-IRWST transition phase, the ADS phase, the sump injection phase and go over briefly as to what we did and what the results were, try to give you a summary overall for what that meant to the integral effects test facilities of SPES and OSU, and then move on to the PSS scaling for containment which will large address the separate effects test and the containment mixing and stratification.

The main goal, of course, for our part in scaling assessment was to try to determine the extent to which the AP600 experimental test data base was applicable to AP1000 to support our safety analysis code validation in accordance with 10 CFR part 52.

So a real simple two-step process we went through, was the first -- take our AP600 PIRTs as they were and then have them reviewed by several industry experts for application to AP1000 and then once we got the results from that we could then look at the import of the high rank phenomenon and then use that to assess these phenomenon relative to AP1000.

MEMBER KRESS: How many of these experts did you have?

MR. BROWN: Several. I'll show you in a list here in a second.

MEMBER KRESS: Oh, you've got a list. I'm sorry.

MR. BROWN: Yeah, I'm going to give you a list here.

MEMBER KRESS: Okay. The usual suspects.

(Laughter.)

Who is this Hochreiter person?

MR. BROWN: This guy?

(Laughter.)

He's a big target back here at one point with the ACRS. Not a big target at Penn State.

Dr. Bajorek from Kansas State, Dr. Bankoff from Northwestern, of course, Dr. Hochreiter, Dr. Larson from INEEL, Dr. Peterson and Mr. Wilson, those were our primary peer reviewers.

Primarily, Dr. Bankoff and Dr. Peterson

had been involved with our containment PIRTs so they primarily focused on containment for us and they looked at the others, and the other four looked at our other events, our large break LOCAs --

CHAIRMAN WALLIS: I am surprised that these four academics used industry as an adjective to describe their expertise.

MR. BROWN: Well. Certainly they worked --

MEMBER SHACK: Discipline experts.

CHAIRMAN WALLIS: Because usually academics are regarded as in other world from industry.

MEMBER KRESS: Independent, right?

CHAIRMAN WALLIS: I'm glad to see that -- well, in a way I'm glad to see at least they're experts.

MR. BROWN: Are you disappointed you're not on the list?

(Laughter.)

CHAIRMAN WALLIS: Why do you call them industry experts?

MR. BROWN: Well, I should say perhaps academic experts who are certainly familiar with our industry history issues.

MEMBER KRESS: I thought maybe you'd have Ivan Katten on there.

MR. BROWN: I did talk to Ivan, but I didn't get a hold of him quite frankly, early enough to do that, but when we went through this process, this was really the starting list and what I sort of decided was I would send them out to this group and if I got anything significantly different or got a lot of comments, then we would continue on with this, but quite frankly the real result of this was there wasn't a significant different by most of the reviewers.

And here, gives you an idea of what the summary of the major changes that they came up with. A large break LOCA, the core entrainment was increased a little bit from 6 to 7 from a median to a high. We addressed this via our BE LOCA methodology.

MEMBER KRESS: Was that because you have a higher steam flow?

MR. BROWN: Yes, right. Because of the higher power and the higher steam flow, they expected additional entrainment than they had up in the upper plenum area, right.

Small break LOCA, same type thing again. Same issue, really with increased entrainment and recommended a high for RWST and sump injection and

I've addressed this via some bottom up scaling on liquid entrainment inception from the hot leg into ADS-4 and the scaling report. And then the ADS-4 two-phase pressure drop was increase the High from IRWST and sump injection as well. And I've addressed this from more a top-down perspective during the IRWST and sump two-phase natural circulation.

In containment, we had no changes whatsoever. The only issues or comments that came up there were with respect to comments that you made similarly earlier, Dr. Kress, with the increased height of the 25 feet in containment, what would that do to mixing and later on in our report we have some CFD analysis to try to address that.

In non-LOCA, there were no important changes either, so the primary changes were really in the small break LOCA. So we took these changes in addition to the things that were already ranked as high and important from AP-600 and we addressed this in the scaling assessment.

CHAIRMAN WALLIS: What effect does it have? Suppose you change a number from 6 to 9 or something, what difference does it make? What the procedure for making it actually make some difference? It's nice to see lots of numbers.

MR. BROWN: I think in the case of the large break, it really doesn't mean a whole lot because you're going to really, you're going to end up doing the analysis anyway, where you're varying each parameter and going through some uncertainty.

CHAIRMAN WALLIS: I've always been curious about PIRTs. You have these numbers and medians and high and all that, that ought to mean that you assign some weighting factor to sensitivity or uncertainty in your later analysis where you somehow complete the loop and come back and see whether you really did a good job or -- I'm never sure that that's actually done.

MR. BROWN: I think you could go through a numerical validation of that after the fact.

CHAIRMAN WALLIS: Otherwise, what's the exercise for except to put a lot of numbers on the matrix?

MR. BROWN: I think it certainly gives you an idea which I used to make sure that these are certainly a checklist of items that you should have included and addressed either in scaling and/or test facilities, certainly it's a good place to start. I agree. I don't think it's something -- I think it's a tool to get started with.

CHAIRMAN WALLIS: You might say, if you have a 9 you need to have independent assessment from three facilities and if you have 6 you only need one. There's got to be some sort of tie in between the numbers in the PIRT and what you actually do.

MR. BROWN: Right. It sounds like you could write a paper on that.

(Laughter.)

CHAIRMAN WALLIS: This PIRT, is it an empty exercise or does it really --

MR. BROWN: Well, as I said I think it helps me to focus on what needs to be looked at as far as scaling. I mean certainly in the areas where if you initially didn't have a test program before we had the AP600 test program, I think this was probably much more valuable, where you said look, I really don't know how this is going to react. Nobody knows. I mean the experts here probably don't know how it's going to react, so we need to do the test.

Yes, now that we've been through the testing process, quite frankly, these particular items here are really more -- came out of -- now that I know what happened in the tests I would have ranked these higher than I would have initially in AP600. So really, if I was going back to the AP600 PIRT I would have increased these a little high as well.

Maybe here if we were using numbers, maybe this was a 9 in the AP600 and maybe it was a 10 in the AP1000, but you would have gone back to do it. So I think when you're initially starting a test program, I think it's pretty helpful. I think once you have done a test program, it's probably not quite so helpful.

CHAIRMAN WALLIS: It might guide the staff, if the staff ever gets hold of your codes and they see that these are 9s, then they might focus on --

MEMBER KRESS: It gives you a place to focus on your sensitivities and things of that nature.

MR. BROWN: I think that helps you as to where you should spend your effort mostly.

Okay?

CHAIRMAN WALLIS: There's no check that you actually did spend your effort. That's the thing that bothers me. It needs to be a loop, a complete loop of the PIRT so it leads to some actually quantitative result in some way.

MR. BROWN: Certainly in the code reports we do identify, I mean all the PIRT items are -- we make sure that we have certainly a model and I think that the scrutiny when looked at the model, the validation as to how does the prediction of the code compare to the test facility is much higher, scrutinized much more heavily when it's a higher ranked item.

CHAIRMAN WALLIS: If we scrutinized we would find that correlation.

MR. BROWN: You should. And for the passive core cooling system then this became the list to include a couple of items which were increased for AP1000 as well as those which were already ranked high. And what I did was I tried to lump these into, especially for the passive core cooling system, I sort did top-down versus what I did bottom-up and some of the things that were mentioned like the ADS two-phase pressure drop and so on are listed in here. And this gives you an idea of the type of things that I tried to do from a system level and quite simply I ended up with something that's of much more local phenomenon that was difficult to include top-up such as entrainment or phase separation and so on. These are bottom-up. So this kind of gives you a list of what were the high ranked or most important.

CHAIRMAN WALLIS: Is there something here about this level swell we were talking about earlier?

MR. BROWN: Level swell in the IRWST?

CHAIRMAN WALLIS: No, in the vessel.

MR. BROWN: In the where?

CHAIRMAN WALLIS: In the vessel.

MR. BROWN: In the vessel. Well, the closest, I guess, you could look at it as one as I have a reactor vessel inventory scaling and then also try to look at the core exit void fraction using the A correlation.

CHAIRMAN WALLIS: It makes a big difference now that you carry out into the rest of the system and a difference in how the actual masses related to whether or not the two-phase level covers the core, pretty critical how you model that phase behavior in the vessel.

MR. BROWN: Yeah, you certainly get into an area though certainly more important, I think, certainly the codes right in their answers as opposed to I'd say scaling where you're not so much after a best estimate answer, but trying to make a relative comparison between a facility and a plant.

Okay, this is a list of the phenomena for the passive core cooling system.

CHAIRMAN WALLIS: How would you scale up to a vessel the business of level swell in the vessel?

MEMBER KRESS: I don't think what you measured was collapse level. When you measure it in the test, I don't think they had a swell level.

MR. BROWN: Right, right. The DP cells --

MEMBER KRESS: The DP cells.

MR. BROWN: -- we had were really measuring a collapsed liquid levels. That's why we know it's much better.

CHAIRMAN WALLIS: So we don't have a measure of these --

MEMBER KRESS: You can do some inferring, but I don't think you have a direct measure.

MR. BROWN: Yes, I think essentially we have the -- certainly you have an idea of what that is based on, the DP cells, but we don't have, again tensitometers sitting in there in the vessel, looking at the level.

MEMBER KRESS: What you have is a heat balance.

MR. SCHULZ: This is Terry Schulz. We had heated rods. If the rods were not adequately covered and cooled, we would see that in temperatures --

MEMBER KRESS: But generally it's hard to see with the level swell. It cools the rods pretty doggone good and it's hard to see it break between

-- where a collapse would be and -- it's hard to find.

MR. BROWN: Unfortunately, in the small break area we don't get the kind of level swelling that you certainly would get in the large break on the initial blow down.

Okay, with that I'd like to move on to the scaling assessments. There's a lot here.

The scaling assessment really focused on the high-ranked phenomenon.

CHAIRMAN WALLIS: Will you let us know when this gets to be priorities?

MR. BROWN: Yes, we're getting there, we're almost there.

We really tried to focus on the small break LOCA with respect to core cooling and vessel inventory and then things like the steam line break for containment pressure. So that was our focus.

And the assessment, looking at the scope of the scaling assessment, phenomena that we find in conventional plants for which there's test data bases that already exist, we did not scale for AP1000 and that includes the large break LOCA, blowdown steam generator circulation phases for the small break LOCA and non-LOCA with the exception of CMT and passive RHR which are items that are unique to passive plants.

And things that were low ranked or medium ranked in the AP600 scaling effort that were already scaled we did not rescale those.

So our basic approach then was starting from the AP600 scaling analysis, using that as a basis for AP1000. We tried to use the insights and lessons and so on and we did not, as I said, reinvent the week completely here. Processes that were not important or minor were not scaled and we certainly tried to use simplified models to try to highlight these differences or features in AP1000 such as core power, volume, ADS vent area and things like that so that we could see what the real differences were and try to root those out to be more obvious in looking at the assessment in AP1000 relative to the AP600.

So we sort of did two types of assessments, if you will. One, we examined the range of operating conditions, geometry, those types of things between AP1000 in each test facility. And usually in those many cases, the AP600 scaling analysis was already sufficient. This typically covered the separate effects test. However, when we tried to look at AP1000 relative to for example integral effects test facility, we definitely needed to be able to supplement this with a scaling analysis, so that's what you'll see here very shortly as some examples of what we did in the integral effects tests to try to assess AP1000 relative to AP600.

So I'm going to give you an idea briefly as to what's covered. In the integral effects we looked at an assessment of both SPES, OSU, ROSA, the ADS test, CMT, PRHR and our DNB tests. And we did an additional new scaling analysis for both SPES and OSU for the integral effects test.

In the area of containment, we did the scaling analysis for the LST, or condensation and heated flat plate tests, water distribution and water fill formation tests.

Now we're going to get into the scaling assessment part which is going to be the priority part of the meeting.

(Whereupon, at 3:21 p.m., the open session went into closed session.)

(Off the record.)

(Open session resumed at 4:49 p.m.)

CHAIRMAN WALLIS: Let's come back into session again.

MR. BOEHNERT: We are in open session.

MR. GRESHAM: My name is Jim Gresham and I'm going to talk about the computer codes used for

AP1000, but I'm not going to get into the details of the codes. Rather, I'm going to talk about the approach that we're going to use on the analysis for AP1000.

And pretty simple, you start with the codes that were approved for AP600, our starting point for the assessing the codes for the analysis and used those as much as possible. Of course, to do that we have to confirm that they're adequate for performing the safety analysis for the AP1000 design and address the concerns that were identified on the AP600 application and make sure that we've reached agreement on applicability after addressing those and then reach consensus with the staff and then when we do that, then we'll use those codes for the FSAR analysis to complete the safety case.

The advantages of doing it this way is we step through in an orderly fashion in the review process which we believe would make it more efficient for us and for the staff in doing that.

We can identify the major deficiencies in the codes and address those prior to the final review. And also, through this we focus on the most important issues, so with the guidance of the PIRT, the scaling and test comparisons and then we can really focus our energies on the important phenomena in evaluating the code acceptability.

CHAIRMAN WALLIS: So how do we resolve these major deficiencies or find out major deficiencies? I'm just wondering where the starting point is. When we had AP600 we started asking questions and eventually got some code documentation which had deficiencies in it. I guess they're not the kind of deficiencies --

MR. GRESHAM: I'm talking about code deficiencies. There may be --

CHAIRMAN WALLIS: Code. Code is whatever this magical thing is that is quite different from all of the --

MR. GRESHAM: I think in a few slides we'll get to this topic a little more and then maybe we can -- there are different ways that we may address --

CHAIRMAN WALLIS: I think there's a real question about whether Westinghouse can assess deficiencies in its own code.

MR. GRESHAM: I believe we can. I don't believe that will be adequate and we will have to discuss that with the staff and reach agreement on that. But I think we're the first ones to address the deficiencies and then our reviewers will decide how well we did.

The code, the major codes that are used for the Chapter 15 analysis, I won't dwell on these, but the COBRA/TRAC is used for the large break LOCA and the long term core cooling. NOTRUMP for the small break LOCA. LOFTRAN is used for non-LOCA transients and for steam generator tube rupture and there is a kind of a derivative code, LOFTTR2 which models some of the operator actions and other phenomena for tube rupture that was within that umbrella. And then WGOTHIC for containment integrity.

In terms of identifying the adequacy of these codes for a performing analysis for AP1000. First step in the process is to identify the important phenomena which is done through the PIRT that need to be addressed and these phenomena have been presented in the PIRT and the scaling and so that task in this process for AP1000 is complete. And then identify the correlations and models used in the code to address the important phenomena and that really was done under the AP600 application and again, we are planning to use the same codes for that. So those have been done. What remains is to demonstrate that they're adequate. And that is done through the scaling to demonstrate that the test data base that we have is adequate for code validation and then to rely on that. And that has also been done through the -- is provided in the scaling report, the determination of the adequacy for both the integral effects test and separate effects test.

And then the remaining thing is demonstrate that the limitations that were identified, what we just talked about for AP600 are addressed on the next slide.

The first is just to acknowledge what I've already said that there were things identified in the AP600 that there were some concerns about and as already mentioned today, the approval was restricted to the AP600 application. So we, I think the burden is on us to present the case on why the codes can be used for the higher power plant and that's what we intend to do.

And again, we have to evaluate those deficiencies.

There are several ways that we think that this can be done. One would be to make some modification to the design to increase margin in the area of the deficiency, to demonstrate more margin. There may be other test validation that can be done to demonstrate that the code is adequate to model that phenomenon. Again, we may just -- maybe additional evaluation margin may demonstrate that yes, there's a lot of margin in this area and therefore the code is adequate to demonstrate safety relative to that parameter.

We may do analyses with other codes, for instance, in the containment analysis example that we already talked about where we did some CFD calculations to confirm the mixing in the AP1000 and the AP600. It would be that kind of analysis or maybe other systems analysis code to provide independent confirmation of some portion of the transient or all the transient.

And it may be necessary to make some changes to the code also. Any of those five we may use or some combination of those five to address these.

We intend to document this work in the Code Applicability Report which is targeted to be complete in April. The key contents of that report will be a discussion of the importance of the important AP1000 phenomena referencing back to earlier reports that we've done, a description of the code that is being used for AP1000. A lot of it is by reference to the AP600 work, but we'll also discuss anything different about it, relative to the work that was done there.

A discussion of the limits of acceptability or acceptability for AP600. We intend to go through the FSER from AP600 and address the major items on the codes that the staff pointed out and I believe that's a good systematic way to make sure that we've addressed all of the items that were identified.

And for each limitation we'll say how that limitation is addressed and there will be some of those components that I mentioned on the prior page.

CHAIRMAN WALLIS: So how do we determine what is a code limitation? Do you look up the SERs, is that what you do? It was not identified then as the code limitation?

MR. GRESHAM: Those are -- we're not aware of any other code limitations that we're addressing, other than those items that were in the FSER. We were holding that open for something that happened in scaling that came out. Nothing did pop out from either the PIRT or the scaling that we thought had to be added to that list.

Just quickly on how uncertainties will be addressed for AP1000. Again, we've talked about all afternoon is that the phenomena are similar to AP600 and the scaling demonstrates that the validation basis for the codes is adequate. We intend to deal with the uncertainties the same way that they were for AP600. For the large break LOCA we are using our best estimate methodology and 95th percentile will be identified as stipulated in the FSER. The reason we said it that way, I believe it was for the passive RHR and the CMT -- it was the CMT. The staff said if the PCT goes higher you may have to do more for uncertainties in looking at those phenomena. So we will factor that in. Otherwise, the methodology will be the same.

For the other codes, we're doing a bounding analysis as we did for AP600. And we will ensure that the assessment is conservative, rather than quantify the numbers in our best estimate.

CHAIRMAN WALLIS: Your AP1000 has higher PCTs.

MR. GRESHAM: That's correct.

CHAIRMAN WALLIS: It's not clear to me that you're doing necessarily with the same uncertainties as you dealt with before with AP600. I know that the phenomena are the same, but you're pushing them to --

MR. GRESHAM: The numbers may be different.

CHAIRMAN WALLIS: For reason of the envelope. It may be that -- so the way in which uncertainties work, there isn't quite the same as the way they did before.

MR. GRESHAM: A good example of that is the oxidation. Down below 1700, the oxidation is pretty minor and as you start to increase and oxidation becomes more important and that is one thing that will have to be dealt with on the AP1000 that we didn't on AP600. So your comment is correct.

CHAIRMAN WALLIS: They're not so similar when you're talking about oxidation. You're actually going to a much higher degree of oxidation than before?

MR. GRESHAM: Yes.

CHAIRMAN WALLIS: So it's qualitatively -- you could almost argue it's no longer similar. It's almost different from an extrapolation, but significantly --

MR. GRESHAM: Okay.

CHAIRMAN WALLIS: Different.

MR. GRESHAM: Valid point.

MEMBER KRESS: What exactly does your sub-bullet up there mean?

MR. GRESHAM: That we will -- the transients will be analyzed in a way to make sure we're on the conservative side. For instance, in the containment where we use test data for the hidden mass transfer correlations and we do a bounding treatment of those --

MEMBER KRESS: I understand you use the conservatisms that are specified in approach. I don't know what it mean as to say that those bound the uncertainties.

Does that mean to say that if I use those conservatisms and I will be -- have a value that's close to the 95 percentile if I did a real uncertainty? What does it mean to say bound the uncertainties? I don't understand the statement.

MR. GRESHAM: Actually, we haven't defined the 95 and won't define the 95th percentile uncertainties.

MEMBER KRESS: I understand that. Nobody has is the problem.

MR. GRESHAM: That's right.

MEMBER KRESS: That's why I always have a problem with this. I know those uncertainties are there, I just don't know how much margin they provide you with respect to the uncertainties.

MR. GRESHAM: I'm using the small break LOCA example we talked about to comparison to the test data on a realistic basis and show that we can model the phenomena and then we'll add the appendix K uncertainties on top of that to ensure it's a conservative assessment. That's the idea on that.

MEMBER KRESS: We'll look at that difference and say there's some sort of margin there.

MR. GRESHAM: Yes. And that margin covers the uncertainty and I know when I say that you can't quantify --

MEMBER KRESS: It doesn't add any meaning.

MR. GRESHAM: The magnitude.

MEMBER KRESS: Bounding the uncertainties has no meaning to me.

MR. GRESHAM: Perhaps it's just better to say we're doing --

MEMBER SHACK: If the analysis is conservative then you've bounded the uncertainties. It's hard to demonstrate that analysis is actually conservative.

MEMBER KRESS: If you believe it's conservative you believe it's conservative enough to have a confidence level in your calculation that's acceptable, but they're saying something than bounding uncertainty. I'm just having trouble with semantics and actually it means to do such a calculation.

CHAIRMAN WALLIS: What do you mean by that? If you have a break, you assume that there was no flashing and it simply came out as pure water, the maximum flow rate you could possibly have is all, is that what you mean by a conservative analysis, bounding something? Look at some extreme assumption which takes you right to the end of what's imaginable and you use that?

MR. GRESHAM: No, I'm not saying that. There's a bound on how we're going to be.

(Laughter.)

That's the idea.

CHAIRMAN WALLIS: Dr. Kress is right then.

MR. GRESHAM: Yes, Dr. Kress has a very good point.

CHAIRMAN WALLIS: I think also when you talk about realistic, I don't know what the criterion is for realism. Just that you look at some data and the curve isn't too far away from them? Once you start to quantify these things in statements like realistic and uncertainties, conservative, you've got to be quite careful in your definitions so that we're all speaking the same language and we can agree on criteria for evaluation.

That's all going to be cleared up.

MR. GRESHAM: You're right. There are different ways to do comparisons and you have to all agree it's a rational approach. I agree.

CHAIRMAN WALLIS: Sometimes it becomes more persuasion.

MR. GRESHAM: Yes. And then the final step in my process was to reach consensus and this is -- again, we're starting from codes that were approved for AP600 and we certainly want to stand on the foundation of that effort and not repeat anything that we don't need to, recognizing that there are still issues that we need to reach agreement on.

We're providing the reports. We've talked about them several times, to the staff for their review, to help to make our case and we will be having discussions with them.

CHAIRMAN WALLIS: You say you're supply reports. Are you supply codes?

MR. GRESHAM: We need to go through these steps before making the decision on that.

If we reach agreement that there have

been, yeah, the codes are also applicable to AP1000 and you've covered all the phenomena and the validation is okay and we don't have to change the code, then it's not clear that we need to provide the code to the staff or the staff needs to exercise those codes in their review.

MEMBER KRESS: Part of that decision may be based on exercising the codes.

CHAIRMAN WALLIS: It's all quite possible for people who exercise a code to do things to get what they want to get, like this business of the homogeneous assumption. Until you really dig into an issue you're running yourself, you don't know how it is you manage to get this answer. One might feel a little queasy if the answer only comes from manipulations performed by Westinghouse. Dials and things can be changed in a way which always transparent.

MR. GRESHAM: I guess my answer to you is that we need to work with the staff to decide where they need to have the codes and where they don't. And --

CHAIRMAN WALLIS: Work with them or you need to give whatever they ask for?

MR. GRESHAM: We won't do that without

assessing --

CHAIRMAN WALLIS: Is there a negotiation --

MEMBER SHACK: Persuasion.

CHAIRMAN WALLIS: Yes. Persuasion.

MR. CORLETTI: This is Mike Corletti. Starting with the basis of the approval of AP600, there was quite an extensive review of the codes. I'd really like to start there. We don't want to go back to 1992 before we submit -- before when we sent in all the code documentation. We're really looking to start where we left off building on that. The best way we see that is what did we learn from that 8-year certification review, what were the hard issues with each of the codes and the way we resolved each of those issues. How does that apply to AP1000 and can we address that?

I think that's -- that is our approach.

CHAIRMAN WALLIS: But a question I think someone raised before is whether the staff is capable of knowing what the issues are with the code unless they actually exercise it themselves because the real issues of a code can be so hidden that it's hard to take what they are.

MR. CORLETTI: I certainly think there's

an onus on us to provide them with the documentation necessary for them to make the determination that the methods that we employ, that the methodologies that we employ are sound and acceptable and I think that onus is on us to give them that sort of documentation. Whether that specifically requires them to exercise the codes, it's not clear to us at this time. I think maybe perhaps as we go through this code applicability report, we understand the phenomena. We understand how the test data applied to AP1000. At that time, we'll have a clear understanding of where such -- where that would be beneficial and where it would not be. At this time it certainly is not clear, the first thing you don't do is jump into exercising the codes. I think we think that would be the last thing we would do eventually.

MR. GRESHAM: On my third bullet, we're asking the staff to agree on the acceptability of these codes for analyzing the AP1000 transients. Now we fully expect that they're going to need some good information to be able to make that decision and we believe much of that is in the documentation already mentioned and if there are changes to the codes there are other significant things it may involve their running the codes, but we need to be looking at this -

- we need to get further in the process before knowing the answer to that question on each of the codes.

MEMBER KRESS: What is it -- is it a difficult thing to transfer a code over to NRC? Does it cause you heartburn for some reason?

MR. GRESHAM: It will add a lot more time to the review process, that's one concern we have.

CHAIRMAN WALLIS: Our contention might be that it would simplify everything and make it a lot more efficient.

MEMBER KRESS: Save time.

CHAIRMAN WALLIS: Save time. You simply are open and say here is it. We think it's robust and you won't find any problems with it. Here it is. But if one has to dig. If one has to say well, I'm a little suspicious about this and Westinghouse has to go away on some things and has come back, and then you say well, maybe this other thing is something we have to worry about and then Westinghouse has to go away and answer that, that might be a very inefficient way of answering concerns. But you don't really know some concerns. They may get revealed as you begin that becomes something that is much quicker to resolve by having the code. This to and fro, taking months every time a question gets asked before you get an answer.

MR. GRESHAM: We certainly don't want that.

CHAIRMAN WALLIS: I think the ACRS has been saying we really support the idea of the staff wanting code and we think that's the most efficient in the long run, the most efficient way there is to assess a code.

MR. CORLETTI: This is Mike Corletti again. The other thing that we have seen that was very successful in us resolving issues on the AP600 was the staff's independent calculations of their independent codes. And those tended to both our analysis and their analysis demonstrated the real large margins of the AP600. We're not in the situation where we have the PCT of 2175 and it's really critical do we get -- are we at 28, 25 degree margin to cut this or not. Kind of where we are with AP600 for most of the small break LOCA no core uncovery. We really are far away from a lot of the limits that historically we've been concerned about.

CHAIRMAN WALLIS: I think that's also in the ACRS letters you'll find that we also support the idea of the staff having its independent code.

It really helps with the public confidence that someone else is running something independently and gets the same answer. It's something --

MR. GRESHAM: That's right.

MR. BOEHNERT: I was just going to comment on what Mike said. My recollection is a little different from Mike's and that is that there was a lot of problems with the codes, particularly NOTRUMP. There was a lot of back and forth and a lot of questions from both the staff and the ACRS and the code and I think it would have been much easier, quicker, if the staff had the code to resolve some of those issues. It turned out to be a very difficult situation.

MR. CORLETTI: And I think at the end all of our codes predicted the same thing, no core uncovery and we weren't anywhere near any regulatory limit, so really, were we talking about the importance of that code in measuring plant safety?

MR. GRESHAM: We do appreciate your feedback on that and we did listen.

Just to summarize, building on AP600 codes that were approved for AP600, we'll confirm the adequacy for AP1000 and address the concerns and there's a number of ways that that could be done. And culminating and confirming they're acceptable and getting some NRC agreement with that and proceed with the safety analysis. That's all I have.

I'll turn it back over to Mike for a brief wrap up.

MR. CORLETTI: That really does conclude our presentation today. I think it's worthwhile to summarize. Again, we've been working on this for quite a while, but I think this is certainly the beginning for you all and going on, I expect at least one more of these after the staff has had a chance to review our submittals. Again, the summary of our proposed approach, we really focused most of our efforts so far on how are the plants different and how are they the same for the important phenomena and really asses how well does the test data support an AP1000 Design Certification. How we used it on AP600 provided us the data to validate our codes. We're hoping that you'll agree that the test data base is sufficient, that it will provide an adequate data base for code validation, then we can concentrate on the validation of those codes and the issues related to those and how we actually would apply --

CHAIRMAN WALLIS: Why would it be any different from what we did for AP600 if the data that you're going to use are the same data and it's the same code, then why should there be anything different from what you did before? Is there something different about AP1000 that would make things different?

MR. CORLETTI: We're certainly starting there. We think it does deserve a review to make sure that there wasn't, like some of these residual issues that have been raised --

CHAIRMAN WALLIS: Well, what would you do, you're running the code to say compare with a ROSA test. You did that for AP600.

MR. CORLETTI: Yes, we did.

CHAIRMAN WALLIS: And you get some data points. Now what's going to be different about what you do now? You've got the same tests and the codes, what's different?

MR. CORLETTI: That is generally, we had to wait until we confirmed that the test was sufficient.

CHAIRMAN WALLIS: Then you don't need to do any more.

MR. CORLETTI: I think we owe it to the staff to go through some of the conditions, especially on like what was mentioned on the oxidation model. We have to commit to that kind of thing. If there is anything else that maybe was the way we resolve certain issues or certain REIs and are they still -- the way we resolve that still applicable? I think it deserves that it's really going to be the content of our Code Applicability Report.

But that generally is our approach and that is the approach that we're --

CHAIRMAN WALLIS: Do you expect some new comparisons between codes and data or just use the old one?

MR. CORLETTI: I think we would only use new comparisons if we had new test data or if there was test data that was new that was suggested that we use. There were additional tests that we didn't look at before because it was not available to us. There was the ROSA test.

CHAIRMAN WALLIS: You claim you can use the AP600 test program for AP1000.

MR. CORLETTI: Yes.

CHAIRMAN WALLIS: The AP600 is already being used to confirm that you can use the codes and you're going to use the same codes, what is left to do, except run the code?

MR. CORLETTI: We'll have to hear from the staff. I agree with your approach.

(Laughter.)

MR. CUMMINGS: I might comment. This is Ed Cummings. In a few cases, the staff accepted our codes. Our use of the codes on the AP600, because of their assessment of the plant safety rather than their love of the code. And you have to revisit those places where they accepted the use of the code because of the clear safety of the plant, to make sure you still have the same condition of acceptability.

MR. CORLETTI: Yeah, the core uncovery issue with some of the models that were employed in NOTRUMP and I'm not going to go any further than that, but I know there were some that we didn't have to evaluate because we didn't have core uncovery and it may -- if we had core uncovery or if we would get into that situation, maybe that would be something that we'd have to address.

MR. BROWN: Bill Brown. Dr. Wallis, a good example, to come back to what Paul Boehnert said was a NOTRUMP, for example, there was not a momentum flux model, okay? This was something that was identified by the ACRS. It's in the FSAR. If for some reason in AP1000 it was deemed that this model needs to be improved for acceptance of the code, then we would need to go back to just check that model and specifically validate that.

CHAIRMAN WALLIS: How would the staff know that? They'd have to really run the code with and without the momentum flux and find out if it mattered. They'd have to do it.

In other words, they wouldn't know if it's an important issue or not, would they?

MR. CORLETTI: I think there's other ways of doing that. There's independent type of evaluation, a phenomena with either a different independent code that says is this important or not. I guess it would be fully best not to get into too many what ifs until we really submit our report, but that's the nature of the kind of assessment we're doing.

CHAIRMAN WALLIS: So what's our role in all of this, ACRS, we're observing this.

MR. CORLETTI: I guess we would be interested in feedback on our overall approach. Are we doing the right thing in regards to our approach with looking at the test data, the kind of scaling approach that Bill has outlined, looking at the PIRT, looking at the scaling and then how we plan on our application of the codes.

MEMBER KRESS: I think we have a legal responsibility to sign off on the certification application.

MR. CORLETTI: That would be the later phase. I think in this pre-certification --

MEMBER KRESS: Not now, but then.

CHAIRMAN WALLIS: So you're going to make a presentation to the full Committee?

MR. CORLETTI: In April, there's a presentation of the full Committee. I think we only have two hours there.

CHAIRMAN WALLIS: They're liable to ask questions, so you have to be pretty brief.

MR. CORLETTI: And it will be on the whole -- there's a couple of issues we really didn't speak of today, so we'll give you a good -- an overview of the Phase 2 process and where we are in that process. We won't probably go into as many of Bill's scaling equations, but we'll probably give a higher level --

CHAIRMAN WALLIS: You need a matrix or something showing that the numbers come out all right.

MR. CORLETTI: Some of the members aren't probably familiar enough with AP600 either and we'll have to at least tell them how big of a test program that we did do. I mean they don't realize we did a $40 million test program on the AP600.

CHAIRMAN WALLIS: Let me ask you a

question, a lot of it, you say, has to be resolved with the staff. So I wonder how we can give the Commission advice until we see how your discussion with the staff works out. We haven't really seen that. We've just seen something that you've presented and you say now we have to discuss with the staff.

Should we be giving the Commission advice until we find out how the staff responds to that?

MR. CUMMINGS: I don't think we can comment on that.

MR. CORLETTI: We were interested in what you had to say about our approach so far, that's probably -- and maybe the staff is also. I don't want to speak for the staff.

CHAIRMAN WALLIS: Well, then I think we've seen some scaling analysis or that's most of what we saw. We might be able to respond to that. The question about whether or not the staff should accept these codes without further requirements, I'm not sure we're in a position to reach any conclusion about that yet.

MR. CORLETTI: Without having seen our code applicability report. I guess some of this starting with where we left off on AP600, addressing the major issues from that and that's sort of an approach question.

MR. CUMMINGS: This is Ed Cummings. Within this Phase 2, however, you will have the code acceptability report.

CHAIRMAN WALLIS: Right.

MR. CUMMINGS: Applicability report and at the end I think we'd like the NRC to address our request which is can we do AP1000 without incremental tests and with the existing codes as modified by our mutual agreement. That's where we'd like to end up with in Phase 2. It says nothing, by the way about what the acceptability of the safety analysis is. That's a Design Certification.

CHAIRMAN WALLIS: We might agree that the AP1000 phenomena is similar to AP600. I think we might be able to agree to that. We might be able to agree that you've given some demonstrations of scaling.

Whether or not the scaling represents adequate validation basis for codes, I wouldn't be sure, myself, until I found out what I needed to know in order to get these adequate validations. So until you actually start doing some things with the codes, I'm not quite sure what is an adequate validation basis. It's a carte blanche that says because you've demonstrated some scaling you've got an adequate validation basis for code. It may be a little hard for us to give you.

MR. CORLETTI: That is based on that data base was sufficient to validate codes for AP600.

CHAIRMAN WALLIS: We don't know what the questions are for AP1000. There may be different questions that come up for AP1000. It's not clear that --

MR. BROWN: I think one example of that which worked out well was -- maybe I shouldn't say well, one example was when we got down to the end to focus on the ADS to IRWST injection phase and we had done, obviously -- we had already done a large bulk of scaling, but for example, this is where that momentum flux issue had come up and in fact, I had gone back and Mike Young from Westinghouse and we had looked at scaling in more detail to come up with the largely hated level penalty approach in NOTRUMP. But again, we went back to scaling for that purpose. So that's probably a good example of something that you're talking about, Dr. Wallis, that we did in AP600. It could come up later.

CHAIRMAN WALLIS: Are you expecting a letter from the Committee or are you expecting to just inform the Committee and wait until we meet again?

MR. CORLETTI: For today's meeting?

CHAIRMAN WALLIS: No, for the full Committee. Do you expect the Committee to write a letter based on what you told them or would you --

MEMBER KRESS: For the April meeting, you mean?

CHAIRMAN WALLIS: View the meeting as being more informative to say this is -- now you can't dispute about where we are.

MR. CORLETTI: We didn't have expectations of a letter, nor did we have expectations of a letter for this meeting.

CHAIRMAN WALLIS: I think it's a little difficult again to write a letter without some substantial input from the staff. In other words, we'd be short-circuiting them. We don't know what their questions may be. They may have concerns we don't know about.

MR. CORLETTI: We agree.

CHAIRMAN WALLIS: Other Members have points you want to raise before you hear form the staff?

MR. CORLETTI: That ends our presentation.

CHAIRMAN WALLIS: I'd like to thank you

for a pretty clear and professional presentation and being very willing to respond to our questions.

MR. CORLETTI: Thank you very much. It's been our pleasure.

CHAIRMAN WALLIS: Can we now hear from the staff?

MR. WILSON: This is Jerry Wilson with NRR. I don't have a formal presentation. I just want to say that staff hasn't officially started its review yet. We're waiting for the remaining submittal from Westinghouse. At that time we're going to do an acceptance review to determine if there's sufficient information to start an efficient review at this time. If there is, then we're going to establish a review schedule, review the information, prepare recommendations on responses to the report questions that Westinghouse has asked and we're going to send a report to the Commission telling the Commission how we plan to answer those questions.

Now we -- I anticipate that the Commission is going to hear from the ACRS on that so we'll be prepared to come and brief the ACRS on our response to the questions that Westinghouse has asked us.

MEMBER SHACK: Will this response be in the form of an SER, for example, on these reports?

MR. WILSON: I wouldn't call it an SER, but it's some sort of a NUREG report and it's kind of like a traditional SER. We're going to have a report and it will be transmitted via a SECY paper.

CHAIRMAN WALLIS: What about the issue of exercising the codes themselves? Do you have a position on that?

MR. CARUSSO: This is Ralph Carusso. I just reiterate the point that Jerry made earlier that we have sent the letter to Westinghouse asking for these codes and we're prepared to run them. And if they've not made the decision yet to provide us with the codes then that's something we'll have to talk to them about.

CHAIRMAN WALLIS: It seems to me we're fairly early in the process. You haven't started a review yet.

MR. WILSON: That's correct.

CHAIRMAN WALLIS: It's premature for us to reach any conclusions at this time.

MR. WILSON: Right.

CHAIRMAN WALLIS: That's it from the staff?

MR. WILSON: Yes, it is.

CHAIRMAN WALLIS: Do you have anything

more to say about any --

MR. WILSON: I don't anticipate that we will.

CHAIRMAN WALLIS: Do my colleagues have questions to raise?

MEMBER KRESS: No questions at this time.

CHAIRMAN WALLIS: Could we meet perhaps to discuss this before we go home, go to dinner?

MEMBER KRESS: Sure.

CHAIRMAN WALLIS: Compare our thoughts and notes.

MEMBER KRESS: Yes.

CHAIRMAN WALLIS: Is there any reason why I shouldn't declare the meeting closed?

MEMBER KRESS: I think it will be a good idea.

CHAIRMAN WALLIS: I'll do so then.

(Whereupon, at 5:33 p.m., the open meeting was concluded and the closed meeting commenced.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Docket Number: (NOT APPLICABLE)

Location: ROCKVILLE, MARYLAND

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

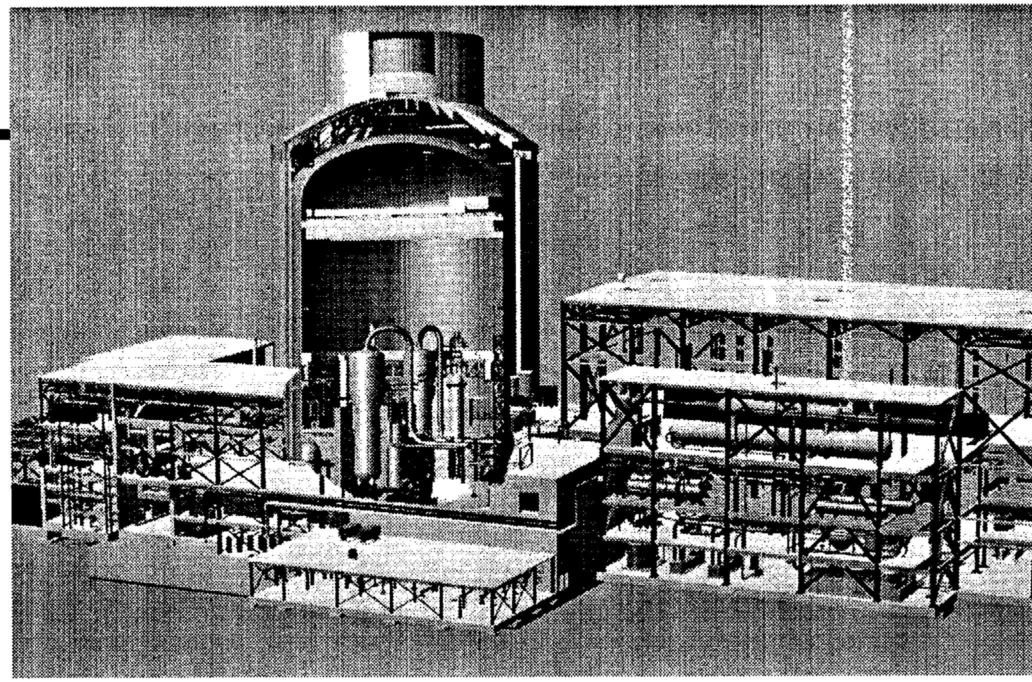
John Mongoven
John Mongoven
Official Reporter
Neal R. Gross & Co., Inc.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE MEETING
WESTINGHOUSE PROPOSED APPROACH TO ADDRESS AP1000 T/H ISSUES
MARCH 15, 2001
ROCKVILLE, MARYLAND

Contact: P. Boehnert (301/415-8065/"pab2@nrc.gov")

PRESENTATION SCHEDULE

TOPIC	SPEAKER	TIME
I. Introduction	G. Wallis, Chairman	1:00 p.m.
II. Westinghouse Presentation: Proposed Approach to Address AP1000 T/H Issues		
A. AP1000 Pre-Certification Review Overview	M. Corletti	1:10 p.m.
B. AP1000 Plant Description • Differences from AP600 Design	M. Corletti	1:30 p.m.
C. AP1000 Passive Safety Systems Design and Analysis	T. Schulz	2:00 p.m.
D. Review of AP1000 PIRT and Scaling Approach (**Closed**)	W. Brown	2:40 p.m.
E. Approach to the Application of Analysis Codes to AP1000 (**Closed**) • Include Discussion of Need for Uncertainty Assessments	J. Gresham	4:30 p.m.
F. Concluding Remarks	M. Corletti	4:50 p.m.
III. NRR Staff Presentation: Comments on Westinghouse Approach • Schedule Milestones • Potential Problem Areas (if any)	J. Wilson	5:00 p.m.
IV. Subcommittee Caucus • Follow-on Items from this Meeting • Future Actions • Committee Action		5:30 p.m.
IV. Adjourn		5:45 p.m.



AP1000 Pre-Certification Review

Kick-off Meeting with Thermal-Hydraulics Subcommittee of the Advisory Committee on Reactor Safeguards

March 15, 2001

Agenda

• 1:10	AP1000 Pre-Certification Review Overview	Mike Corletti
• 1:30	AP1000 Plant Description Overview	
• 2:00	AP1000 Passive Safety Systems Design and Analysis	Terry Schulz
• 2:40	Review of AP1000 PIRT and Scaling Approach (Closed session)	Bill Brown
• 4:30	Approach to the Application of Analysis Codes (Closed session)	Jim Gresham
• 5:00	Closing Remarks	Mike Corletti
• 5:15	NRC Staff	Jerry Wilson

Purpose of Today's Meeting

- Informational Meeting
  - Introduce ACRS T-H Subcommittee to AP1000
  - Explain the objectives of the AP1000 Pre-Certification Review
  - Review our proposed approach to resolution of two key issues:
    - Applicability of AP600 test data to support AP1000 Design Certification
    - Applicability of analysis codes approved for AP600 to the AP1000
- Feedback on our approach
- Expectations for future meetings

AP1000 Pre-Certification Review Overview

Mike Corletti
AP600 Engineering

AP600 Major Uprate - Objectives

- Increase Plant Power Rating to Reduce Cost
  - Obtain a capital cost that can compete in U.S. market $900-1000/KWe for n^{th} twin plant

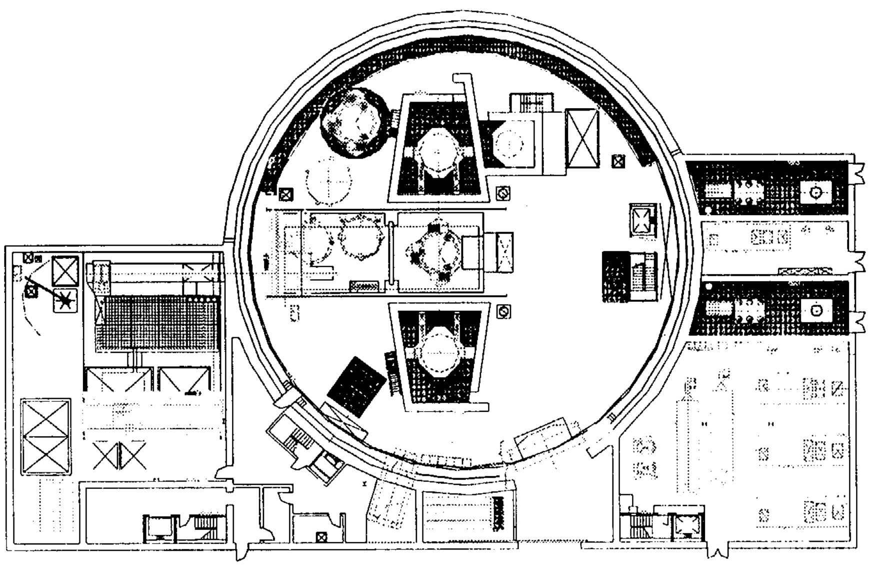
- Retain AP600 Objectives and Design Detail
  - Increase the capability/capacity within "space constraints" of AP600
  - Retain credibility of "proven components"
  - Retain the basis for the cost estimate, construction schedule and modularization scheme

- Retain AP600 Licensing Basis
  - Meet regulatory requirements for Advanced Passive Plants
  - Accept AP600 policy issues

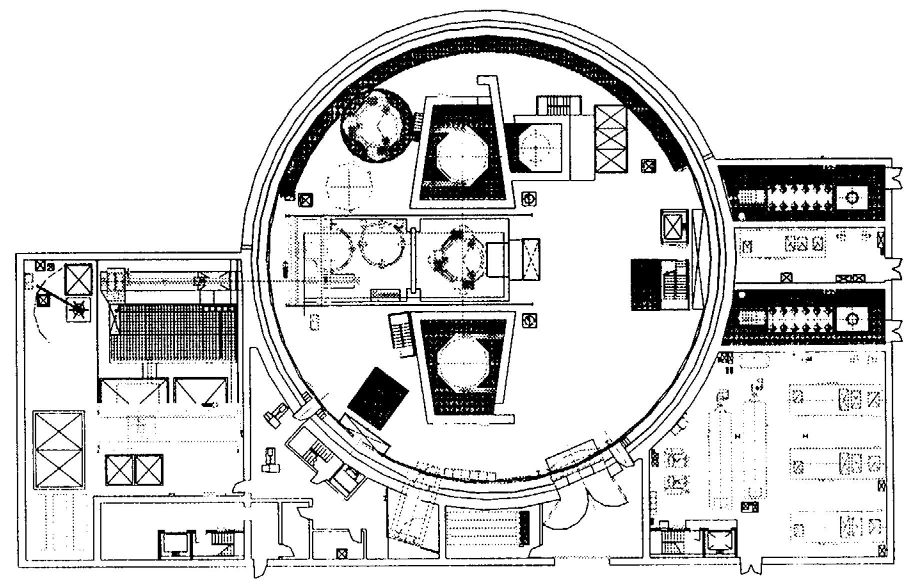
AP1000 General Arrangement

Plan at Elevation 135'

AP600



AP1000



AP1000 Pre-Certification Objectives

- Obtain agreement on how AP600 Certification can be used as a basis for AP1000 Design Certification
  - Improve efficiency of licensing process
  - Identify path for leveraging AP600 Certification to AP1000

- How do we plan on meeting this objective?
  - 3-Phase Approach Suggested by NRC
    - Phase 1 - Identified 6 issues to evaluate in Pre-certification review
      - Issues that potentially have a large impact on design certification licensing cost and schedule
        - ACRS provided insights and guidance
    - Phase 2 - Pre-certification review of the issues identified
      - Two items deferred until Design Certification due to W budget contraints
        - Portions of AP600 SSAR retained for AP1000 - 80%
        - Application of AP600 PRA to AP1000
    - Phase 3 - Design Certification

AP1000 Phase 2 Issues

1. Sufficiency of AP600 Test Program to meet 10 CFR Part 52 requirements for AP1000

2. Applicability of NRC-approved AP600 analysis codes for AP1000 Design Certification

3. Acceptability of using Design Acceptance Criteria in selected areas

4. Applicability of Exemptions granted to AP600

Phase 2 Review Status

- Plant Description and Analysis Report - December 2000
  - Plant Design Comparison
  - Safety system margins assessment
  - Safety analysis assessments using AP600 analysis codes
    - Characterize performance of passive safety systems

- PIRT and Scaling Assessment Report - March 2001
  - AP1000 PIRT and Comparison to AP600 PIRT
  - AP600 Test Program Overview and Applicability to AP1000
  - AP1000 Scaling Assessments
    - Separate effects & integral systems tests

- AP1000 Code Applicability Report
  - Planned approach for use of analysis codes for AP1000

AP1000 Plant Description & Analysis Report

WCAP-15612
December 2000

Comparison of Selected Parameters

PARAMETER	AP600	AP1000
Net Electric Output, MWe	610	1090
Reactor Power, MWt	1933	3400
Hot Leg Temperature, °F	600	615
Number of Fuel Assemblies	145	157
Type of Fuel Assembly	17x17	17x17
Active Fuel Length, ft	12	14
Linear Heat Rating, kw/ft	4.10	5.71
Control Rods / Gray Rods	45 / 16	53 / 16
R/V I.D., inches	157	157
Steam Generator Surface Area, ft^2	75,000	125,000
Reactor Coolant Pump Flow, gpm	51,000	75,000
Pressurizer Volume, ft^3	1600	2100
Containment Diameter / Height, ft	130 / 190	130 / 215

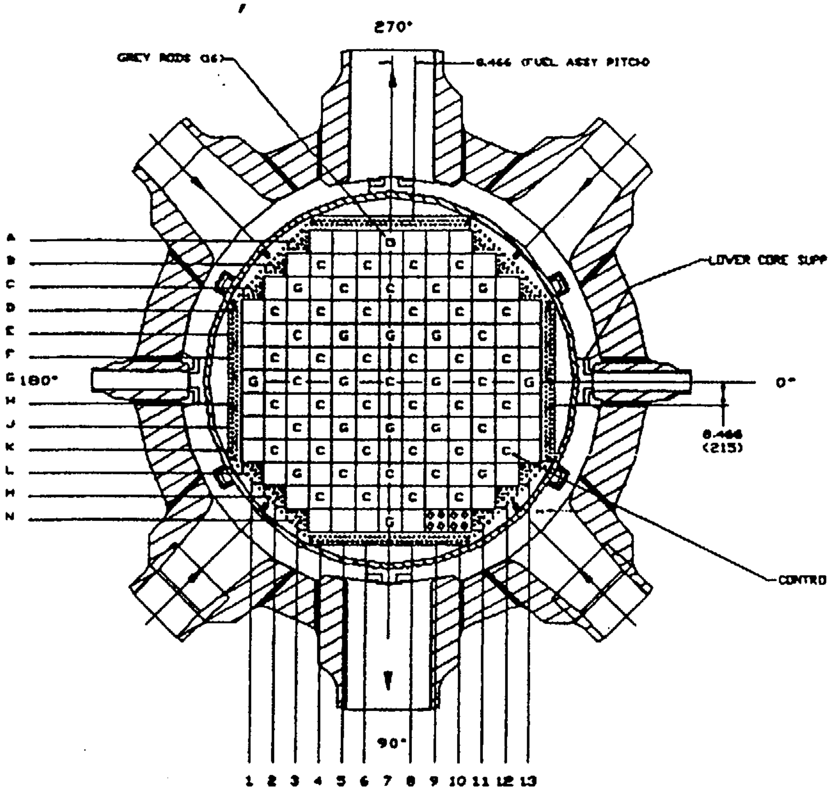
AP600 Major Uprate

- Select proven fuel design
  - W 3XL and 4XL designs
    - Doel 4, Tihange 3, South Texas Units 1 & 2
      - 14 ft active fuel length
      - 17 x 17
    - Core power density increased
      - Same as operating 3-loop plants

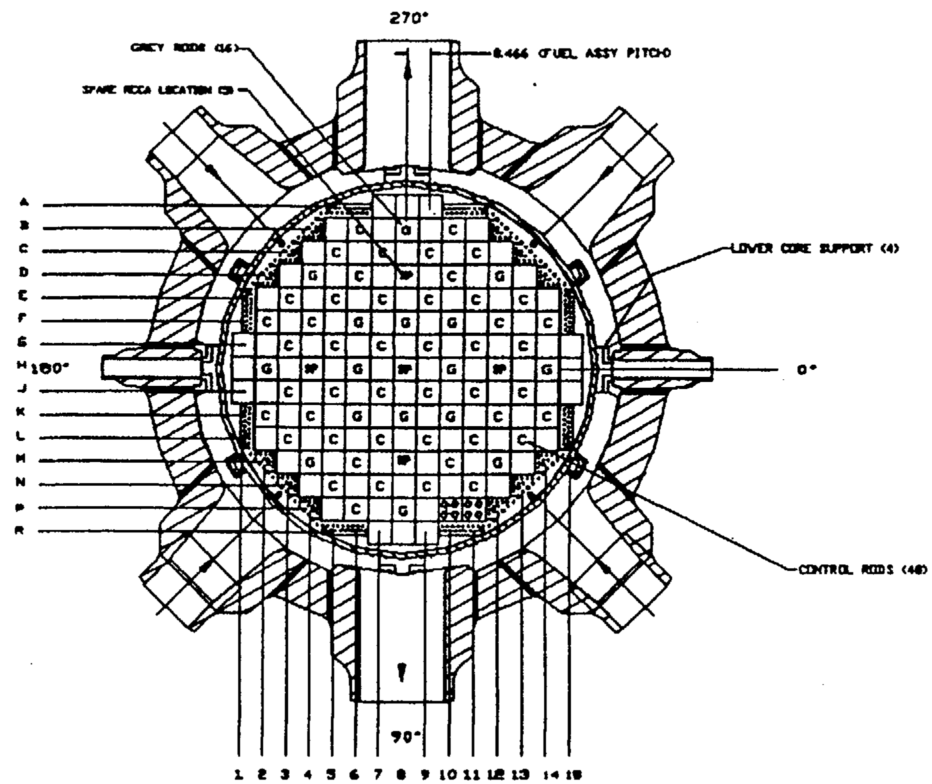
- Size key NSSS components
  - Reactor Vessel - Similar to Doel 4; Tihange 3
  - Steam Generator - Δ125 similar to ANO replacement
  - Reactor Coolant Pump - increase capacity
  - Pressurizer - increase volume

Core Design

AP600



AP1000

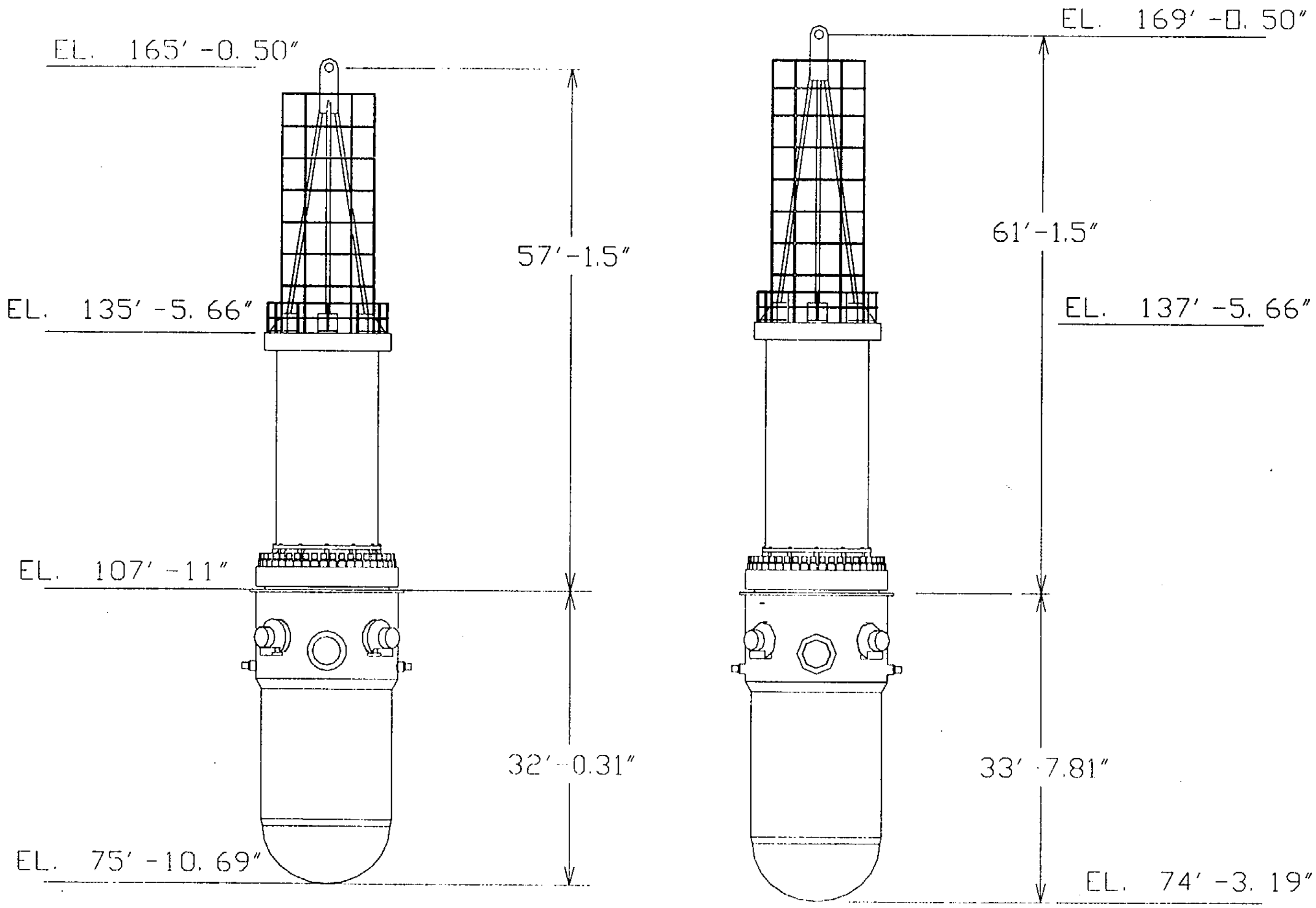


- Number of Fuel Assemblies Increased from 145 to 157
- Active fuel length increased from 12 ft to 14 ft
- Number of Control Rods Increased from 45 to 53

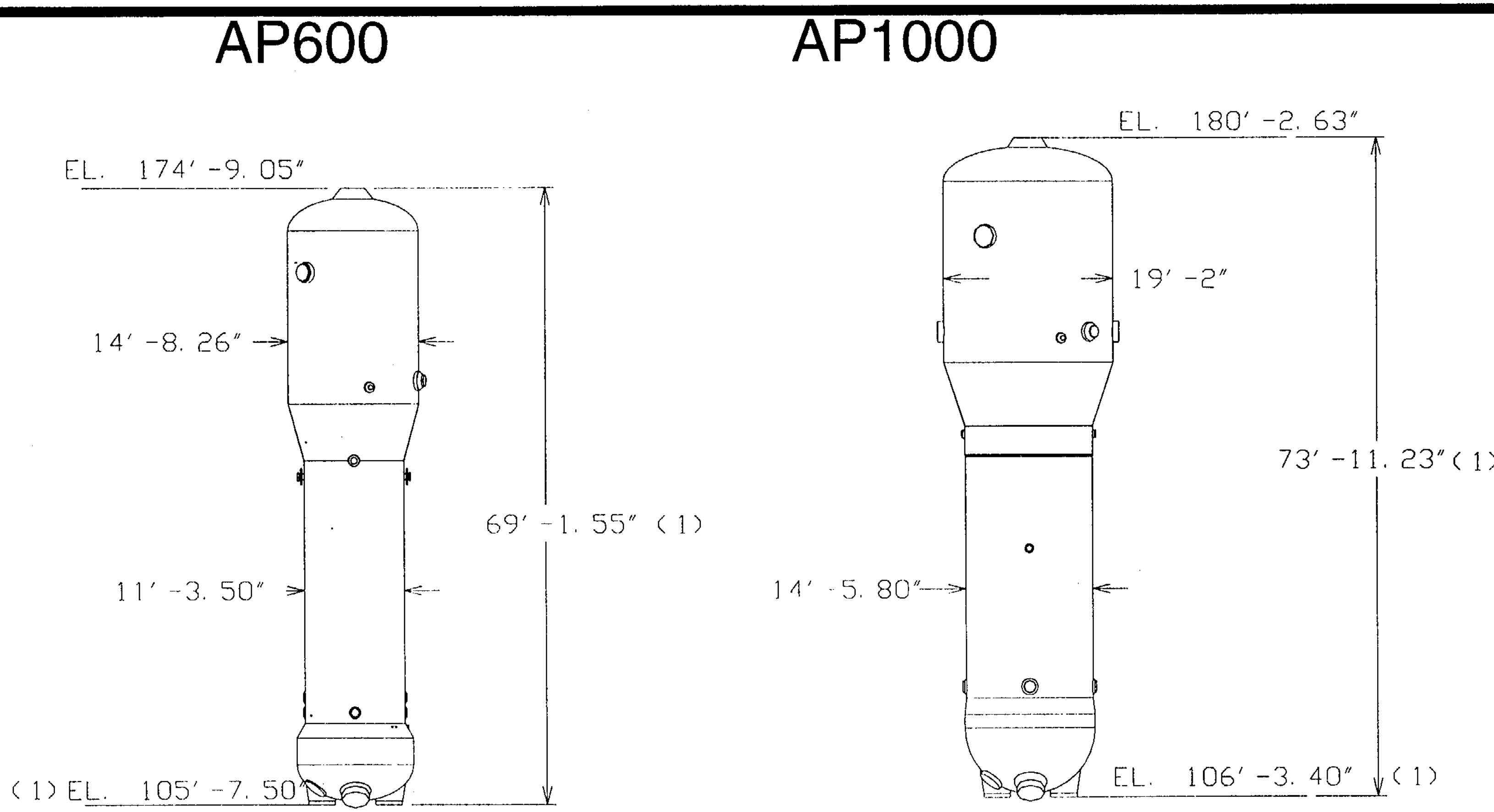
Reactor Vessel

with Integrated Head Package

AP600 AP1000



AP1000 Δ125 Steam Generator

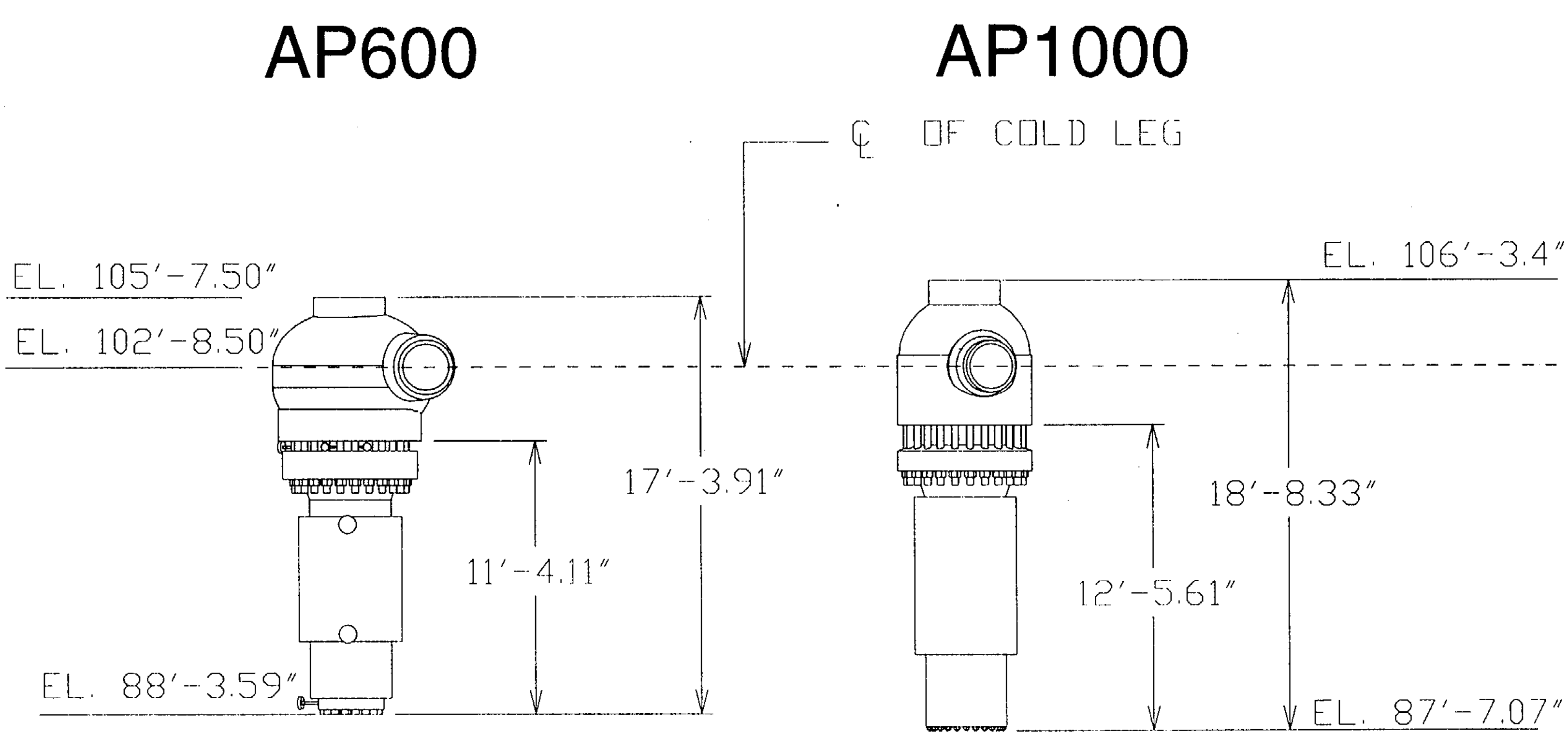


(1) - S/G OUTLET NOZZLE TO RCP CASING WELD

Reactor Coolant Pump

- AP600 RCP based on proven motor design
- Increase capacity for AP1000
  - AP1000 higher power density core requires longer flow coast down - more pump inertia
  - Pump flow requirements increased to accommodate higher core power
- Impacts to pump design minimized
  - Use motor rating at hot coolant condition
  - Variable speed controller added to reduce motor power in cold coolant conditions
    - Only used during shutdown operations
  - Use APWR hydraulics

Reactor Coolant Pump



Parameter	AP600	AP1000
Design Flow, gpm	51,000	75,000
Design Head, ft	240	350
Rotating Inertia, lb-ft^2	5,000	15,000
Motor Rating, Hp	3200	6000

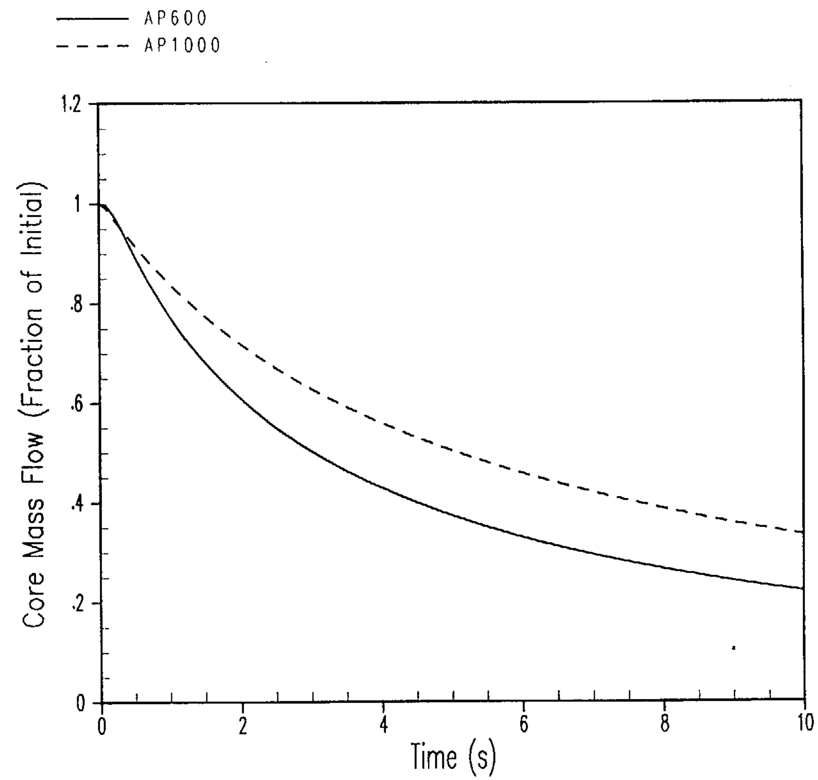
AP1000 Safety Assessment

- Analysis of complete loss of RCS flow
  - Conservative analysis to assess pump coastdown
  - Same assumptions and methods as AP600
    - Rod Drop Times ➔ Longer
      - Longer Fuel
      - Higher RCS Flow
    - Pump Coastdown ➔ Longer
      - Pump inertia increased
- Acceptance Criteria
  - RCS and SG pressures < 110% of Nominal
  - DNBR within acceptable limits

Complete Loss of RCS Flow Assessment

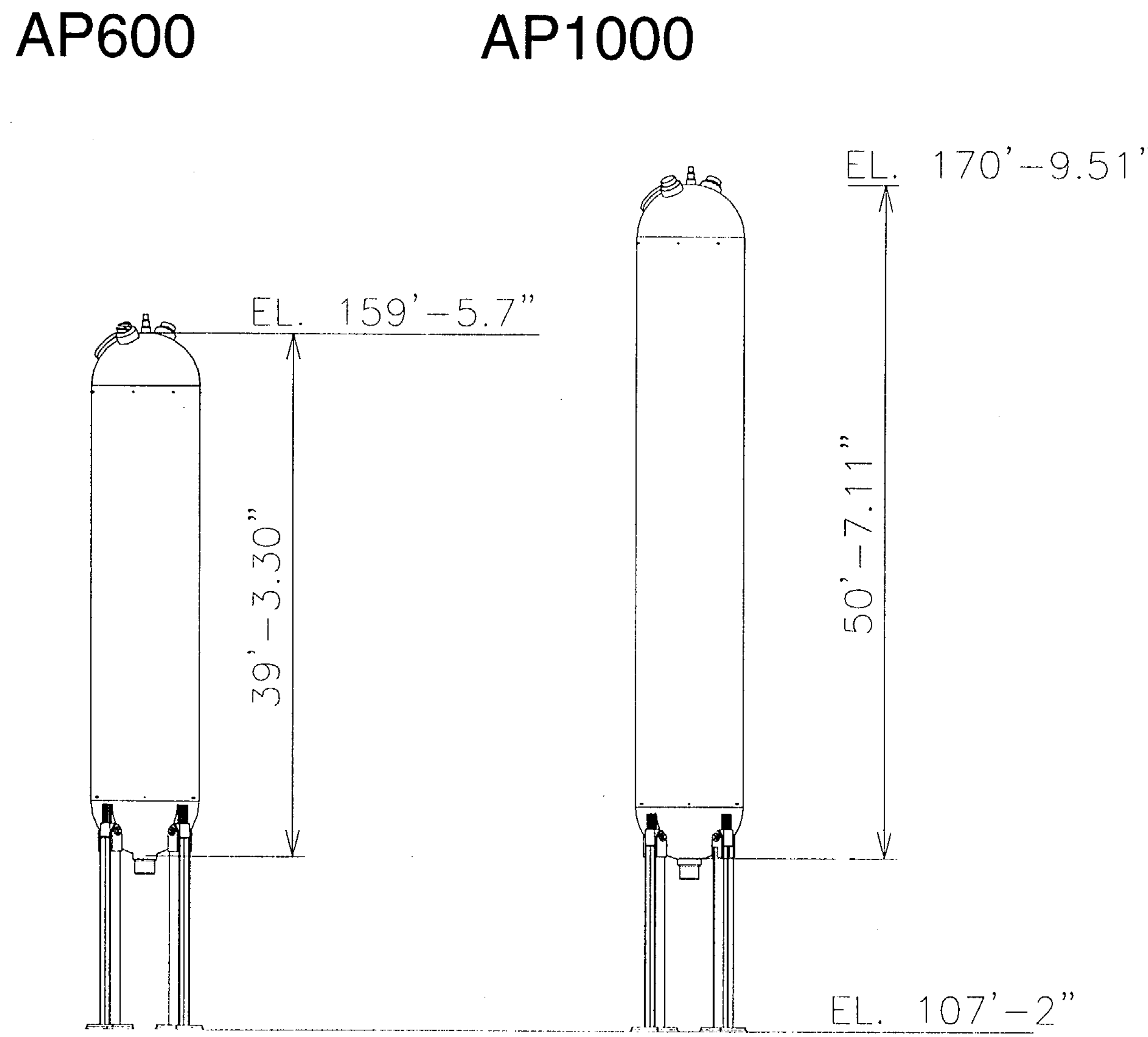
Preliminary analysis show DNBR margin is similar for both plants

AP1000 flow at time of minimum DNBR is within limits of standard plant DNB correlation



	AP1000	AP600
DNBR Limit (typical cell)	**1.24**	**1.24**
Minimum DNBR	**1.447**	**1.484**
DNBR Margin	**13.6%**	**15.8%**
Mass Flow (lbm/hr-ft^2)	**1.11×10^6**	**0.78×10^6**

Pressurizer

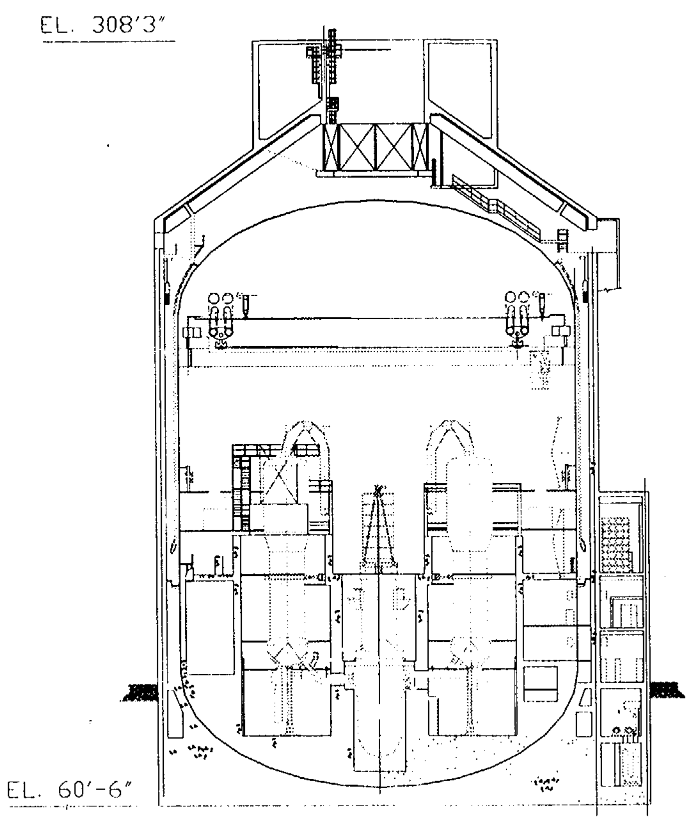


- Pressurizer volume increased from 1600 ft^3 to 2100 ft^3

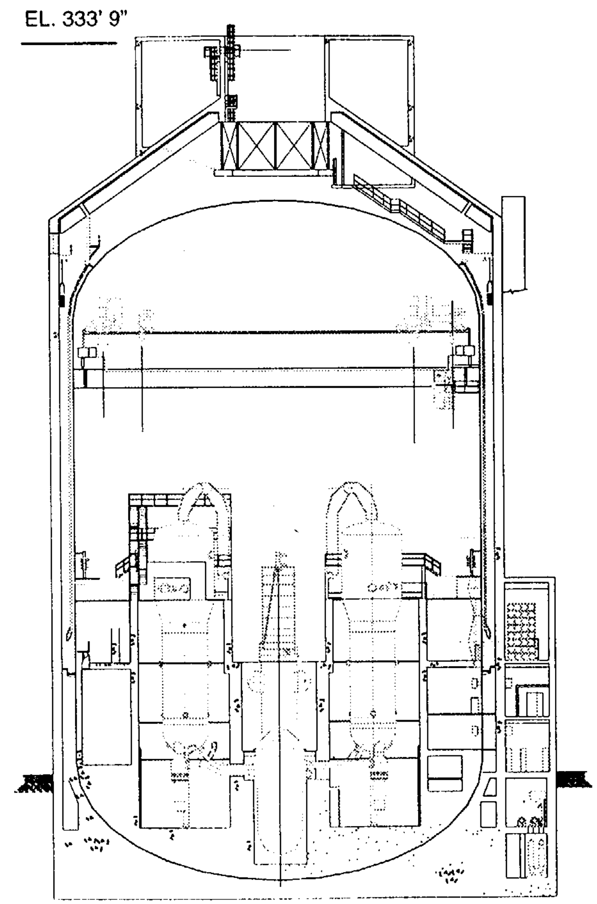
AP1000 General Arrangement

Containment Section View

AP600



AP1000



AP1000 Passive Safety Systems

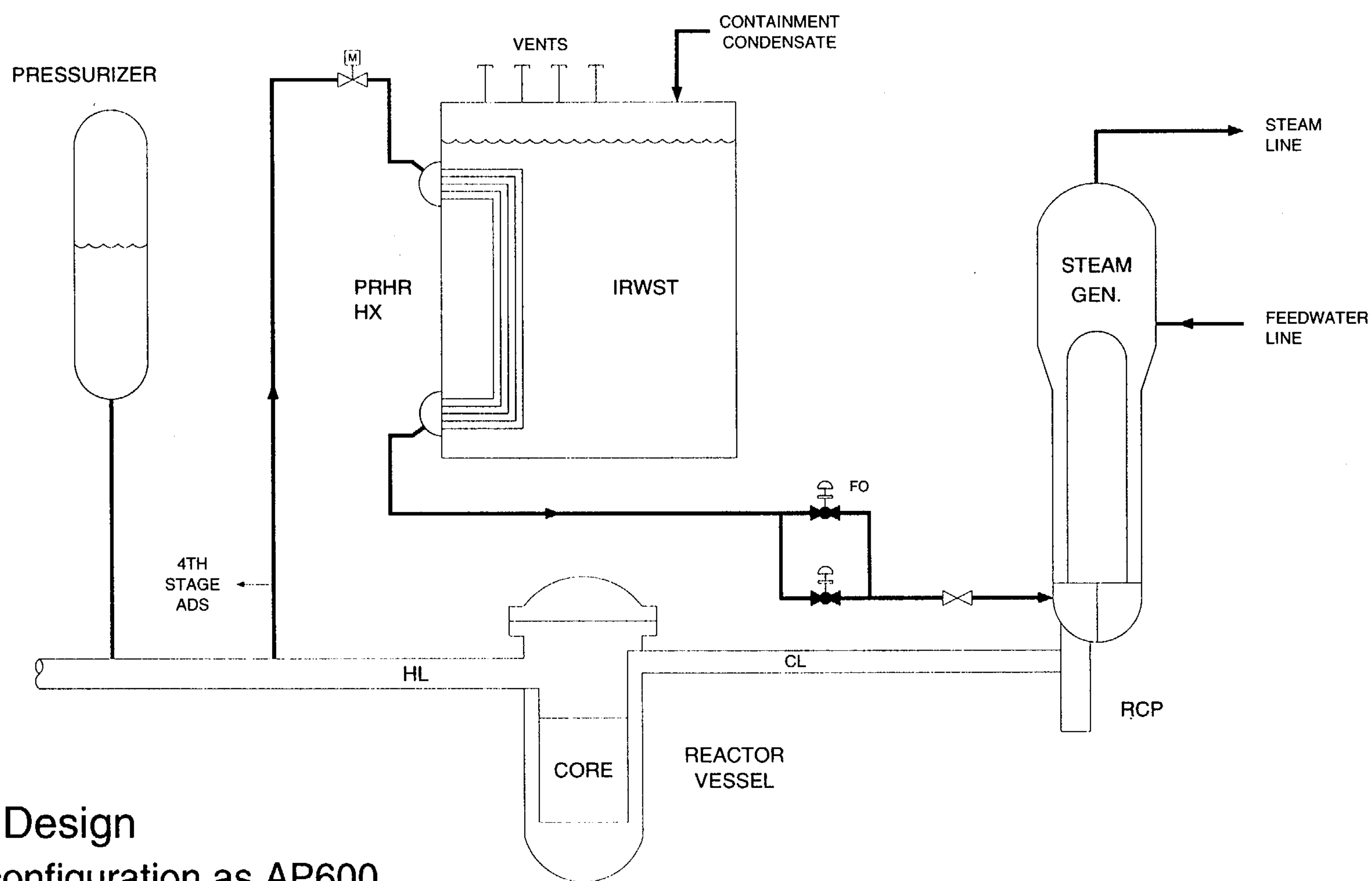
Terry Schulz
Advisory Engineer

- **AP1000 Passive Safety Systems Design**
  - Design Changes
  - Margins Assessment
    - Using first principals hand calculations
  - Supporting Plant T&H Analysis
    - Using SSAR computer codes to assess system changes
    - Not final Chapter 15 safety analysis

AP1000 Passive Safety Systems Design

- AP1000 Design Approach
  - Use AP600 configuration / arrangement
  - Increase capacities as needed to
    - Maintain adequate safety margins
      - ◆ Consider both deterministic and probabilistic criteria
        - – Meet deterministic safety criteria
        - – Maintain PRA success criteria for Level 1 and Level 2
      - ◆ Provide margin where there is uncertainty in AP600 tests / computer codes

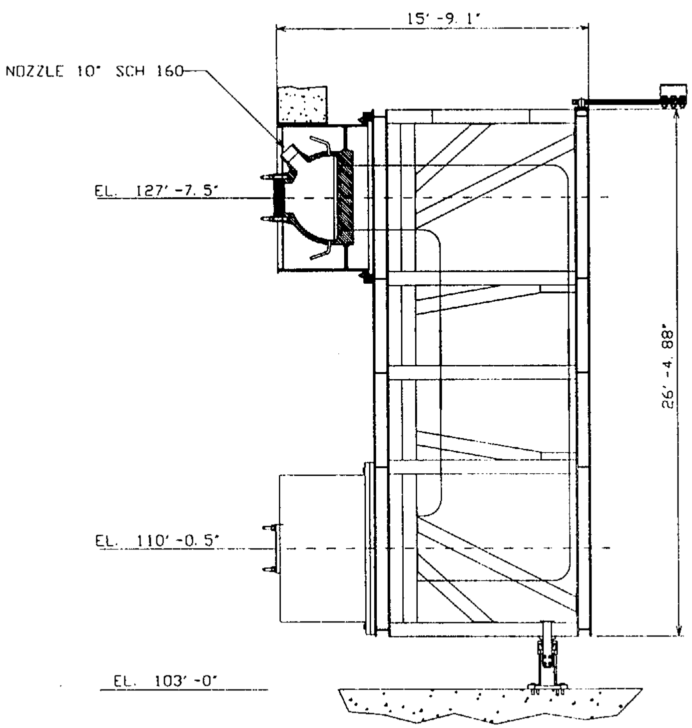
Passive Decay Heat Removal



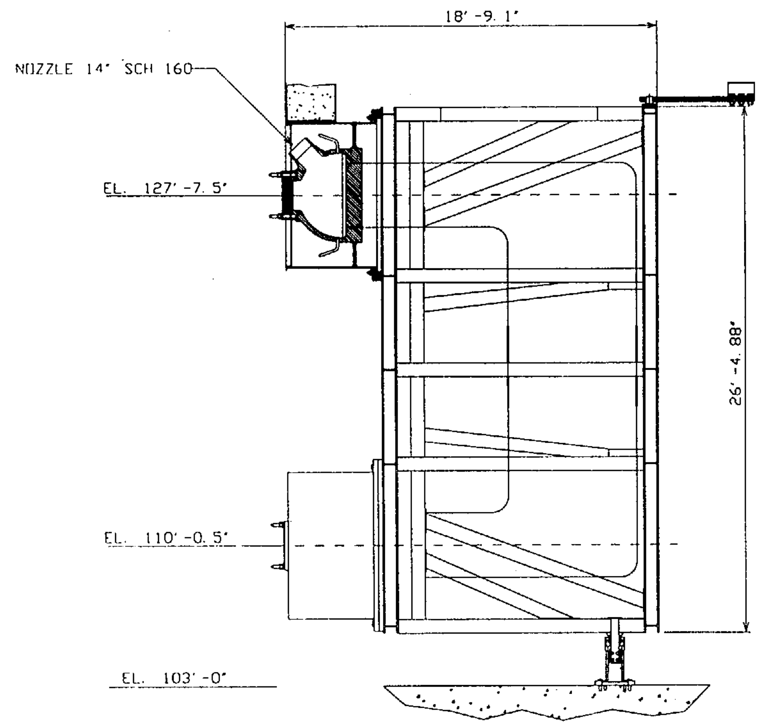
- PRHR HX Design
  - Same configuration as AP600
  - Same elevations as AP600
  - Larger pipe sizes (14 vs 10")

Passive RHR Heat Exchanger

AP600



AP1000



- PRHR HX Surface Area Increased 22%
  - Added 18 tubes
  - Increased horizontal tube length 3'

PRHR Margin Assessment

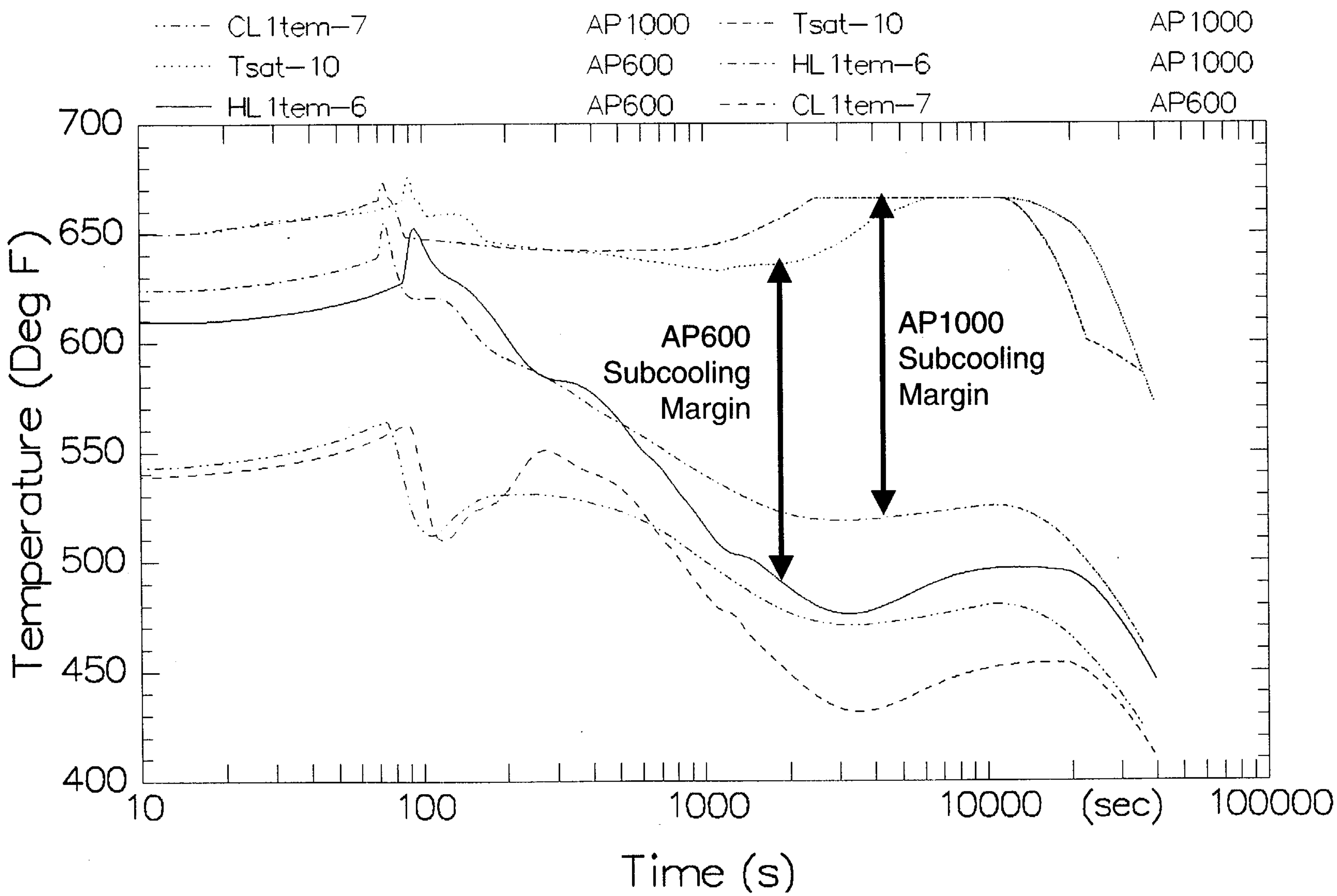
	AP600	AP1000
PRHR HX Surface Area	100%	122%
PRHR HX Line Sizes, Inlet / Oulet	10”	14”
PRHR Flow Path Resistance	100%	33%
Calculated PRHR Heat Transfer (Nat Circ)		
, HL temperature	556 F	567 F
, HX outlet temperature	178 F	197 F
, HX flow rate	100%	174%
, Heat transfer	>>> 100% <<<	>>> 172% <<<
, Peak Heat Flux (Nat Circ)	100%	131%
, Margin to critical heat flux	63%	51%
Time to Match Decay Heat (min.)	38	44
SG Secondary Side Water		
, Initial Water Mass per MW	100%	136%
, Final Water Mass per MW	>>> 100% <<<	>>> 212% <<<

- **AP1000 PRHR HX Expected to Increase Margins**
  - PRHR HX heat transfer capacity increased by core power ratio (176%)
  - SG secondary mass increased greater than core power ratio

AP1000 PRHR HX T&H Assessment

- Transient Analysis Performed on AP1000
  - Assess adequacy of PRHR HX changes
  - Same assumptions and methods as AP600
    - Conservative inputs and models
  - Following transients were analyzed for AP1000
    - Loss of AC Power
    - Loss of Feedwater
    - Feedwater Line Break
    - Steam Generator Tube Rupture

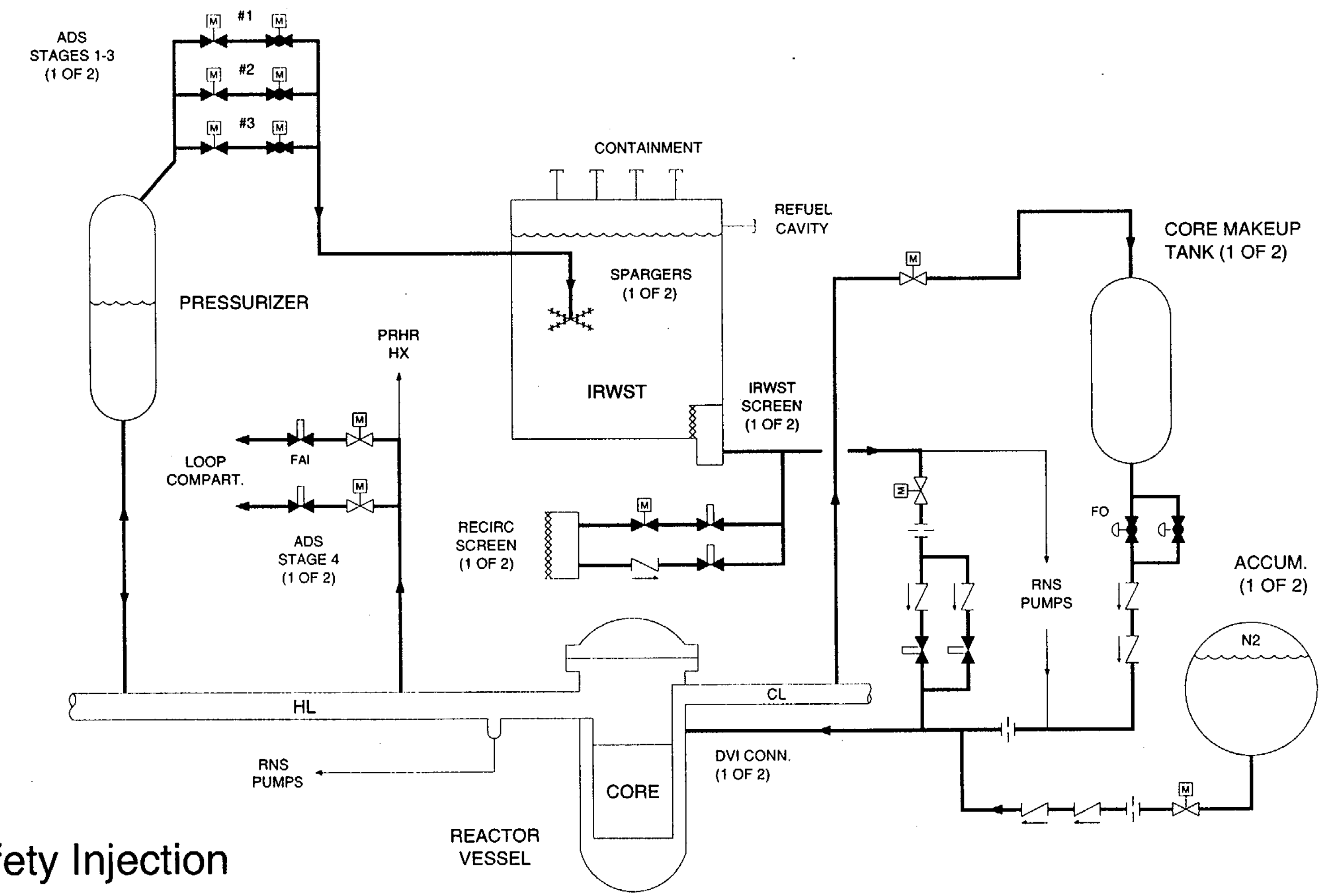
Feedline Rupture - Comparison



AP1000 PRHR HX T&H Assessment

- Scoping AP1000 Transient Analysis Indicates Comparable Margin to AP600
  - Plant behavior is similar to AP600
    - Large subcooling margin is maintained
    - AP600 & AP1000 provide more margin than operating plants

AP1000 Passive Safety Injection



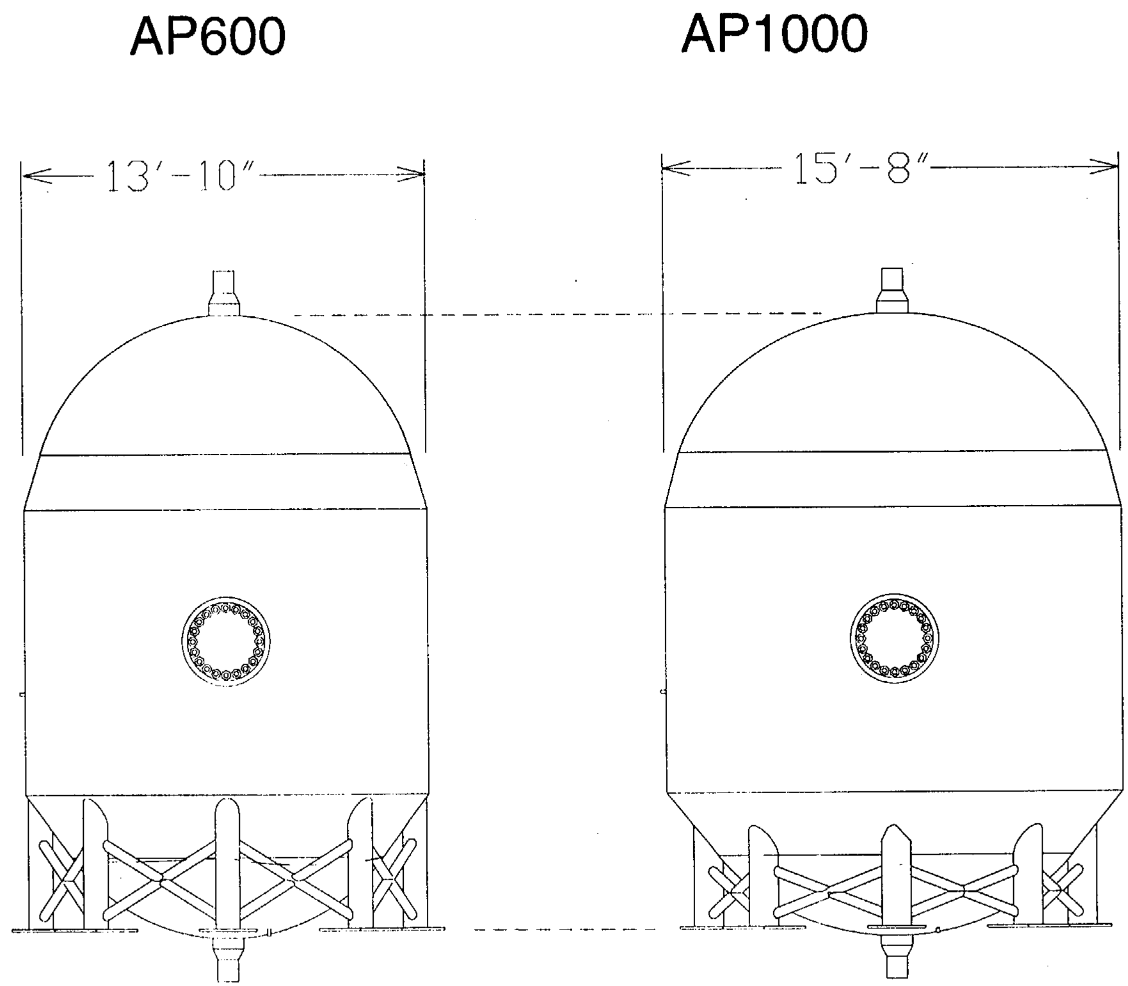
- Passive Safety Injection
  - Same Configuration as AP600
  - Larger CMT and CMT flow tuning orifice
  - Larger IRWST, Recirc, ADS 4 pipe sizes

Accumulator Margin Assessment

	AP600	AP1000	
		Case 1	Case 2
Accumulator injection capability	100%	100%	100%
End of blowdown PCT (F)	1100	~1100	~1200
Reflood heatup duration (sec)	43	~43	~50
Full power linear power (kw/ft)	4.10	5.707	5.707
Reflood PCT temperature rise (F)	290	~410	~470
Reflood PCT without uncertainty	1390	~1510	~1670
Reflood PCT with uncertainty	>> 1644 <<	>> ~1770 <<	>> ~1940 <<

- AP1000 Accumulator Expected to Provide Adequate Margin
  - AP1000 uses same accumulator capacity as AP600
    - Water volume, gas pressure, line resistance
    - Same mitigating feature as operating plants, little uncertainty
  - Large LOCA PCT should have comfortable margin
    - Same reactor vessel lower plenum volume
    - Similar to operating plants, less than AP600
  - Sufficient flow rate / duration to mitigate small LOCA's

Core Makeup Tanks



- **Core Makeup Tank Volume and Flow Rate Increased 25%**
  - 2000 to 2500 ft^3

CMT Margin Assessment

	AP600	AP1000
CMT line resistance (outlet CMT to DVI)	100%	64%
CMT flow capability	100%	125%
Time accumulators empty in a DVI LOCA (sec)	600	600
CMT flow capability vs. required flow (flow required to remove decay and sensible heat at time of accumulator empty)	>>> 138% <<<	>>> 129% <<<

- **Core Makeup Tank Expected to Provide Adequate Margins**
  - Both tank volume and flow capacity increased by ~ 25%
    - Maintains injection duration of CMT same as AP600
    - Maintains time available for ADS to depressurize RCS to IRWST cut-in
  - AP1000 CMT has sufficient capability to mitigate small LOCA's
    - Increase in CMT would not be required for DBA small LOCA's
    - Increase in CMT capacity provides margin for DBA small LOCA's and multiple failure accidents

ADS Margin Assessment

	AP600	AP1000
ADS 4 valve vent flow area	100%	176%
ADS 4 flow resistance	100%	28%
ADS 4 differential pressure	100%	100%
ADS 4 vent flow capability	>>> 100% <<<	>>> 189% <<<

- **AP1000 ADS Expected to Provide Increased Margin**
  - ADS 1, 2, 3 not changed
    - Not important in providing IRWST injection / containment recirc
    - Water in Pzr severely limits vent flow at low pressure
  - ADS 4 capacity increased
    - Very important in providing IRWST injection / containment recirc
    - Line sizes increased
      - HL common line increased from 12” to 18”
      - ADS 4 valve line increased from 10” to 14”

IRWST Margin Assessment

	AP600	AP1000
IRWST injection line resistance	100%	32%
IRWST initial water level (ft)	130.00’	131.58’
DVI nozzle elevation (ft)	99.00’	99.00’
RCS pressure - containment pressure (psi)	4.0	4.0
Available driving pressure (%)	100%	108%
IRWST injection flow	>>> 100% <<<	>>> 184% <<<

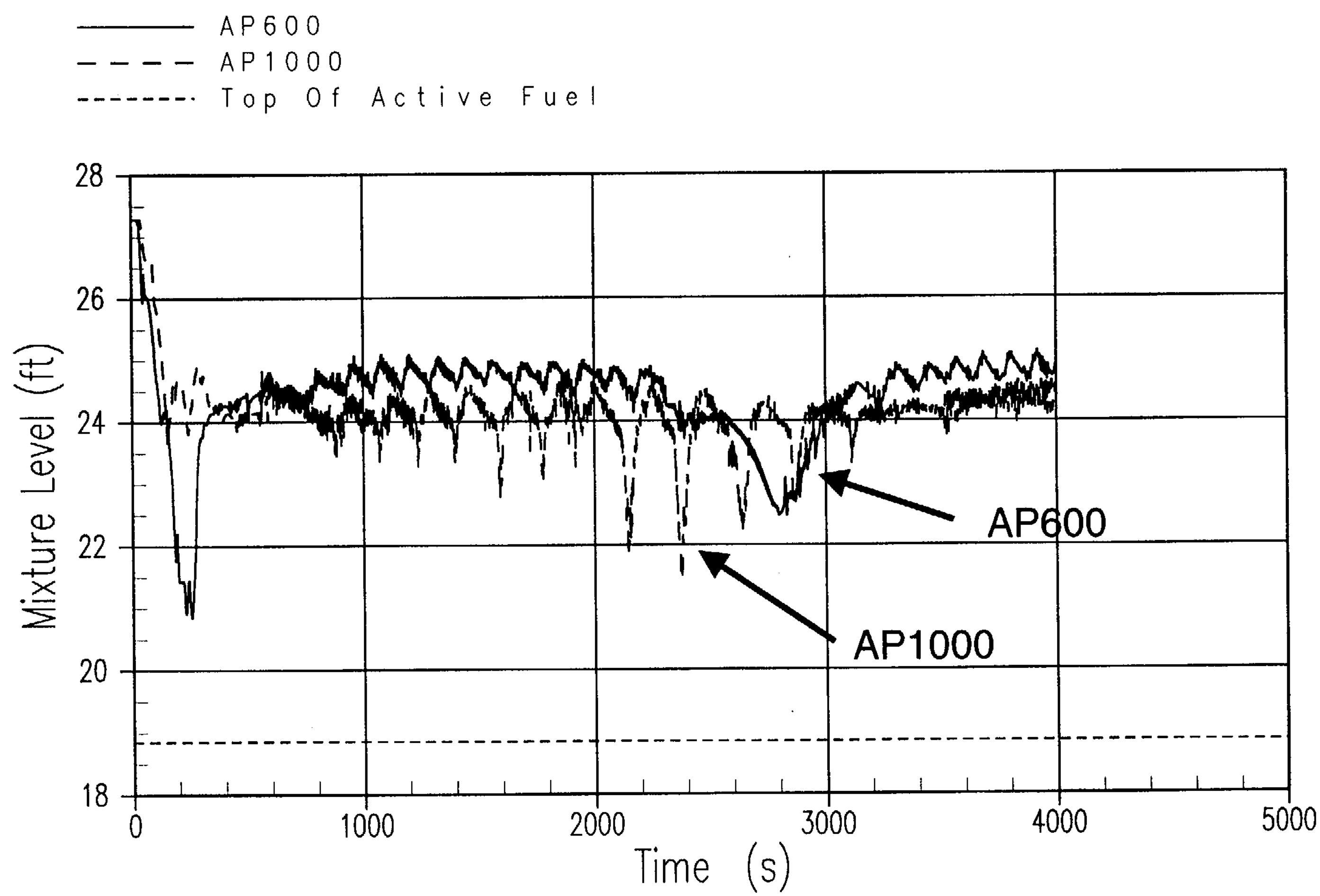
- **AP1000 IRWST Injection Expected to Provide Increased Margin**
  - Initial driving head increased
    - Minimum normal water level increased
    - Add more accurate, narrow range level sensors
  - Line resistance reduced by increasing pipe sizes (6” to 8”)

AP1000 SBLOCA T&H Assessment

- DBA Analysis Performed to Assess PXS Design Modifications
  - Same assumptions / methods utilized for AP600
    - 10 CFR Appendix K based analyses
  - Acceptance criteria
    - Peak Clad Temperature < 2200 ºF
  - Performance goal
    - No core uncovery for small LOCAs
      - Direct Vessel Injection (DVI) line LOCA or smaller
  - Several small break LOCA's were analyzed
    - 2" Cold Leg break, DVI line bBreak, inadvertent ADS

DVI LOCA Comparsion

Core/Upper Plenum Mixture Level



AP1000 SBLOCA T&H Assessment

- Scoping AP1000 Analysis Indicate Comparable Margin to AP600
  - For DBA LOCA's
    - Plant behavior is similar to AP600
    - No core uncovery occurred in cases analyzed
    - Larger AP1000 physical size / core power results in breaks behaving like smaller breaks in AP600
  - For multiple failure cases
    - Plant behavior is similar to AP600

AP1000 Cont Recirc Margin Assessment

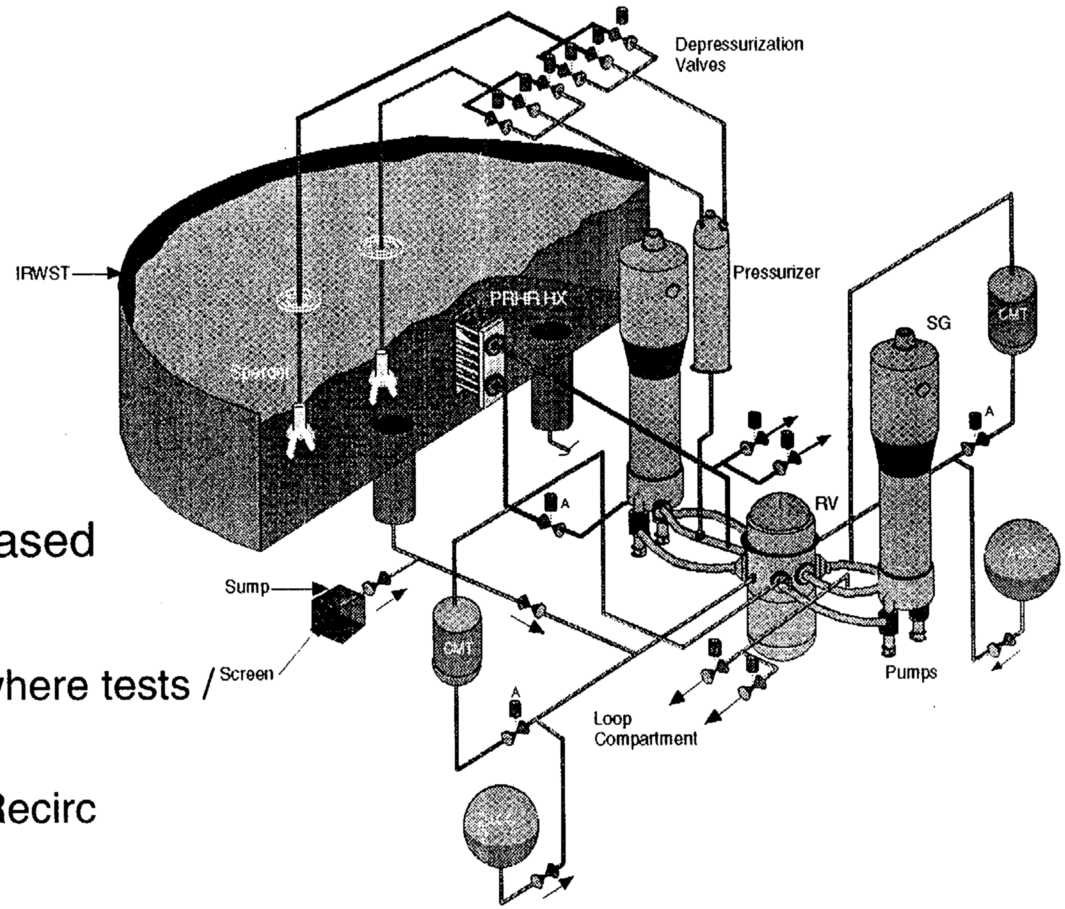
	AP600	AP1000
Containment Recirc Line Resistance	100%	39%
DVI LOCA with RNS Operation		
- Time recirc occurs (hr)	2.10	~2.67
- Containment water level (ft)	106.2’	108.4’
- Available driving pressure (psi)	100%	210%
- Required flow (core power, recirc time)	100%	~159%
- Calc passive recirc flow (%)	>>> 100% <<<	232%
DVI LOCA without RNS Operation		
- Time recirc occurs (hr)	4.76	2.67
- Containment water level (ft)	106.2	107.7’
- Available driving pressure (psi)	100%	177%
- Required flow (core power, recirc time)	79%	159%
- Calc passive recirc flow (%)	100%	>>> 213% <<<

- AP1000 Containment Recirc Expected to Provide Increased Margin
  - Containment water flood level increased
    - Increased initial IRWST level
    - Eliminated holdup volume in refueling cavity
  - RNS operation case made non-limiting by using outside water supply
    - Prevents adverse draining of IRWST by RNS
  - Line resistance reduced by increasing pipe sizes (6” to 8/10”)

AP1000 Long-Term Cooling

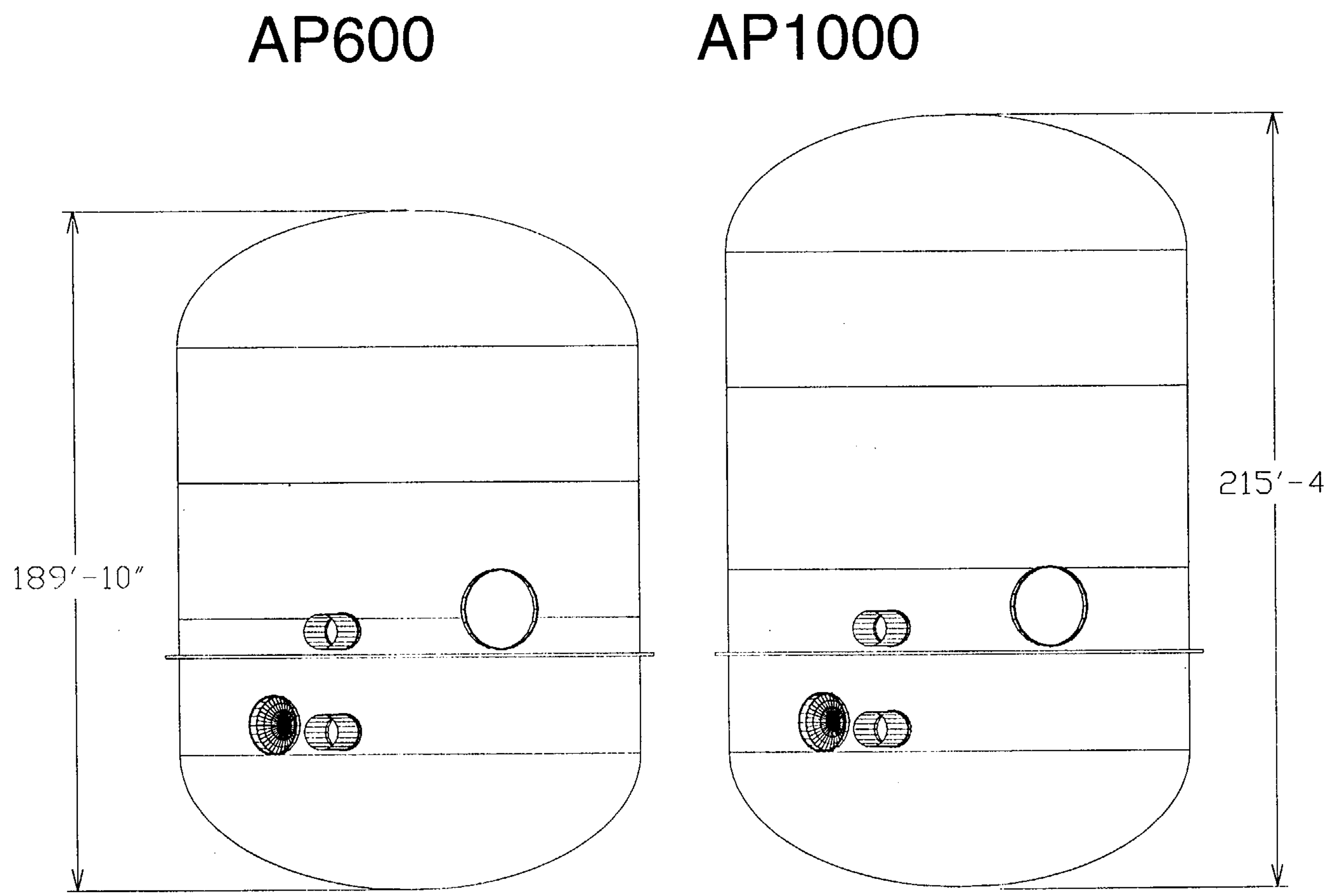
- Analysis Performed to Assess PXS Design Modifications During Post LOCA Long-Term Cooling
  - Same assumptions / methods utilized for AP600
  - Acceptance criteria
    - Stable IRWST injection and containment recirculation flow
    - Core cooling maintained indefinitely
  - Performance goal
    - No core uncovery
  - Limiting AP600 SSAR case analyzed (DVI LOCA)
    - AP1000 limiting DVI case is without RNS injection
  - Assessment Results
    - Similar behavior / performance to AP600
    - No core uncovery

AP1000 Passive Core Cooling System



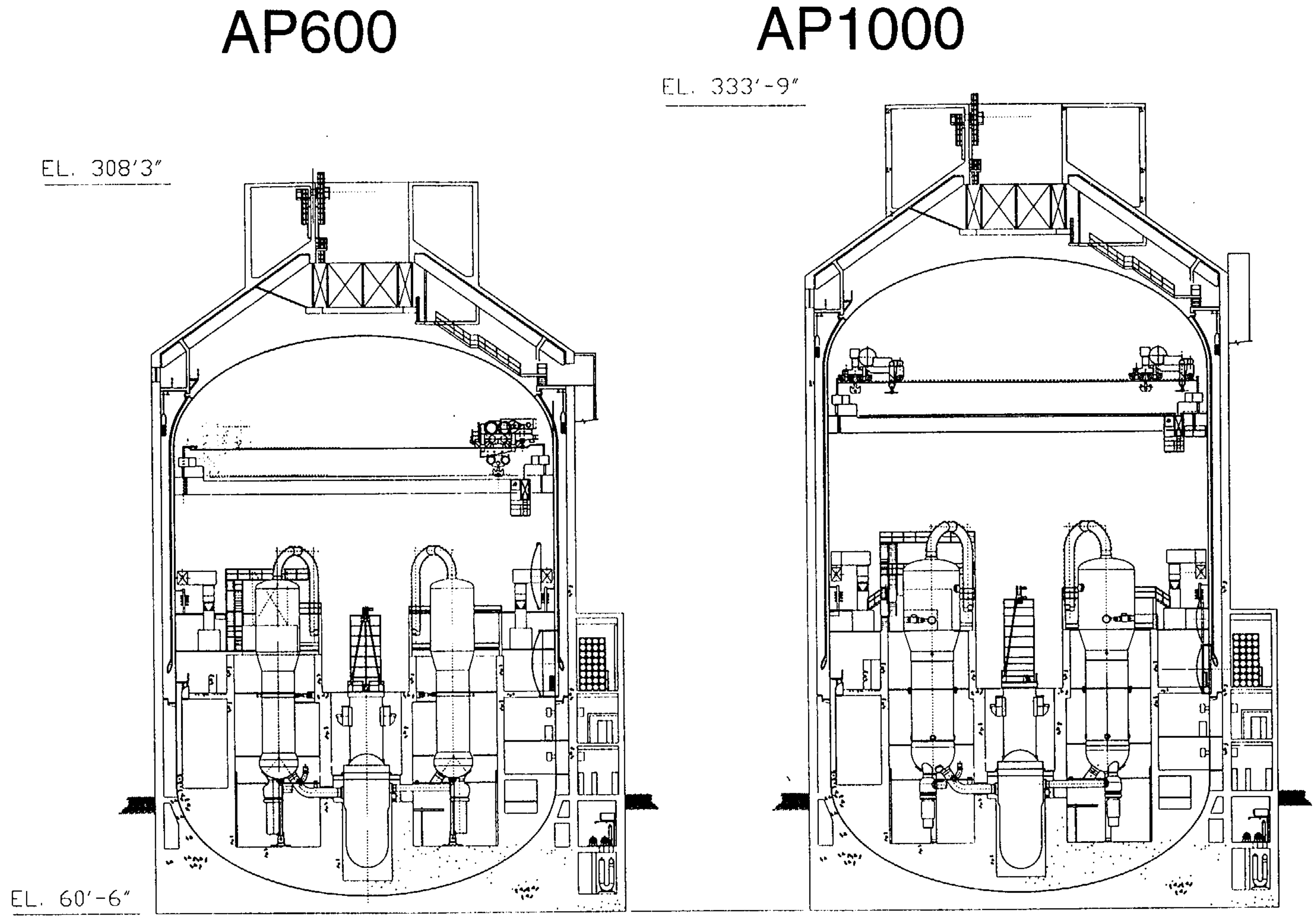
- PXS Configuration Retained
- PXS Capacities Selectively Increased
- System Margins Assessed
  - Margins increased significantly where tests / anslysis indicate most beneficial
    - ADS 4, IRWST inject, Cont Recirc
- System Performance Assessed
  - PXS capacity increases should provide adequate margin
  - Similar behavior to AP600

Containment Capacity



Parameter	AP600	AP1000
Shell Thickness	1 5/8"	1 ¾"
Total Free Volume, ft^3	1.7×10^6	2.07×10^6
Design Pressure, psig	45	59
Material	A537 Class 2	SA738 Grade B

AP1000 Containment Comparison

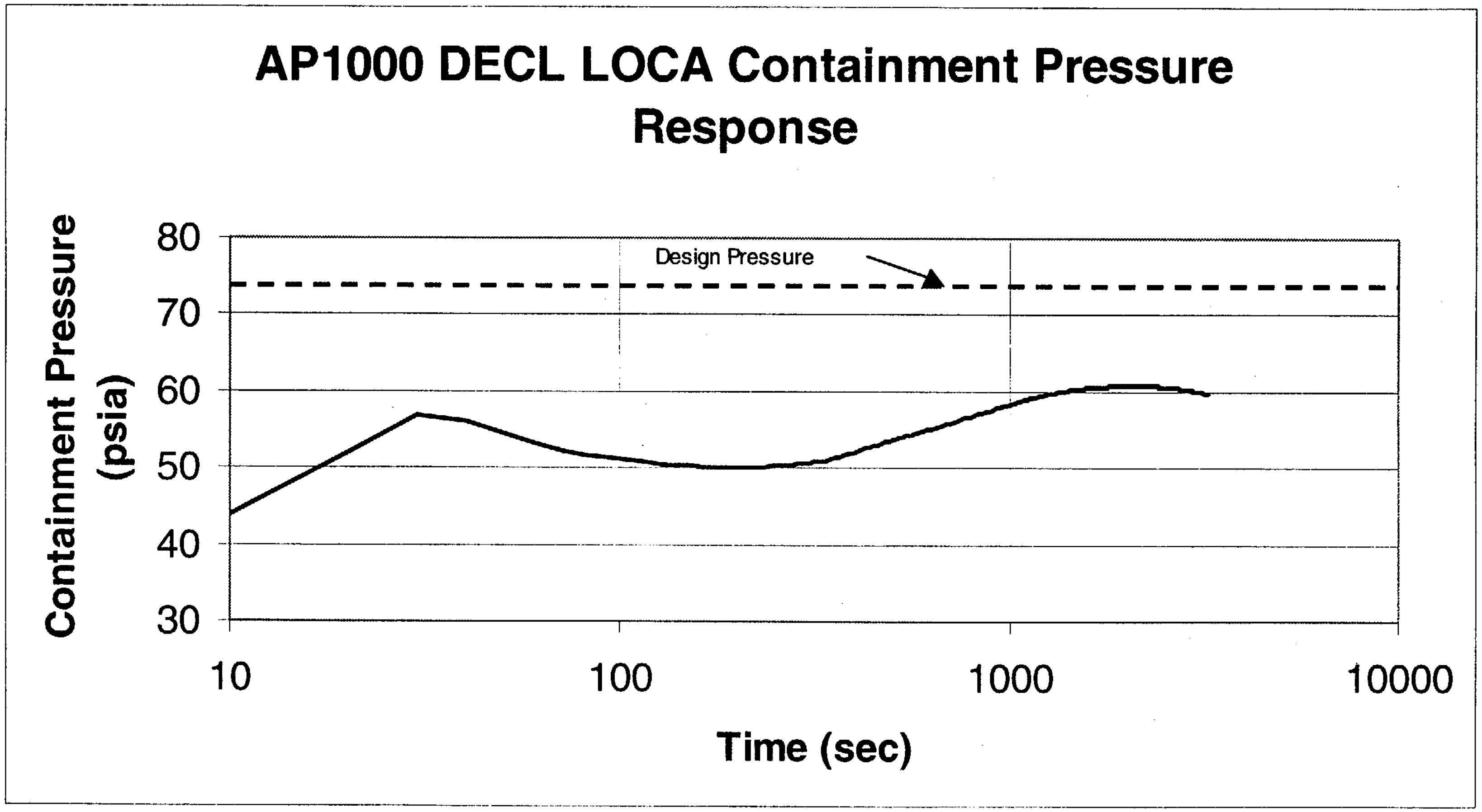


- PCS Water Storage Tank Increased from 540,000 to 800,000 gal
- Water Drain Flow Increased

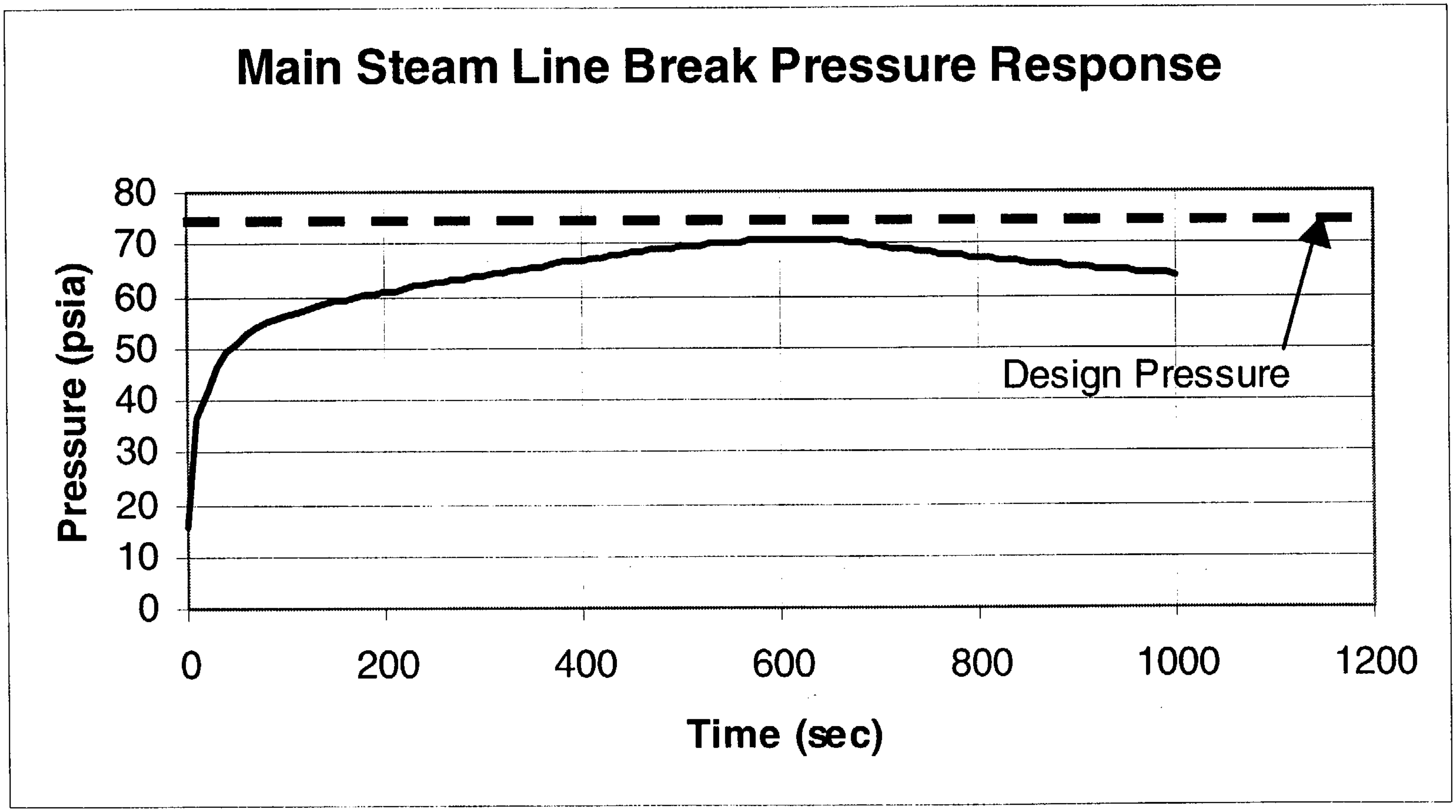
AP1000 Containment T&H Assessment

- T&H Analysis Performed to Assess Cont. / PCS Design Modifications
  - Same assumptions / methods utilized for AP600
    - Conservative assumptions / models
      - ◆ More realistic large LOCA SG energy input
  - Acceptance criteria
    - Maximum containment pressure less than design
  - Limiting AP600 SSAR cases analyzed
    - Double ended large LOCA
    - Large steam line break

Lg LOCA Containment Response



MSLB Containment Response



AP1000 Containment

- AP1000 Containment Expected to Provide Increased Margins
  - Containment capacity increased
    - Volume and design pressure
  - PCS capacity increased
    - Water storage volume and drain flow rates increased
  - AP1000 containment response similar to AP600
    - Large LOCA has large margins
      - With more realistic SG energy input
    - MSLB is limiting
      - Not sensitive to PCS performance
    - Similar behavior to AP600
    - AP1000 has larger margin to containment design pressure than AP600

AP1000 PIRT and Scaling Assessment

William Brown
LOCA Integrated Services

Outline of PIRT/Scaling Assessment Presentation

- PIRT Assessment
  - Identify PIRT reviewers
  - Summarize important changes to PIRTs for AP1000
- Scaling Assessment
  - Scope of Scaling Assessment
    - Identify tests and scaling assessment vs. analysis
  - Basis and approach to scaling assessment
  - PXS Scaling analysis/results
    - General scaling process/acceptance criteria
    - Selected phases of SBLOCA transient
    - ADS-IRWST transition phase - Reactor vessel inventory scaling
    - ADS Phase - RCS pressure scaling
    - Sump injection phases - Core exit quality scaling
    - Summary of results for SPES and OSU facilities
  - PCS Scaling analysis/results
    - Heat/mass transfer
    - Evaporation
    - Water coverage
    - Containment Mixing/Stratification

Main goal of PIRT/Scaling assessment

- Determine extent to which AP600 experimental test database is applicable to AP1000 to support safety analysis code validation in accordance with 10 CFR part 52.

Steps to Perform PIRT and Scaling Assessment

- First, AP600 PIRTs reviewed by several industry experts for application to AP1000.
- Then, scaling of most important phenomena (high-ranked) obtained from PIRT review assessed relative to AP1000.

PIRT Assessment

PIRT Reviewers for AP1000

- PIRT reviewers included the following industry experts:
  - Dr. S. M. Bajorek, Kansas State University
  - Dr. S. G. Bankoff, Northwestern University
  - Dr. L. E. Hochreiter, Penn State University
  - Dr. T. K. Larson, INEEL
  - Dr. P. F. Peterson, University of California
  - Mr. G. E. Wilson, INEEL

Summary of Important PIRT Changes For AP1000

- LBLOCA
  - Core entrainment/de-entrainment increased from 6 to 7 (Medium to High)
    - Addressed via BE-LOCA methodology.
- SBLOCA including long term cooling
  - Entrainment increased to High for IRWST/sump injection.
    - Addressed via bottom-up scaling of liquid entrainment inception from hot leg into ADS-4.
  - ADS-4 two-phase pressure drop increased to High for IRWST/sump injection.
    - ADS-4 two-phase pressure drop included in top-down scaling for IRWST/sump two-phase natural circulation.
- Containment SLB/DE CL LOCA
  - No changes.
- Non-LOCA
  - No important changes.
- Important PIRT changes listed above plus other important phenomena addressed in scaling assessment.

Summary of Important PXS Phenomena Addressed in Scaling Analysis

- Top-Down Scaling
  - Reactor vessel inventory
  - Core exit quality
  - RCS pressure
  - Core decay heat
  - ADS flow
  - ADS-4 two-phase pressure drop
  - CMT injection
  - IRWST injection
  - Sump injection
  - Natural circulation-PRHR
  - Pressurizer level
- Bottom-Up Scaling
  - Entrainment in HL/ADS paths
  - Hot leg/cold leg flow pattern
  - Surge line pressure drop
  - Phase separation at CL-CMT balance line tee
  - Core exit void fraction

Scaling Assessment

Scope of Scaling assessment

- Scaling assessment focuses on high-ranked phenomena for passive plants:
  - Small Break LOCA - core cooling/vessel inventory.
  - Steam Line Break - containment pressure.

Scope of Scaling Assessment

- Phenomena found in conventional PWR plants for which test databases already exist need not be scaled for AP1000 such as:
  - LBLOCA phenomena.
  - Blowdown & S.G. circulation phenomena of SBLOCA.
  - Non-LOCA (except for CMT/PRHR phenomena).
- Scaling assessment of low-ranked/medium-ranked phenomena in AP600 scaling effort sufficient for AP1000.

Basis and Approach for AP1000 Scaling Assessment

- AP600 scaling analyses serve as basis for AP1000.
- AP1000 scaling assessment leverages results, insights, lessons learned from AP600. AP1000 assessment does not re-invent the wheel.
  - Processes found not important or minor are not scaled.
  - Simplified models and equations used to highlight important features.
- Emphasize features different or scaled up from AP600 (core power, volume, ADS4 vent area etc).

Basis and Approach for AP1000 Scaling Assessment

- Scaling assessment accomplished via examination and comparison of range of operating conditions and geometry similarity between AP1000 and test facility. AP600 scaling analysis usually sufficient.
  - This is typically sufficient for separate effects tests.

- Where comparison between AP1000 and test facility not easily accomplished from examination described above, then assessment is supplemented with scaling analysis for AP1000.
  - This is typically needed for integral effects tests.

AP600 Test Data Sources Included in PXS Scaling Assessment

	Assessment	Scaling analysis
• Integral Effects Tests		
• SPES-2	√	√
• OSU	√	√
• ROSA-AP600	√	
• Separate Effects Tests		
• ADS (1-3)	√	
• CMT	√	
• PRHR	√	
• DNB	√	

AP600 Test Data Sources Included in PCS Scaling Assessment

	Assessment	Scaling Analysis
• Integral Effects Tests		
• LST	√	√
• Separate Effects Tests		
• U.of Wiscon. Condensation	√	√
• Heated flat plate	√	√
• Water distribution	√	√
• Wind tunnel/bench exper.	√	
• Air-flow path Δp	√	
• Water film formation	√	√

PXS Scaling Assessment

General Scaling Process

- SBLOCA event divided into major phases.
- System level (i.e., top-down) equations (conservation of mass, energy, and momentum) written addressing important processes during phase of transient. Processes not readily addressed at system level addressed with model or correlation (i.e., bottom-up).
- Equations put in form that highlights key parameter of interest such as reactor vessel inventory, pressure, or quality/void fraction. Equations combined to reduce number of scaling groups and allow greater number of phenomena to be directly compared.
- Variables in equations non-dimensionalized using references values. Reference values may be boundary/initial condition or max. value such as obtained from steady- state condition. Choice of reference values should render dimensionless quantities to be of order one.
- Resulting dimensional coefficients in equations normalized using one of coefficients in equation. End result yields dimensionless π groups, and time constants, τ, or frequencies, ω, (for transient equations). Ratios of dimensionless π groups, time constants, τ, or frequencies, ω, obtained by comparing test facilities and plant scaling ratios.
- Acceptance criteria applied to important scaling ratios; determine which phenomena are acceptably scaled to support code validation and which are too distorted to use.

Scaling Analysis Acceptance Criteria

- Acceptance criteria used for AP600 was important scaling ratios between test facility and plant must be within a factor of 2 of ideal scaling.
- AP600 acceptance criteria will be used for AP1000.
- Therefore, for dimensionless π ratios:
  - $0.5 \leq \pi_R \leq 2.0$

    where $\pi_R = \pi_{TEST} / \pi_{AP600 \text{ or } AP1000}$
- For frequency ω ratios:
  - $0.5 \leq \omega_R \leq 2.0$ for SPES and ROSA (time preserved facilities)

$$(\omega)_{R-IDEAL} = \frac{\omega_{SPES}}{\omega_{olant}} = \frac{(\pi_{SPES} / \tau_{SPES})}{(\pi_{plant} / \tau_{plant})} = \left(\frac{\pi_{SPES}}{\pi_{plant}}\right) \cdot \left(\frac{\tau_{plant}}{\tau_{SPES}}\right) = (1) \cdot (1) = 1.0$$

  - $1.0 \leq \omega_R \leq 4.0$ for OSU (time scaled facility)

$$(\omega)_{R-IDEAL} = \frac{\omega_{OSU}}{\omega_{plant}} \frac{(\pi_{OSU} / \tau_{OSU})}{(\pi_{plant} / \tau_{plant})} = \left(\frac{\pi_{OSU}}{\pi_{plant}}\right) \cdot \left(\frac{\tau_{plant}}{\tau_{OSU}}\right) = (1) \cdot (2) = 2.0$$

Phases of SBLOCA Transient

- Blowdown
- Natural Circulation
- ADS
- ADS-IRWST Transition
  - CMT injection dominant
  - IRWST injection dominant
- IRWST Injection
- Sump Injection

- Most important phase of SBLOCA transient for passive plant is period of transition from ADS to IRWST injection as this is typically where minimum reactor vessel inventory occurs.
- Therefore, ADS-IRWST transition phase is focus of scaling analysis.

Summary of Important PXS Phenomena Addressed in Scaling Analysis

- Top-Down Scaling
  - Reactor vessel inventory
  - Core exit quality
  - RCS pressure
  - Core decay heat
  - ADS flow
  - ADS-4 two-phase pressure drop
  - CMT injection
  - IRWST injection
  - Sump injection
  - Natural circulation-PRHR
  - Pressurizer level
- Bottom-Up Scaling
  - Entrainment in HL/ADS paths
  - Hot leg/cold leg flow pattern
  - Surge line pressure drop
  - Phase separation at CL-CMT balance line tee
  - Core exit void fraction

Reactor Vessel Inventory Scaling

- Transient: SBLOCA
- Phase of Transient: ADS-IRWST Transition ; CMT injection dominant
- Parameter of Primary Importance: Reactor vessel inventory
- Scaling Perspective: Top-Down
- Important Phenomena addressed:
  - Core decay heat
  - CMT injection
- Governing Equations: Transient conservation of mass for reactor vessel inventory supplemented with steady state momentum/energy eqns. to estimate CMT/core exit flow.

RCS Pressure Scaling Analysis

- Transient: SBLOCA
- Phase of Transient: ADS
- Parameter of Primary Importance: RCS pressure
- Scaling Perspective: Top-Down
- Important Phenomena addressed:
  - Core decay heat
  - ADS flow
  - Gas volume compliance
- Governing Equations: Transient pressure equation for ideal gas derived from conservation of mass and energy equations and ideal gas equation of state. Steady state energy balance on reactor core and steady state critical flow relation also used to estimate core steam generation and ADS steam flow.

Core Exit Quality Scaling Analysis

- Transient: SBLOCA
- Phase of Transient: Sump injection
- Parameter of Primary Importance: Core exit quality
- Scaling Perspective: Top-Down
- Important Phenomena addressed:
  - Core decay heat
  - ADS flow/two-phase pressure drop
  - Sump injection
- Governing Equations: Steady state conservation of mass, momentum, and energy are combined into a single equation similar to Reyes, Todreas and Kazimi, or Duffey and Sursock for a two-phase natural circulation path.

Summary of Results of PXS SET Scaling Assessments

- AP600 SETs acceptable for AP1000.
  - ADS test acceptable as ADS 1-3 valves/sparger same as AP600. Tested range of conditions covers AP1000.
  - CMT test covers range of conditions in AP1000.
  - PRHR test covers tested range of conditions in AP1000. Heat transfer correlation developed from test provides acceptable agreement with ROSA-AP600 results.

PCS Scaling Assessment

Summary of Important PCS Phenomena Addressed in Scaling Assessment

- Top-Down Scaling
  - Containment pressure
  - Break mass/energy into containment
  - Containment volume/gas compliance
  - Heat/mass transfer to internal heat sinks
- Bottom-Up Scaling
  - Condensation on inside surfaces
  - Evaporation on outside surface containment shell
  - Water film stability/coverage on outside shell surface
  - Circulation/stratification inside containment

Major Results of PCS IET Scaling Analysis

- As with AP600, LST is distorted for code validation of AP1000 pressure transient
  - AP600 used bounding analysis for pressure transient
  - AP1000 use the same approach

- LST acceptable as separate effect test data base for validation of steady state heat/mass transfer correlations for AP1000

Heat and Mass Transfer Scaling Summary

- The key dimensionless groups for scaling external heat and mass transfer are the riser Re_d and Gr_d
- The key dimensionless parameter for scaling internal heat and mass transfer is the difference in film surface to bulk air/steam mixture density divided by the film surface air/steam mixture density ($\Delta\rho/\rho$)

Overall Conclusion of AP1000 PIRT and Scaling Assessment

- PIRT/scaling assessment demonstrates that the AP600 integral effects test/separate effects test facilities capture the important phenomena for AP1000 and provide acceptable test database for code validation in accordance with requirements of 10 CFR part 52.

Computer Codes to be Used for AP1000 Design Certification

J. A. Gresham, Manager
LOCA Integrated Services

AP1000 Safety Analysis Approach

- Start With Computer Codes Approved for AP600
- Confirm Adequacy for Analysis of AP1000 Design
- Address Potential Concerns Identified in AP600 Review
- Reach Consensus on Acceptability

Advantage of Approach

- Provides an efficient hierarchical review process
- Identifies and resolves major deficiencies before final detailed review
- Focuses review on most important phenomena and issues.

Codes Approved for AP600

- WCOBRA/TRAC
  - LBLOCA
  - Long Term Cooling
- NOTRUMP-AP
  - SBLOCA
- LOFTRAN-AP
  - Non-LOCA Transients
  - Steam Generator Tube Rupture (LOFTTR2-AP)
- WGOTHIC
  - Containment Integrity

Confirm Adequacy of Codes for AP1000 Design

Process

- Identify important phenomena (via PIRTs) that must be addressed by code (Complete - AP1000 PIRT & Scaling Report)

- Identify correlations and models used in code to address important phenomena (Complete - AP600 Design Certification)

- Demonstrate that adequate test data base exists to support validation of correlations/models via scaling analyses (Complete - AP1000 PIRT & Scaling Report)
  - Separate Effects Tests
  - Integral Effects Tests

- Demonstrate limitations identified in AP600 FSER are addressed for AP1000

Approach to Address Limitations Identified in AP600 Review

- Approval of code features limited to AP600 application in the AP600 FSER

- AP1000 Approval
  - Evaluate important limitations to assess adequacy for AP1000
  - Address important limitations
    - Design Modification
    - Additional Validation against Tests
    - Evaluation of Margin
    - Supplementary Analyses
    - Code Enhancements

Contents of Code Applicability Report

- Important AP1000 Phenomena and Comparison to AP600 (PIRT)
- Code Description
- Code Acceptability for AP600 (FSER)
- Code Limitations and How Each Is Addressed

Code Uncertainties

- AP1000 Phenomena Similar to AP600
- Scaling Demonstrates Adequate Validation Basis for Codes
- Code Uncertainties for AP1000 Will Be Handled the Same as in AP600
  - LBLOCA - Uncertainties Considered In Establishing 95th Percentile PCT In Accordance with AP600 FSER
  - Others - Conservative Analyses Will Be Used to Bound Uncertainties

Reach Consensus on Acceptability

- Analysis Codes Approved for Passive Plant Analysis in AP600 Design Certification

- Staff Review of AP1000 Reports
  - AP1000 Plant Description (December 2000)
  - Scaling Analysis (March 2001)
  - Code Applicability Report (April 2001)

- Meetings with Staff to Discuss Technical Issues

- Westinghouse Is Asking the NRC to Agree on Applicability of the Approved Codes to AP1000 Analysis

AP1000 Codes

- Approved AP600 Computer Codes Will Be Used
- Confirm Adequacy for AP1000 Design
- Potential Concerns Addressed
- Confirm Acceptability
- Reach Consensus

Summary

Summary of Proposed Approach

- Staff review applicability of AP600 test programs
  - Understand AP1000 configuration & phenomenon
  - Assess requirements and use of AP600 test program for AP1000 Design Certification
    - AP1000 important phenomenon (PIRT)
    - Scaling adequacy of tests to AP1000
- Staff review applicability of approved analysis codes to AP1000