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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SUBCOMMITTEE ON THE WESTINGHOUSE AP1000 DCD AND

AP1000 STANDARD CONTENT COL

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OPEN SESSION

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THURSDAY,

APRIL 22, 2010

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Mr. Harold Ray, Chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

HAROLD B. RAY, Chairman
J. SAM ARMIJO
SAID ABDEL-KHALIK
SANJOY BANERJEE
DENNIS C. BLEY
MARIO V. BONACA
CHARLES H. BROWN, JR.
MICHAEL T. RYAN
JOHN D. SIEBER
WILLIAM J. SHACK

CONSULTANTS TO THE SUBCOMMITTEE PRESENT:

WILLIAM HINZE
THOMAS S. KRESS
BOZIDAR STOJADINOVIC

NRC STAFF PRESENT:

WEIDONG WANG
PETER C. WEN
EILEEN McKENNA

ALSO PRESENT:

ROB SISK

DICK HESSLER

CHUCK BROCKHOFF

TOBEY BURNETT (via telephone)

ED CUMMINS

WALT LYMAN (via telephone)

PHIL KOTWICKI

MARK STELLA (via telephone)

MIKE MELTON

C O N T E N T S

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

8:29 a.m.

CHAIR RAY: If we could come to order please. This meeting is a meeting of the AP1000 Reactor Subcommittee for any of you who are in the wrong room, a standing subcommittee of the Advisory Committee on Reactor Safeguards.

I'm Harold Ray, Chairman of the subcommittee. ACRS Members in attendance are Mario Bonaca, Charles Brown, Bill Shack, Mike Ryan, Dennis Bley, Said Abdel-Khalik, Sam Armijo, Jack Sieber, Sanjoy Banerjee, did I miss anyone?

We also have in attendance our consultant Tom Kress and we will later have consultant Bill Hinze and we have with us our consultant Bozidar Stogadinovic. I'm sorry, you must get a lot of apologizes, but I'll try and do better.

In any event because we're starting with a closed meeting on a subject that the latter two of our consultants Bill and Bozidar are not directly involved in. They will be joining us after the closed meeting is over on the first subject that we will be addressing.

We'll go into closed meeting after I am done with my remarks and NRO has made their opening remarks.

Weidong Wang is the designated federal official for this meeting and he is joined by ACRS staff member Peter Wen. The main purpose of this meeting is to review first status of Vogtle Units 3 and 4 AP1000 combined operating license application in the area of large areas -- loss of large areas of the plant due to explosions or fire.

Secondly, the status of the shield building redesign activities for the AP 1000. And third, action items from the past AP1000 subcommittee meetings.

This review is part of the ongoing review of the proposed amendment to the AP1000 pressurized water reactor design control document and review of the associated referenced combined operating license application.

In the past we had four two-day meetings of the AP1000 subcommittee; in July, October and November 2009 and then in February of 2010.

And I'll say parenthetically to the members after we go off the record late this afternoon, I will be wanting to have a discussion about their availability for the next scheduled two-day meeting.

At this meeting we will hear presentations from NuStart, Westinghouse and NRC staff. We have received no written requests -- no written comments or request for time to make oral statements to members of the public regarding today's meeting.

Portions of this meeting will be closed, as I indicated earlier, in order to discuss unclassified safeguards, information or information that is proprietary to the applicants and its contractors, which go to 5 USC 552b(c)(3) and (4).

Attendance at those portions of the meeting dealing with such information will be limited to NuStart, Westinghouse representative, NRC staff and its consultants and those individuals and organizations who have entered into an appropriate confidentiality agreement with them.

Consequently, we need to confirm that we have only eligible observers and participants in the room for the closed portion.

The subcommittee will gather information, analyze relevant issues and facts and formulate a proposed positions and actions as appropriate for deliberation by the full committee.

The rules for participation in today's meeting have been announced as part of the notice of meeting previously published in the Federal Register.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice, therefore we request that participants in this meeting use the microphones located throughout the meeting room when addressing the subcommittee.

The participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

We'll now proceed with the meeting, and first Said wished to make a statement.

MEMBER ABDEL-KHALIK: Thank you, Mr. Chairman. I will not participate in discussions specifically related to the Reference COL application because of a conflict.

CHAIR RAY: Thank you. With that, the next item on the agenda is to have any introductory remarks from NRO. Eileen?

MS. MCKENNA: Yes, thank you. My name is Eileen McKenna, AP1000 Projects in the Office of New Reactors.

As you indicated, the first topic this morning is a combined license topic and we are providing this informational briefing by NuStart and by the staff because this is an area where we do not have an SER with Open Items to bring before the committee earlier and we wanted to have the opportunity to have any dialog and exchange on the topic before we reached the final SER Phase 5 dialog with the committee.

So we hope that you'll find this informative and we look forward to your discussion. And with that, I'll turn it over to NuStart.

CHAIR RAY: Well, let's see, we need to close the meeting, I believe.

MS. MCKENNA: Yes, we do.

CHAIR RAY: All right. With that then, I'll ask that those who are not part of this discussion of loss of large areas, which is security related or unclassified safeguards information, I would ask leave the room until we again open the meeting for open items after this is over.

Thank you Bozinar. Anyone else?

MEMBER RYAN: Is there a bridge line open?

CHAIR RAY: Good point Mike, it wasn't in the prepared statements, but I should ask. Do we have a bridge line? Does anyone know?

PARTICIPANT: Yes, we have one.

CHAIR RAY: Is it open?

PARTICIPANT: Yes, he says cut it off automatically.

CHAIR RAY: All right, thank you. But, definitely that's an issue to be addressed at this time and we'll reestablish the bridge line once the closed session meeting has ended. So we'll wait a minute. So, give us a minute, please.

(Whereupon, the Open Session went off the record at 8:36 a.m. and went back on the record at 10:08 a.m.)

CHAIR RAY: We will come back into order please. We will be, I believe, Weidong is this correct, pass around copies of the action items? I'll assume that that will take place during the course of the first part of this meeting.

We'll get to looking at it later. We have items on our agenda for today from that list that hopefully we'll have a discussion sufficient to close the items or if not, identify precisely anything else that may be needed.

So, the first item on the list, as shown on the screen here now, is AP 1000 reactor coolant pump flywheel. Rob, go ahead.

MR. SISK: Thank you, Mr. Chairman and good morning. Today we are hoping in the next available time slot here between now and lunch to close out four of the action items that I believe are currently on the list and look forward to a discussion.

We'll start first with the reactor coolant pump flywheel. I'd like to introduce Dick Hessler as one of our subject matter experts in the PRA area, as I believe the questions were centered around how the reactor coolant pump flywheel was handled within PRA.

So Dick, why don't you go ahead?

MR. HESSLER: Yes. I'm Dick Hessler, I work at Westinghouse. I'm in the risk-applications and methods group. And we're the group that works on the AP 1000 PRA model.

The purpose of this presentation is to respond to an ACR request for information on the reactor coolant pump flywheel failure frequency that's used in the AP 1000 PRA model.

The AP 1000 PRA model does not explicitly model the failure of the reactor coolant pump flywheel and consequently, we don't have a failure frequency to present to you because it's not explicitly included in the model.

But what I want to do on the next couple of slides is explain how we got to that point. One of the -- probably the most likely failure consequence of a flywheel failure would be a locked rotor initiating event in the reactor coolant pump that the failure occurred.

In our PRA model, we group initiating events together and run them through our event tree analysis. And these events are grouped based on the commonalities of what would be required to mitigate the initiating event.

So, the flywheel failure we would categorize as a locked rotor event. There are other things, you could have a bearing failure that could also cause a locked rotor event.

But if we were to explicitly analyze it, we would probably put it in the locked rotor event category. The locked rotor event category is combined with other single-loop loss of reactor coolant flow events.

And, for example, these would be if you had a shaft failure of some sort and lost your impeller force or if you lost power to a single reactor coolant pump. That would be a single-loop loss of reactor coolant flow.

So the locked rotor gets combined with those, then the effects of those on the plant are analyzed and the single-loop loss of reactor coolant flow events are combined with other initiating events and analyzed in the PRA model under the category of transient with main feed water.

Because they all share that same characteristic that you haven't done anything to affect main feed water, you have a transient which caused a reactor trip main feed water is available, now you're going to see how you're going to mitigate that.

MEMBER BONACA: Would the flow course vary from event to event?

MR. HESSLER: Yes, it would. But that's a very short term effect and in the PRA model we're looking out over 24-hours.

So some of the initial event conditions that are more important when you talk about safety analysis are less important when we're looking at the success criteria, the longer term success criteria for PRA.

CONSULTANT KRESS: Do you actually have a value for the locked rotor initiating event in the PRA?

MR. HESSLER: No, we don't. And that's a good lead-in to the next slide. When we look at the transient with main feed water event frequency, it's dominated by spurious reactor trip and turbine trip events.

So there was not a specific number calculated for locked rotor because when you look at the numbers, it would contribute -- you wouldn't notice the contribution if you added it to a spurious reactor trip and turbine trip frequency.

So we didn't even get as far as calculating a locked rotor number as we were going down these chain of events. So what we have is again, your question was what's the failure frequency used in the PRA.

The answer is, we don't have a specific failure frequency, but the logic that was used to get there is that the flywheel failure is a subset of a locked rotor event category.

Locked rotor event is a subset of the single-loop loss of reactor coolant flow events. And those are a subset of the transient with main feed water events, which are highly dominated by just your spurious reactor trip and turbine trip.

MEMBER BLEY: I'm going to back you up to the first thing you told us.

MR. HESSLER: Sure.

MEMBER BLEY: Do you have analysis showing that a ruptured flywheel can't penetrate the boundary and can't lead the vibration such that it generates a LOCA?

MR. HESSLER: There was an analysis --

MEMBER BLEY: Something where you did doesn't --

MR. HESSLER: Right. Yes.

MEMBER BLEY: -- get you through the impact.

MR. HESSLER: And that's right. That's right. It doesn't -- what it's saying is we're not looking at it from the standpoint of creating a LOCA.

MEMBER BLEY: And you have --

MR. HESSLER: There was -- it's my understanding, we have a report, it's my understanding it was submitted to the NRC as a response to an RAI.

And the report was done by Curtiss Wright and the title is "Structural Analysis Summary for the AP 1000 Reactor Coolant Pump High Inertial Flywheel." The document number is AP 1000 RCP-06-009 and the non-proprietary version is -NP.

It's revision 2 and there is a section in that document -- I'm not an expert on that document by any means.

MEMBER ARMIJO: I read that document and it did have a very good explanation of the consequences of such a failure and they showed what they did to demonstrate the structures around it.

The surrounding structure was strong enough to present missiles from flying off of the pump. And so, you know, the full committee hasn't addressed it, but it looked pretty strong to me.

My issue on this thing was what testing has the Curtiss Wright or anyone else done to demonstrate that failure of that flywheel, that retainer ring which holds that heavy metal is, you know, have you done any stress corrosion cracking testing in environments of interest.

And the way I understand the pump, it's a very -- it's not subject to routine inspection, particularly the retainer ring and the flywheel are contained in an Ally 625-welded sealed can.

And there's no provisions that I could find for routine inspection to make sure that that wasn't leaking, do something, a failure of a weld, stress corrosion crack, whatever.

And this material, this 18-chrome, 18-manganese material is a very high strength material and it's not commonly used in PWR water environments.

So I asked, has anybody done any stress corrosion cracking test of that retainer ring material.

The response I got, or at least somebody sent me was that, yes, there's been some stress corrosion cracking tested in other environment and it's very good material, which doesn't answer the question because stress corrosion cracking is very specific material and in environment.

So unless you've tested in the environment of interest, you really haven't tested it. So, my interest is what, you know, can you -- is there enough testing been done to demonstrate that in the event that you get water in between the Alloy 625 can or the retainer ring is operating under very high stress, very high strength material, have you demonstrated that it's got some stress corrosion cracking resistance or not.

And so far, I haven't seen any evidence that there's been any testing done. In fact, I think that was the feedback we got from the staff.

CHAIR RAY: Before anyone responds further, may I ask those on the bridge line to make sure their phones are on mute. There's quite a bit of background noise coming over the bridge line as people are breathing and doing other multi-tasking chores.

Thank you.

Please go ahead and respond. What you recited is precisely what we captured in this action item or part of the action item.

MEMBER ARMIJO: Yes. And you have it exactly right. And it may be my misunderstanding, but it looks like this is a component that is not going to be inspected very frequently.

It's going to operate for very, very long times and you're not going to disassemble that pump to inspect that Alloy 625-can to see if the welds are holding and if you've got leakage into the retainer ring region or not.

So if that's the case, you have to do a lot, in my opinion, to demonstrate that even if it did leak and you didn't spot it during some interim inspection, that it's a good material and it will retain and it won't be subject to cracking like the stress-corrosion mechanism.

So that's the whole story of my concern.

MEMBER BONACA: Wouldn't the vibrations be picked up?

MEMBER ARMIJO: I didn't hear you Mario.

MEMBER BONACA: Wouldn't the vibrations in the pumps resulting from the condition they're describing?

MEMBER ARMIJO: Well, no. If it's just cracking and it creates a, you know, a stress corrosion crack, it's not going to unbalance it, it's going to fall apart if it gets -- if the crack gets big enough, you can just fracture the component.

And so, if there's been some testing in PWR water of this material, it would give me a lot of comfort. But if there's been no testing, I don't think you can say, well I tested it in this other environment, therefore it ought to be good in PWR water.

CHAIR RAY: Well, isn't it canned -- you're talking about the can leaking and getting in there.

MEMBER ARMIJO: The can leaks.

MEMBER BROWN: There's no inspection of the can.

CHAIR RAY: No, I understand that.

MEMBER ARMIJO: Now if you're going to inspect that can periodically you have to take the pump apart and I don't think that's part of the plan.

So if you don't inspect that weld, then you have to assume that it might leak and if it does leak, is the material resistant to PWR water stress corrosion cracking. That's the simple --

MEMBER BROWN: So you're looking for some type of test like thermal cycling test --

MEMBER ARMIJO: No, no. Stress corrosion --

MEMBER BROWN: -- or just SCC?

MEMBER ARMIJO: The industry guys know how to do stress corrosion cracking tests.

MEMBER BROWN: On the Alloy 625.

MEMBER ARMIJO: Of Alloy 600, Alloy 625.

MEMBER SHACK: No, he wants the 18/18.

MEMBER ARMIJO: Yes, you take the 18/18.

MEMBER SHACK: I mean it is true Sam that the 625 has a good history in PWR water.

MEMBER ARMIJO: I know 625 is good, but even so, this is a really important component and so many of our important welds are inspected. This component I don't think is inspected. It's inspectable, but I don't think that's the plan to do that routinely.

MR. SISK: Well, let me, if I can, check on the phone. We do have one of our subject matter expects. Dale Wiseman, are you online? Dale Wiseman?

What we will do, because I do think we should take -- what I'd like to do is focus a response on the material and the testing of the reactor coolant pump, which is what I'm hearing. And Dick was addressing primarily the PRA, to resolve the PRA concerns and we will get back to you on the material question.

MEMBER ARMIJO: Yes, we tried to be explicit in our -- in the language in our action item 4 just to make sure that nobody misunderstood what we were looking for.

And so I don't know how it became, also became a PRA question.

CHAIR RAY: Well there were two questions here, Sam as you can see here. And I want to make sure, just from an accounting standpoint, that we take care of Tom's question, which we were pursuing a few minutes ago.

Is there anything more that's needed? We've had the PRA discussion here which was intended to be responsive.

CONSULTANT KRESS: I think normal lock rotors are nominated by this, but I'm concerned that Sam's issue may change the lock rotor frequency. So I would like to see, and I turn to Sam, that's why I say okay.

CHAIR RAY: All right. So, but we could

say we have an answer at least based on the assumption given relative to PRA. The question is whether the assumption --

MEMBER BLEY: Before we say that, I wouldn't say that.

CHAIR RAY: Okay. I was going to come to you next Dennis, but --

MEMBER BLEY: Okay. We're moving on.

CHAIR RAY: No, I'm just trying to keep track of things, that's all. Go ahead, please.

MEMBER BLEY: I agree with Tom. It's not unreasonable that if this happens you'll get a locked rotor. That is a possible outcome, but there are other possible outcomes and the question is, have they been considered and it sounds like the answer is no, not in the PRA.

And Sam's issue could elevate it to the point that maybe it really ought to be.

CONSULTANT KRESS: Yes, that's my concern.

CHAIR RAY: Okay. What are the outcomes of concern here in addition to locked rotor? There was a question of penetration reactor coolant pump and I wanted to figure out are you satisfied that even if this thing fails every other day that the penetration of the reactor coolant pump boundary is not --

MEMBER ARMIJO: There is a lot of margin in that structure around that flywheel. But, you know, that's just me.

CONSULTANT KRESS: Okay. That high inertia --

MEMBER ARMIJO: That's not my concern. My concern is it shouldn't read have untested material that's basically uninspectable.

CHAIR RAY: Okay. I hear you and we'll capture that. But again, I'm trying to figure out is that associated with any particular threat sequence?

MEMBER ARMIJO: Yes, because I don't know if all lock rotor events are the same. You know, if this rotor locks up when it's running at full speed when a flywheel comes apart, it may be different than some other type of locked rotor event. I think it would be a pretty violent --

CONSULTANT KRESS: Well as the best I remember, that high inertia flywheel was put in there because you needed the coast-down in order to provide that cooling. And I'm not sure whether or not your event, not necessarily results in a locked rotor, but might affect the coast-down ability of the pump.

MEMBER ARMIJO: It would be a pretty violent thing if that thing came apart.

CONSULTANT KRESS: Yes, well, you know, it could just get slowed down in there or, you know, it doesn't have to fail all the way.

MEMBER ARMIJO: I wouldn't want to be around it --

CHAIR RAY: All right. So it's the thermal hydraulic implications potentially that --

MEMBER ARMIJO: Yes.

CHAIR RAY: -- not the penetration reactor coolant pressure boundary.

MEMBER ARMIJO: Basically we test all the materials. It's not a pressure coolant boundary system, but it is a very important component. And if it was subject to routine inspection, periodic inspection, I'd be less worried.

But if you're not going to do that, you should really test the materials in the environment that could be there.

CHAIR RAY: Okay.

MR. SISK: So it's the question then looking at the material, I guess I'm separating that out because the plant is capable of dealing with the locked rotor event and I guess that's to analyze.

MEMBER ARMIJO: I think I agree with that, but, you know, basically it's have you tested 18-

chrome, 18-manganese retainer ring material of properties you intend to use in PWR water just in case it's exposed to that environment.

MR. SISK: And I wanted to make sure I captured that correctly as a material question not really a safety question in that the locked rotor event is captured from a safety aspect.

MEMBER ARMIJO: Well, that's for the committee to decide.

CHAIR RAY: Yes. I think Rob, the way to best carry this forward is the subcommittee or members of the committee are not satisfied that we should be unconcerned about failure of this flywheel.

And given that fact, in other words, answer to the question that we got satisfies the narrow issue, but it doesn't say, and therefore don't worry about failure of the rotor flywheel. I'm sure you guys don't either.

And so the question is then, well, okay given that we continue to have a concern that this material may be susceptible to the kind of failure that Sam's described, how can we resolve that concern? Okay?

So we go the PRA answer, we appreciate that. If there's any more questioning on that we'll be taking advantage of the fact that we --

MEMBER SIEBER: Would that include the demonstration that the plant could withstand a locked rotor plus if the rotor did disintegrate it wouldn't penetrate the pressure house. Either one of those would be an alternate way to resolve it, right?

CHAIR RAY: Well, that's why I asked Jack if Sam was satisfied with what he had reviewed about penetration the pressure boundary.

MEMBER SHACK: As a safety question?

CHAIR RAY: Yes. And I believe he said he was. I mean, you may look at it and come to a different conclusion. But we have a reference to look at in terms of what hazard does a flywheel failure present to the reactor coolant pressure boundary from a standpoint of either a loss coolant accident or an interconnected system event cooling, motor cooling system leak,.

MEMBER SIEBER: It's a safety question.

CHAIR RAY: What?

MEMBER SIEBER: It is the safety aspect of the question, however.

CHAIR RAY: It is, at least it's one of them at least. He was talking about the possibility that the thermal hydraulic question --

MEMBER ARMIJO: Well it's an initiator and if you can prevent an initiator by demonstrating by test that it's resistant to this problem, then everybody should be much more comfortable.

CHAIR RAY: Dennis, are you satisfied here?

MEMBER BLEY: I haven't read that report. I have to go look at it. I guess the other thing, and the flywheel is not on the boundary, but it's attached to the whole pump mechanism.

So if instead of ripping apart and stopping, it causes some severe vibration, then you could lose seals and you could have -- no, there's probably more likely LOCAs than that.

MEMBER ARMIJO: The narrow question of whether a missile will fly through that super heavy structure I think is pretty solid because they have tons of margin.

MEMBER BROWN: This doesn't have seals, this is a canned rotor pump. If you --

MEMBER ARMIJO: It's sealed to the -- the bonnet where the pump attaches to the --

CHAIR RAY: To the steam generator lower head.

MEMBER SIEBER: Yes, you've got a couple.

MEMBER BONACA: For low-head pumps for current generation of reactors the frequencies are soon to be E 10 to the minus 4 for the failure of the locked rotor. You know, is there any parallel information that can be used for current pumps?

Because given the frequency, then some fuel damage is allowed in license space for cooling events.

MR. HESSLER: A frequency, I guess, could be determined. I'm not aware that it has been for the AP 1000 RCP. I didn't see it, I didn't look at that report in detail, but it looked like they were focusing on meeting stress limits, you know, how far --

MEMBER ARMIJO: They just assumed it fell apart at full speed with lots of margins on all of these things and they looked at the body of the -- of the pump body and it's really robust and they concluded it wouldn't -- missiles wouldn't fly through that thing.

And in that narrow sense it was pretty convincing, but there are other issues, you know, I didn't look into it. But my question was, why would we ever use an untested material retaining such massive components turning at such high speeds. So that's where I'm at.

CHAIR RAY: All right. So we still have a concern that would be best addressed by saying this material is not going to be susceptible to stress corrosion cracking in the event it's exposed to reactor coolant system or service.

MEMBER ARMIJO: Or the plan is for periodic inspection of the can around it. And --

CHAIR RAY: Yes. That's another problem --

MEMBER ARMIJO: That's another solution, but, you know, I'd rather test. I'm a metallurgist, so I like to test everything.

CHAIR RAY: Okay. Is that clear enough now Rob?

MR. SISK: Yes, sir.

CHAIR RAY: I'm trying to narrow it down, but still satisfy the issue. I don't think saying, well it won't penetrate the boundary or we can withstand a locked rotor puts it to bed. If it's a critical component as it is here. And by the way, there are two flywheels right?

MEMBER ARMIJO: Top and bottom.

CHAIR RAY: And we're talking about both of them.

MEMBER ARMIJO: And this is the change from the old AP 1000 pump.

MR. SISK: I appreciate the clarity and we'll have the materials and be able to discuss that in more detail in the future.

CHAIR RAY: All right. I'm sorry, that, you know, I'm just a bookkeeper here I'm trying to check things off. But, we're not going to check this one off. What do you got next?

MR. SISK: The next part we're going to talk about flow measurement and I'd like to invite Mr. Chuck Brockhoff to join us up front.

MR. WANG: This is the next slide, number 10 in the table.

CHAIR RAY: Thank you Weidong.

MEMBER BANERJEE: I'm sorry, this is elbow taps?

MR. SISK: This is the elbow taps, correct, sir.

MR. BROCKHOFF: Yes, sir. My name is Chuck Brockhoff and I'm one of the lead system design engineers for AP 1000 and I wanted to go through a large handful of slides on our flow -- alternative flow measurement process, we've suggested to do in DCD Rev. 17.

There were questions in a previous meeting on RCS flow measurements specifically how we do that and questions relative to the uniformity of flow.

I wasn't there for the meeting, but the gist of it was the questions about the use of elbow taps for flow measurements, some information on uniformity of flow to provide some additional background how we'll monitor RCS flow measurements for the system and the alternative methods that we've proposed then are going to use both hot leg and cold leg flow taps that we have.

The RCS flow is one of three DNB perimeters in tech spec 341. So these surveillances are in the tech spec to go in and make sure that we have the required flow. And obviously we tripped the reactor on 90 percent flow and that's our safety analysis with uncertainties.

The Westinghouse generic tech specs, the standard improved tech specs are NUREG-1431 and they have the use of the precision calorimetric from the secondary system as a basis for flow measurement.

We've developed the AP 1000 generic tech specs from that really changing only the differences that were technically related.

And generally that precision calorimetric calculates reactor power from feed water perimeters and then we look at T_C minus T_H and we just divide that by and come up with flow maintenance. So that's the typical method that we do

The accuracy isn't affected by anything that affects the temperatures. In this case hot leg streaming, for example, would give you non-uniform flows and that has some effect on accuracy.

AP 1000 geometry and the low leakage loading patterns may potentially contribute to hot leg streaming and we considered that uncertainty in our calculation.

The tech spec surveillance requirements 3.4.1.4 as we've written it, allows the use of an alternative precision flow measurement, which is the use of d/p taps.

We're going to do something different for our plant that we can do on startup that a traditional plant typically doesn't have. And the goal was eventually to get to slide seven and we can look at the details of that.

So what we're doing is we're allowing an in situ test of hot leg and cold leg flow taps, flow d/ps in the channels to be an alternative method to calculate flow instead of using precision calorimetric divide by temperatures, delta T.

This president exists already in plants that's licensed for Farley, South Texas, Diablo Canyon, Seabrook and Watts Bar. And basically that surveillance requirement says that we can use flow measurement or calorimetric divided by the temperature.

So there's an alternative way. So we're basically doing that except we're using both hot leg and cold leg instrumentation.

MEMBER ABDEL-KHALIK: Just for reference, what is the uncertainty in the RTD measurement?

MR. BROCKHOFF: I believe it is -- wait a minute, uncertainty in the RTD?

MEMBER ABDEL-KHALIK: Right.

MR. BROCKHOFF: Let me ask Rick Tully, are you online?

MR. BURNETT: No, Tobey Burnett here.

MR. BROCKHOFF: Okay. Tobey, do you know that answer to the RTD uncertainty? I don't actually do the uncertainty calculations.

MR. BURNETT: The RTDs themselves are quite accurate, they're well within one degree Fahrenheit. However, they can only measure the temperature of that platinum coil.

There will be variations, at least plus or minus 10 degrees between the temperature of any RTD and the mixed mean hot leg temperature. That's the sorts of the error we're speaking of.

MEMBER ABDEL-KHALIK: So you're measuring T hot and T cold individually?

MR. BURNETT: Yes.

MEMBER ABDEL-KHALIK: So the uncertainty comes in, in both measurements?

MR. BROCKHOFF: And the uncertainty calculation would account for that. So the DCD, Rev. 17 application that proposes to do the baseline flow measurement testing at the time of startup.

When we build the plant, we go in and test it with perfect flow conditions essentially and that gives us a maximum flow of what we would expect to see under conditions and then use that for in situ calibration of the flow instruments for both hot leg and cold leg bends later on through plant life.

So we would use those full elements for further flow measurement as an alternative to the precision flow rate that we would calculate.

But the key is, and we'll look at how we do this in a couple of slides, is we would take a bunch of baseline data that typically wouldn't be available for an existing plant that backfitted this. And that becomes our benchmark for the rest of the plant operating history.

MEMBER ARMIJO: Would you recalibrate periodically?

MR. BROCKHOFF: There's a requirement to calibrate every refueling cycle. So if you measure d/p and you calculate that to be a flow, then from there on out you set that d/p and adjust the instrument to make that read it when you recalibrate the same value.

So that way you can see if d/p changes due to corrosion or some other problem, degradation of the pump impeller performance, you'll see the flow decrease over time. If you plug steam generator tubes, you get lower flow.

But it's all based on that benchmark Day One Data.

MEMBER ABDEL-KHALIK: Let's just stick with the first bullet. Is this a primary measurement or a derived measurement?

MR. BROCKHOFF: Let me go through on slide seven and answer that question. We looked at the d/p that comes to the sensor and we use that to calculate. So it's an actually measured value from the flow instrument itself.

MEMBER ABDEL-KHALIK: No. The question is you're saying that during startup you'll have some other mains of measuring flow and you will use those to do in situ calibration of your delta P measurement versus flow in whatever secondary measurements your doing.

And the question is, are those additional baseline measurements primary measurements or derived measurements?

MR. BROCKHOFF: Well they would be a primary measurement. For example --

MEMBER ABDEL-KHALIK: You measure the flow directly?

MR. BROCKHOFF: No, you don't -- we use the d/p. We measure differential pressure directly, we could measure pump rotor speed because we have a speed sensor on it.

MEMBER ABDEL-KHALIK: Right.

MR. BROCKHOFF: So we're measuring process perimeters that we use to calculate the flow. The differential pressure sensor has a characteristic that would tell us the differential pressure it's measuring the flow tap.

For example, we expect it maybe to be 24 psid at 100 percent flow with the sensor.

MEMBER BANERJEE: But even the calibration is not a direct measurement.

MEMBER SIEBER: No, you're getting it from the secondary calorimetric.

MEMBER BANERJEE: I mean you could make a direct measurement using time of flight or something, clearly, but I think the answer to your question is it's not.

MR. BROCKHOFF: No. For example, the pump manufacturer gives you a pump speed versus flow curve for that pump based on that impeller configuration. So when you put it in the loop, if you have this certain rotational speed of the pump you know the impeller is delivering this volumetric flow rate.

Then that fits into the -- you know where on the head curve you are as far as delivering flow.

MEMBER ABDEL-KHALIK: But the fact that this is coming from the pump manufacturer doesn't mean that the flow rate indicated on the pump characteristic is actually a directly measured quantity.

MR. BROCKHOFF: No, but eventually when we do the -- I'll show you later on the pre-operational startup test. When we do the startup test, we back calculate to verify the flow.

So until we do the precision calorimetric and some other precision measurements that we do, we try to correlate them all as part of our baseline report.

MEMBER BANERJEE: So let me clarify this. So imagine that you have a venturi in a line and they're using that to measure the flow. All right, you have issues, maybe the venturi throat gets a little rough over time.

MR. BROCKHOFF: Yes.

MEMBER BANERJEE: So how do you calibrate this or ultrasonic flow meter? One possible way is to use a time of flight measurement, which is that imagine that you activate with a 14 MeV neutron source or something, I'm just giving a taught experiment, which has been done by the way.

And you then look at when that pulse passes another point using a radiation detector. Now knowing that distance and knowing the time it took, you first can get precisely a flow rate.

Now there are issues maybe with averaging a little bit, but nonetheless those have been taken care of in many straight pipes, okay.

The issue that's coming up here is how do you -- is this a direct measurement or indirect measurement, that's his question. Clearly if you knew the amount of power to be generated precisely as you can, and you knew the temperature precisely without the RTD, then it's a direct measurement, okay.

That's the question. Now, I'm waiting for your answer too. So just to explain what the question is, all the things you've said are not direct measurements, up to now.

MR. BROCKHOFF: No. The final direct measurement will be during our startup testing where we do a precision calorimetric, we know the uncertainty of the instruments and we back calculate the flow and we would cross compare that to all the flow measurements and the other indirect measurements --

MEMBER BANERJEE: Perhaps explain this precision calorimetric. If you're going to do that, then let's go on.

MR. BROCKHOFF: Yes. When we get to slide seven it lists all the things that --

MEMBER BANERJEE: Well what is it? What is this precision calorimetric?

MR. BROCKHOFF: The precision calorimetric that we do is we basically take enthalpy rise across the feed water with systems in the generator pressure to the feed water temperature so we have a temperature uncertainty there with the precision flow meter.

And that calculates the heat transferred out of the primary and then on the primary loop, we know the T_H of the core and T_C going back to the core and so we take that power and divide by that delta T and that gives us our mass-flow rate of the reactor coolant system.

MEMBER BANERJEE: I guess that's the question he asked. What's the uncertainty on those temperature measurements?

MR. BROCKHOFF: On the -- well that's what Tobey was answering. We do have a specific uncertainty calculation that's done for all of our temperature and pressure, anything that gives us trip or safeguards actuation, there's a set point study that combines those, there's a methodology that we use to do that.

So we would know what those values are based on the instruments we pick. And when we calculate the flow rate, it obviously conservatively applies those uncertainties.

I don't know what they are specifically without looking at the uncertainty report, but we do evaluate that and that's one of the requirements that make sure our actuation set points are correct for the plant.

MR. BURNETT: This is Tobey again. With response to -- in response to that direct question, what is the accuracy of that, on existing plants we achieve accuracy in the vicinity 1 percent give or take.

On AP 1000 we are confident we will be able to achieve 3 percent. We probably may get within 2 percent, it might be less than that. The limiting factor is our ability to measure the mixed mean hot leg temperature because temperatures will be different in different parts of the hot leg.

MEMBER BANERJEE: I guess that was exactly the question.

MEMBER ABDEL-KHALIK: It's not just that the temperature is non-uniform, but it's the -- you're measuring these two quantities independently, you're not measuring the temperature difference directly.

MR. BROCKHOFF: Yes.

MEMBER ABDEL-KHALIK: And therefore you have uncertainty in both hot leg measurement and the cold leg measurement.

MR. BURNETT: Yes.

MEMBER ABDEL-KHALIK: And the measurement itself.

MR. BURNETT: The uncertainty in measuring the hot leg temperature swaps out all of the other uncertainties.

MEMBER ABDEL-KHALIK: But if you look at that, that's --

MR. BURNETT: It's by far the largest.

MEMBER ABDEL-KHALIK: -- that is a significant fraction, the uncertainty is a significant fraction of the delta T, but I suspect much more than 3 percent. But we'll wait and hear.

MEMBER BANERJEE: You are going to have to defend the 3 and 2 percent, okay.

MR. BROCKHOFF: Yes, sir. We would have to defend the value that we include in our uncertainty calculation, which it factors into each of the individual measurements.

Every measurement includes the instrumentation uncertainty plus the physical process. For example, in the hot leg we have six RTDs that measure in the same plane so we can get a better indication of any potential streaming effects, so.

But the end result is we would like to eventually use those flow elements and we do use those flow elements throughout the cycle variations, which you'll see in just a minute.

And this, I put this drawing in so you could see where this actually lies. There's an elbow going up to the hot leg right here and there's an elbow in the cold leg between the pump and the vessel or bed.

And we use this taps here and taps for each cold leg and there will be multiple taps in each location.

MEMBER ARMIJO: And they are located where?

MR. BROCKHOFF: Well, the taps are located typically, the pressure variation gets on the outside of the bend from the centrifugal force going through there.

So your hot pressure tap is here and the low pressure tap would be in the inside of the elbow. And so this methodology exists in every Westinghouse plant in the downcomer between the steam generator going over the reactor coolant pump, the elbow --

MEMBER BANERJEE: But it's a question of calibration, really.

MR. BROCKHOFF: Yes, sir.

MEMBER BANERJEE: Because the original

question arose because, you know, the roughness of the walls and all these things change over a period of time. So you've got to periodically recalibrate them, which is what you're saying you do every refueling outage, right?

MR. BROCKHOFF: Yes.

MEMBER BANERJEE: If I understand you.

MR. BROCKHOFF: Yes, sir. What happens, if we measure day one values, this differential pressure, and we use the instrumentation to calculate a flow that we eventually determine is to be correct, that d/p that exists at that flow condition always is used to reestablish the calibration of that instrument.

And what happens is that over time if you get smoothness of the walls getting better, the d/p would actually go up because physical flow increases.

If you plug generators, the flow goes down and the d/p would go down and therefore your indicated flow would go down. But every refueling cycle you calibrate back to the original d/p should equal this value from that instrument.

And so whatever the physical changes you'll see that reflected in your indicated value. Flow would typically go down over time as you plug generators and your pump impeller performance degrades maybe over 60 years.

So you're using that benchmarked data day one to tell you what the correct calibration should be because the taps don't change, you can change an instrument channel, but in the end result, this d/p set into the prime standard measurement d/p transmitter should give you this output. And whether the flow physically changes, you will see that.

MEMBER BANERJEE: Well the issue is this, that the pressure drop or pressure change across the elbow is related in some complicated way to the flow rate, let's say volumetric flow rate.

Now it's a complicated problem because the water is there and they're affected by the wall roughness and there's a whole lot of things.

So what you're trying to do is calibrate this periodically to understand how the relationship between the pressure difference and the volumetric flow is affected.

MR. BROCKHOFF: Yes.

MEMBER BANERJEE: Now what we are concerned about is, yes, that's nice, we want to know how accurate your benchmark against which you're doing this calibration is.

Because let's say if you're doing this based on a heat balance, which is what you're suggesting, then it becomes a function of how accurately you can measure reactor power and how accurately you measure temperature or how accurately you're measuring some flow rate somewhere else.

We haven't yet closed that loop, okay. We understand that you recalibrate, we're still open as to how you do that.

MR. BROCKHOFF: Okay. Let me see if I can get to slide seven. I think it will show you the range of things we're looking at to make them all --

MEMBER ABDEL-KHALIK: Just before we get there. This may be a cartoon, but is the angle of the bend in the hot leg as shallow as this one shows?

MEMBER SIEBER: Yes.

MR. BROCKHOFF: That's the 3-D, yes, sir. It's not an --

MEMBER ABDEL-KHALIK: But, I mean, you know, the field installation is going to --

MEMBER BANERJEE: It's not 45 degrees.

MEMBER ABDEL-KHALIK: It's not a 90 degree, it's not 120 degrees --

MR. BROCKHOFF: It's not 90 degrees. It's about 45. I forget the specific geometry, but I believe 45 degrees.

But anyway, this is a 3-D sketch that shows the relative configuration of the two elbows.

MR. BURNETT: We calculate approximately a 25 psi delta P between the inside and outside of the hot leg elbow.

MEMBER ABDEL-KHALIK: Despite the relatively sort of minor bend that you have in there rather than a large angle bend?

MR. BROCKHOFF: It's not a 90 degree bend, it's approximately a 45 degree --

MR. BURNETT: I can't vouch for how representative the picture is, but as I say, we calculate about 25 psi delta P from the -- between inside and outside of the bend. It is not a long radius bend.

MEMBER ABDEL-KHALIK: It sure looks like it.

MEMBER BANERJEE: That's probably accurate, that 25 degrees, yes. Whatever the artistic picture is because that's where we worry about reflux condensation, not in your system. It's pretty sharp.

MR. BROCKHOFF: Now, as part of our startup procedure there's two tests that we do. In 14-210 we do a flow measurement prior to criticality to verify that we get about 90 percent of flow.

We know what we get from the design and what we expect to see. And the goal is this is our design basis number that used in safety analysis and we expect to get maybe like 102 percent or something.

And then as part of our startup testing, we actually take the reactor critical and we do calorimetrics on our way up to 100 percent power. So when we get to 100 percent power, we know that we're at 100 percent power and that we should be at least 90 percent or more of flow and expect more beginning to life.

MEMBER SIEBER: Those are secondary calorimetrics.

MR. BROCKHOFF: Yes, sir. They're secondary calorimetrics across using precision --

MEMBER SIEBER: As opposed to primary calorimetrics.

MR. BROCKHOFF: Yes, sir. Our standard is that we use is a secondary calorimetric.

MEMBER SIEBER: Over the last 50 years?

MR. BROCKHOFF: Yes.

MEMBER SIEBER: Okay.

MR. BROCKHOFF: Yes, I've done many of them. Anyway, so we will do a calorimetric at 100 percent power and we'll calculate flow using a precision calorimetric but we also think we can get better overall accuracy by evaluating data from other sources, which we'll look at next in establishing this baseline for the plant.

The baseline flow measurement that we will document in an engineering report at the completion of the plant start up testing is to measure reactor d/p compared to the factory tests that we use with the d/p.

We've got d/p measured in the plant and the testing made at the factory. We can use RCP motor current for example, as an indication of power. We have the differential pressures available from the taps and we also may choose to install other differential pressure measurements as part of the testing once we evaluate what we want to do to plant his.

And then the at power contribution is a delta T and a calorimetric we just talked about using T_H versus T_C. And we can use T_H and T_C in the loop, we can also use core exit thermocouples that give us a better distributed average of T_H for a measurement.

So there's lots of different things we look at and the end result would be that knowing the instrumentation uncertainties as measured, we would go back and try to determine what the overall uncertainty was in flow measurement.

And the report would basically give us some flow rated X plus or minus gallons per minute based on the overall process on accuracies in each individual --

MEMBER ABDEL-KHALIK: Do you really expect to be able to use the core exit T_c measurements to give you a better estimate of the hot leg temperature?

MR. BROCKHOFF: It will give us supporting data for it. I suspect it won't be the thing that we use. But one, it can give us one expectation of the distribution coming out of the core.

The accuracy though obviously isn't the same as the accuracy loop instruments.

MEMBER ABDEL-KHALIK: Not just that, but do you know the individual flow within individual assemblies that are right below these T_cs?

MR. BROCKHOFF: No, you obviously don't. So it's an input that we can use to help us understand is there some benefit we can gain from that.

You're right, we don't know the flow through an individual channel and there's not of other things that can contribute. There's leakage around the vessel that comes into play, because that eventually comes back in the hot leg.

So the goal is to look at the range of instrumentation and information we have and that we can maybe add special stuff to go in and evaluate this and give us a benchmark that the plants that use this today didn't have when they established this process.

So we think we'll have better information and we'll figure out how we want to use this and how we can best --

MEMBER ABDEL-KHALIK: And yet the statement was made earlier that in current plants you can measure the flow within 1 percent and in this case you expect to be able to measure it within 3 percent.

MR. BROCKHOFF: I don't think --

MEMBER ABDEL-KHALIK: Could you explain why that's different?

MR. BROCKHOFF: I didn't say 1 percent of flow measurement.

MEMBER ABDEL-KHALIK: Somebody on the phone said that.

MR. BURNETT: Yes, this is Tobey Burnett. What would you like explained, please?

MEMBER ABDEL-KHALIK: Why is it that the uncertainty in flow for the AP 1000 is expected to be greater than that for current plants?

MR. BURNETT: Predominately the two loop geometry, second to that the very large hot leg pipe diameter and the very low large -- the extreme low leakage loading pattern.

The low leakage loading pattern will cause large variations in temperature coming out of the different core's assemblies. Those will not be completely mixed at all in the hot leg.

So the variations in hot leg temperatures at different places, as I've said, we expect to see plus or minus 10 degrees from the average.

Now we have 14 total hot leg RTDs at different locations. Each one of them individually is accurate to well within 1 degree. In the cold leg there are a total of 12 RTDs, averages of all of them we expect to be good to within a few tenths of a degree.

However, the variation in hot leg temperature, as I've indicated, means that there is uncertainty in the average of the hot leg RTD temperatures and the mixed mean hot leg temperature.

MEMBER ABDEL-KHALIK: Thank you.

CONSULTANT KRESS: I would envision each of these methods give you a different flow value and a different estimating uncertainty. I'm not sure how you look at all those measurements and come up with this bottom line and some sort of average flow with an average uncertainty. I don't know how to combine all those things.

MR. BURNETT: Each method will have -- has its own uncertainty associated with it and it will be the purpose of the report to reconcile all the variations and explain the differences beside the uncertainties.

I'll point out that two plants that I know of, the core exit thermocouples turned out to be the most accurate means of determining flow. There are other plants where the core exit thermocouples prove to be of no value for that.

So all we can do is say we will examine them and extract whatever information we can from it.

MEMBER BANERJEE: Now, when you do those d/p measurements on the elbows the uncertainty also takes into account that you periodically recalibrate them, is that --

MR. BURNETT: No, the elbows themselves are not recalibrated, only the instruments that measure the d/p.

MEMBER BANERJEE: Right. But there's a

different relate as time evolves the relation between d/p and flow will change or maybe expected to change due to changes in roughness and other factors, right?

MR. BURNETT: We do not expect any significant change in flow due to roughness of piping. There has been a very small change in measured reactor coolant pump performance because of the phenomena called impeller smoothing.

We do not believe that there would be any significant effect on the roughness of the pipes in the reactor coolant piping system.

MEMBER BANERJEE: So you don't expect the d/p-flow relationship to change over time?

MR. BURNETT: Say again please?

MEMBER BANERJEE: So you don't expect the d/p versus flow relationship to change over time?

MR. BURNETT: No, we do not.

MEMBER BANERJEE: And is that borne out by current operating plants?

MR. BURNETT: Yes.

MEMBER BANERJEE: And how do you know that? Do you periodically check that relationship?

MR. BURNETT: That was the basis for the work that was done on the plants that mentioned on the first slide, Farley, South Texas, Seabrook and so on.

In those cases for these plants and treatment plants, measurements over various cycles indicated no changes in the delta P.

However, in that case there was a reason to be concerned about that because those were bends, elbows in the cold leg and the concern was that they could be impacted by changes in steam generator two plugging.

The indication -- the results of the measurements over time indicated that there was no impact.

MEMBER BANERJEE: And how did you determine that? Was that by doing some precision measurements? That's what we were trying to understand.

MR. BURNETT: On those plants the basis had been the calorimetric delta T method.

MEMBER BANERJEE: And where was this calorimetric delta T done, on the primary side of the secondary?

MR. BURNETT: Well, the primary is the hot leg and cold leg temperature, the secondary is the feed water calorimetric, feed water flow temperature and steam pressure.

MEMBER BANERJEE: So was that the primary measurement that you used to determine whether this d/p changed or not? Was it the latter measurement or the primary measurement?

MR. BURNETT: Originally that method, feed water calorimetrics and primary delta T had been the primary method used to measure flow.

MEMBER BANERJEE: And is that what you used to determine that the d/p was not changing with time over the hot leg and cold leg bends?

MR. BURNETT: That substantiated it.

MEMBER BANERJEE: What other method was there?

MR. BURNETT: I beg your pardon?

MEMBER BANERJEE: What other method -- if you just say this act substantiated it --

MR. BURNETT: Oh, one does not expect the elbow tap delta P to change with time. It is a function of the geometry and since the geometry does not change, one does not expect the calibration -- the delta P characteristics to change. That's why I said it was substantiated.

MEMBER BANERJEE: Yes, but that's not what you find with Venturis that were used --

MR. BURNETT: Venturis can foul and since they are very sensitive to the throat diameter, that can occur. But when you have 31-inch ID pipe, no fouling is not a factor.

MEMBER BANERJEE: Well it's not the fouling which is what caused the problem with the Venturis, the throat roughness.

MEMBER SIEBER: It depends on the Venturi.

MEMBER BANERJEE: Yes. The problem is a different one because when you go around the bed, what you set up is a secondary flow, which is very, very sensitive to all roughness. Therefore, I can't take that as the primary answer, you must check that against some other measurement.

So if you say that you check it against delta Ts and things, that's fine, but I wouldn't go into the assumption that you're not expecting the shape to change.

Nobody expects the shape to change, it's the roughness which changes. Maybe the roughness doesn't change on the primary side, I don't know, but I wouldn't assume it.

MR. BROCKHOFF: Sir?

MEMBER SIEBER: Do you use the elbow taps in the primary system, the differential pressure, which is an indicator of flow for any safety signal in the plant reactor trip, for example?

MR. BROCKHOFF: We use the hot leg for low flow trip indication.

MEMBER SIEBER: Hot leg temperature or --

MR. BROCKHOFF: No, we use the hot leg flow tapping. Well, the temperature is used for o/p and o/t delta T indication.

MEMBER SIEBER: Right. What do you use the flow, is there a reactor trip that comes from a flow signal?

MR. BROCKHOFF: Yes, sir. A low flow, at 90 percent in the hot leg. So that tells us we lost flow to either steam generator and we could generate a trip. That's why the original 90 percent in that previous slide. At any rate, let me --

MEMBER ARMIJO: How deep into the flow do your --

MEMBER BANERJEE: I thought they were on the wall.

MEMBER ARMIJO: -- are they wall taps or do they go in a couple inches?

MR. BROCKHOFF: They're wall taps.

MEMBER ARMIJO: They're right on the wall, so it's surprising that surface roughness or oxidation over time wouldn't change the d/p.

MEMBER BANERJEE: Well, they do, so it's

not correct that they don't. They do change, that's the thing. So there is a -- definitely we know with Venturis, it's not fouling, it's simply roughness changes which causes this problem.

Okay. So there is a significant issue. Now maybe it doesn't happen in this case, but in general it does. So it's not a general conclusion.

MR. BROCKHOFF: Well the purpose -- again, the purpose to integrate everything is to try to compare the various measurements against one another and to have this baseline report to start with.

CHAIR RAY: Well, but wait. I think there's a key point here which Sanjoy keeps coming back to, which is does the characteristic change d/p, elbow d/p over time? Because that's not going to be discerned by any of the --

MEMBER BANERJEE: No, it's true because of the comparison periodically calibrated. So I --

CHAIR RAY: Yes, but you were asking if you could infer the change in the characteristic of the elbow d/p versus flow and I thought he said no.

MEMBER BANERJEE: No I think maybe I got the wrong end of the stick, but I thought that periodically you could compare that with your delta T measurements and things but on startup and things like this where your core temperature variations are not that great.

MEMBER SHACK: I think the difference was that Sanjoy looked to that answer to really answer the question.

MEMBER BANERJEE: I thought it was answered actually.

MEMBER SHACK: What we heard was his initial conclusion that it wasn't going to change, but that's, you know, it's a semantics sort of thing. I mean, the --

MR. CUMMINS: Maybe I can help. The tech specs for you to every outage to calibrate the flow with a calorimetric. So yes, you must, yes you must calibrate it with a calorimetric.

MR. BURNETT: No.

MEMBER BANERJEE: That answers the question, you don't need to say more.

MR. BURNETT: No.

CHAIR RAY: Somebody's saying no.

MEMBER BANERJEE: Yes, Tobey.

MR. BROCKHOFF: Let Tobey talk, he knows best.

MR. LYMAN: May I interject something here at this point? Walt Lyman, right. Concerning elbow taps, we use as a reference the ASME fluid meters book, which itself refers to many, many elbow tap tests.

And one of the conclusions that the tests have come out with is that roughness on the surface of the elbow has no effect on the measurement. And that's what we rely on as backup as a reference.

Meanwhile, the plant data that we have does not indicate that there's a systematic effect on flow with time.

MEMBER BANERJEE: Well, but you do have the ability to check that, right?

MR. BURNETT: I would disagree with that. That is it is my belief that once you have a flow calculated for -- once you know what the d/p characteristic of the elbow is, it will be superior to any other means by which you can check flow.

You can look at what we call the calorimetric delta T method on later cycles and that will help you determine how much in error the calorimetric delta T is with time.

MEMBER BANERJEE: I guess we're not going to resolve this.

MR. BURNETT: But if you want to know the flow, then look at the delta P from the elbow taps.

MEMBER BANERJEE: I guess we now go back to Said's original question.

MEMBER ABDEL-KHALIK: Let me just put the question differently. Do you expect the relationship between, let's say hot leg flow and delta P in the tap to be a unique relationship independent of the temperature distribution within the hot leg?

MR. BURNETT: Essentially yes. That is, we do not expect it to change with time.

MEMBER ABDEL-KHALIK: No, no, no, no. That's not the question. The question is, is it independent of the temperature distribution within the hot leg.

If you're telling me that the temperature across the hot leg can vary by as much as plus or minus 10 degrees from the average hot leg temperature, the question then is is this a unique relationship?

If you have a -- now, it's not just geometry --

MR. BURNETT: Part of it will be somewhat stable, but not necessarily because they are forced by the variation in the core exit temperatures and the peripheral assemblies will always be cooler than the average toward the center, but there will be variations in the core power distribution and core exit temperatures.

MEMBER ABDEL-KHALIK: I think we're sort of drifting from the core of the question. You implied that the delta P across the tap versus flow is dependent only on the geometry.

So if I had significant variations in density of the fluid that's going through this pipe, that doesn't have any impact on this relationship?

MR. BURNETT: It has an impact, but I submit that that is second order because the variation and density. We're not talking about the difference in density between the hot leg and cold leg, we're talking about less than plus or minus 10 degrees maximum.

MEMBER ABDEL-KHALIK: What is delta T across the core?

MR. BURNETT: Average between hot leg and cold leg about 75 degrees.

MEMBER ABDEL-KHALIK: Okay. So 20 degrees out of 75, that's a significant fraction, don't you think?

MR. BURNETT: Yes.

MEMBER BANERJEE: And the effect of the roughness, by the way even if it is small, is because you've got wall taps. And the problem that happens with wall taps is that if you change the roughness in their vicinity, their measurement changes significantly.

So unless you can guarantee absolutely that the taps stayed perfect -- how large are these taps in size? How big are they? Are they --

MR. BROCKHOFF: I believe they're one inch.

MEMBER BANERJEE: One inch taps?

MR. BROCKHOFF: Yes, sir. That's our standard smallest line size.

MEMBER BANERJEE: And these are flush with the wall?

MR. BROCKHOFF: Interior wall, yes, sir.

MEMBER BANERJEE: They are just little holes?

MR. BROCKHOFF: So there's no turbulence added by the tap.

MEMBER BANERJEE: Well there's always turbulence because you get a --

MR. BROCKHOFF: I mean not protrusion other than the turbulence of the actual hole itself.

MEMBER BANERJEE: So typically what happens at these taps is that you get a little vortex sitting in there and usually they're affected. Now you may have a magic tap, which is not.

Having made pressure tap measurements all my life, I see this as not that easy to guarantee that doesn't change. But maybe it doesn't, I don't know. I'm not going to pursue it, so let's leave it. Move on.

CHAIR RAY: Well, Sanjoy I --

MEMBER BANERJEE: I'm so skeptical that things don't change. Even in an experiment in the lab they change over a period of time.

CHAIR RAY: I'm happy to move on, but I don't want to drop this item. Can we narrow it down to this question that you are still discussing --

MEMBER BANERJEE: Well I think that -- you know what I'm most satisfied with actually is that you have several different methodologies that you periodically check it and then it just becomes a matter of opinion. Which is more accurate or not? I don't think it's particularly relevant to the discussion.

We simply wanted to be sure that you had a robust way to measure things which did not only depend on elbow measurements. So I think you answered those two things.

CHAIR RAY: So you're satisfied that you don't need any further follow up?

MEMBER BANERJEE: No, because they have many redundant methods that can do a reconciliation, I mean the procedure seems okay. They are going to do secondary site measurements, they're going to do primary site, you know, startup, tech specs.

CHAIR RAY: Do you want to carry it any further?

MEMBER ABDEL-KHALIK: I mean, I'm not really concerned about the 90 percent core flow trip signal or any of this stuff. There are other things that are highly dependent on core flow as you're well aware.

When you calculate how much sub-cooled boiling you'll have in the hot channels, that will depend -- that will be very sensitive to core flow.

And therefore, you know, when you talk about crud accumulation in the hot bundles, et cetera, that will be dependent on this. And any calculation that you may make about boron deposition and impact on shut down margin and all that will be significantly affected by whatever calculation of core flow you'll come up with.

CHAIR RAY: But given Sanjoy's assessment that there are multiple methods that are going to be cross checked against each other, it seemed like the only issue was the time duration variation and the elbow tap measurement.

MEMBER ABDEL-KHALIK: I agree with the issue as posed by Tom. Each one of these will give you a different answer, will give you a different uncertainty and I'm not sure how you'll come up with that bottom line.

MEMBER BANERJEE: Presumably they have to satisfy somebody that they've been reconciled.

MEMBER ABDEL-KHALIK: It will satisfy the 90 percent requirement, that's not a problem. That's not a problem.

CHAIR RAY: Would you like to frame a further item?

MEMBER ABDEL-KHALIK: I don't know how to pose the question other than, you know, perhaps the way that Tom posed it, is how are you going to reconcile all these different presumably independent ways of estimating a core flow and the uncertainty in core flow. Is that?

CONSULTANT KRESS: That's my question.

MEMBER ABDEL-KHALIK: Right.

MR. BROCKHOFF: And that's one of the --

that's really one of the tasks from our engineering report is to do that with to the satisfaction of staff review. I mean, that's our plan.

MEMBER BANERJEE: But I don't think it's satisfactory to refer to some ASME document and say that, you know, this is why we have such faith in this measurement.

MR. BROCKHOFF: Well I think the may and the faith is the different ways that we measure it and satisfy that if there is variation we've identified it, we think from the various methods that are available.

CHAIR RAY: Okay. Are we satisfied with the staff review then of what they do in accordance with this multiple sources of checking flow? Anybody want to carry an additional item otherwise we're going to close this and move on? Thank you Rob.

MR. SISK: Excuse me Chairman, is this closed?

CHAIR RAY: Yes. It's closed until we open it again.

MR. SISK: Fair enough. I'd like to invite Mr. Phil Kotwicki up to one more item that we'd like to discuss this morning, I think it's item 29 on your action item list. It's the criteria for striping.

CHAIR RAY: Actually, it's thermal stratification and cycling and striping, more elegantly stated. Harold will be back in a minute, but we can proceed.

MR. KOTWICKI: Okay. My name is Phil Kotwicki, I'm a member of the AP 1000 piping and support group. We're going to talk about thermal stratification and cycling and striping.

That issue is something that we basically follow the MRP-146 guidelines to do our screening. Basically a first step is to look at your normally stagnant branch lines and the MRP-146 was really looking at just the lines that feed into the reactor coolant loop.

What's changed over the years is this potential for turbulent penetration or swirling that can move up into or down into lines that typically you wouldn't expect that to occur with.

Normally, you can do the first step just by starting with a P&ID or piping and instrument diagram to look at the paths and look at flows stagnant systems to see where you're going.

There are three example. Again, these are pretty much pictures out of the MRP-146. You've got an up-horizontal configuration, you got basically a horizontal piping configuration or a downward horizontal piping configuration.

And again, there is no flow into or out of these lines other than what you would get from this penetration that we're talking about. You can get, obviously, migration of denser colder water downward and less dense hotter water upward, but that's less of an issue than some of these other a little more complicated penetration issues.

What we found and what MRP-146 has identified is that when you do have a certain level of stratification, you can kind of tie this to an endurance-limit kind of thinking so that the global vending that you would get from a stratified pipe in addition to the local stresses that would induce to give you a peak stress kind of value when you've got maybe a 50 degree top to bottom across, a cross-section kind of temperature differential.

It's kind of the threshold where you're starting to get concerned. So if you get a value less than that, you're basically looking at something that is less than the endurance limit and if you've got 10 million cycles, it's still okay.

MEMBER BANERJEE: How are these -- was

there some sort of accelerated testing done to come up with these criteria? Because it depends on the number of cycles, right?

MR. KOTWICKI: Right. I mean they're basically going into the fatigue curves and saying this value is at what, 2.5 times 10 to the seventh and it gives you this value. And as long as that number of cycles associated with that stress --

MEMBER BANERJEE: So it's expected to last 60 years or whatever the number is?

MEMBER SIEBER: It's pure elastic.

MEMBER SHACK: He's not really trying to design this, he wants to get down to where the endurance limit, to where the life is very, very long. And so, you know.

MEMBER BANERJEE: Okay. So you're going to asymptotic?

MEMBER SHACK: Right.

MEMBER BANERJEE: And saying that this is the --

MEMBER SHACK: Since it's not truly asymptotic he's always going to give you a number, but it's a number that's out to like 10 to the seven cycles. It's a very large number, you're not going to sit there and try to count them, you just --

MEMBER BANERJEE: And this is established over a basis of experiments?

MEMBER SHACK: Right. Well, experiments, you don't do any experiments at the 10 to the seven.

MEMBER BANERJEE: You can do it with the rapid cycling?

MEMBER SHACK: Yes, you could -- I haven't seen those too many out there, but yes, you get them as far out as you can and then you have rules for how to conservatively extrapolate.

MEMBER BANERJEE: Extrapolate, okay.

MR. KOTWICKI: Again, the screening is really the first step in a larger process. The screening is trying to say can I look at something and dismiss it immediately or do I need to carry it along as a potentially susceptible situation, so.

The real small sizes we really don't expect to see, and we're identifying two-inch and smaller as that size to kind of dismiss because the type of penetration we're talking about isn't really significant for that.

Pressure devices in the line, very relatively long vertical sections where, you know, something can happen in the vertical section, but unless the horizontal turn is close enough, you're really not going to be too concerned about it, so.

MEMBER ABDEL-KHALIK: Could you explain the last bullet on this? What does it mean when something's greater than the maximum or less than the minimum specified in XYZ?

MR. KOTWICKI: When we're looking -- there are ranges for this vertical length of piping where if it's long enough you don't need to worry about it, this phenomena developing into the horizontal section.

So if all of this is going on in the vertical section, you're not really getting stratification. You don't get -- you can get stratification at a vertical section, but it doesn't really do you any damage.

When you get it in the horizontal section is when it starts causing bending and issues that you're concerned with. So they're identifying a maximum and a minimum in this document to be concerned with. Your question?

MEMBER BANERJEE: I guess it would be nice if those limits were clearer is what you meant. How much is it?

MR. KOTWICKI: Well, it will be -- it will depend on pipe size and other perimeters.

MEMBER BANERJEE: Right. So there's some

relationship they've given you.

MR. KOTWICKI: I mean if you've got a 30-inch pipe it may -- it will be a different value than if it's --

MEMBER BANERJEE: Is it sort of an L by B or something?

MR. KOTWICKI: That probably factors into it, I'm not sure that I completely understand where those things came from, from this particular document, but.

MEMBER BANERJEE: I mean, the main thing is that this document exists as guidance.

MR. KOTWICKI: Yes.

MEMBER BANERJEE: When I ask the question I remembered from tests that were done in France back in the maybe 20, 25 years ago which showed this closed-end pipes that they were very serious effects due to the vortices going in and out and creating thermal striping.

MR. KOTWICKI: Right.

MEMBER BANERJEE: And obviously EPRI did something about it after that.

MR. KOTWICKI: Well, this has got a history, there have been --

MEMBER BANERJEE: It's been going on for a long time.

MR. KOTWICKI: -- come up where, you know, cracking has occurred and leakage has occurred.

MEMBER BANERJEE: Right.

MR. KOTWICKI: We've got a new design we want to be looking at this type of thing.

MEMBER BANERJEE: Yes, so let's go on.

MEMBER SHACK: This is screening for both the stratification and the striping? I look at them as different.

MR. KOTWICKI: Well, yes. The striping is a little peculiar, and again, this is really if you've got stratification, you really need stratification to get striping, it's just a different phenomenon in a downstream phenomenon in the way we would look at it.

I think of striping more as you've got a pretty well defined boundary of cold and hot and that boundary --

MEMBER SHACK: Shifts up and down.

MR. KOTWICKI: -- tends to fluctuate. So, until you get the stratification, you don't have the striping. So we'll screen according to that in the first place.

MEMBER BANERJEE: It's really the striping which gives you --

MR. KOTWICKI: Right.

MEMBER BANERJEE: -- the moving?

MR. KOTWICKI: Yes. And that's the kind of thing we would look at, you know, as part of a fatigue analysis. And what we've done -- and we've already gone through at least the screening aspect of this in the AP 1000 plant.

We've identified in the DCD those lines that again, the first cut, these are potentially susceptible to thermal stratification and potentially striping.

So we've listed the lines, it doesn't necessarily mean that all of these lines are going to be something we need to do something very positive about, but what it does indicate is that we will take these lines, potentially go to a next step of doing an analysis to define what that level of stratification is.

If that's bad enough, then we'll take the next step of doing, you know, incorporate a fatigue analysis. The MRP-146 says, you know, depending on where you are with all of these types of inputs, do I do more inspection, should I monitor this line, should I change the layout it's so bad, do I get a UC factor that says this is horrible you better do something else.

So, the screening is just the first part that says here's what you have that's susceptible, you know, the next step do an analysis and see whether that susceptibility is high enough to worry about.

You know, the next step might be, you know, some kind of a design change, but --

MEMBER BANERJEE: But when is this process going to be closed? I mean, this is an ongoing process right now, right?

MR. KOTWICKI: The overall process of addressing the issue of thermal stratification and striping, you know, you got the screening, which is all we're really talking about here, you've got the analysis, this would factor in to the ultimate fatigue analysis.

So we have that factor and this, I expect, to be -- we're hoping we're done with this by the end of the year.

CHAIR RAY: This, being the screening?

MR. KOTWICKI: This being the screening analysis and the follow up analysis and incorporation into a fatigue analysis.

MEMBER BANERJEE: So assuming that you buy into the screening, which there's no reason why not to, those are essentially the lines which appear to need some further analysis.

MR. KOTWICKI: Well, and we'll say potentially susceptible to.

MEMBER BANERJEE: Yes, potentially susceptible. So now let's say that you do more detailed work on these and a couple of them turn out to be problematic, what would you do about it? You might change something, right, but you're going to close this whole process by the end of the year?

MR. KOTWICKI: Well, and again, if a little more severe action is required, then we may need, you know, a regulatory review of a change.

But if we do something that says, I can't stand the way that this thing is laid out because it's giving me problems, I may change the layout. We wouldn't be anxious to do that.

MEMBER BANERJEE: Obviously not. But there is sort of, if you like a sort of a process now in motion that one you screen, two you do some analysis, three you come to some decisions as to whether anything needs to be changed.

Some of these changes, if any, may not have any regulatory impact, but some of them might. So that's eventually potentially a small number of items which might need regulatory blessing at some point that it's okay.

And I'm wondering if that whole process can be done by the end of the year, because it looks like you've got to do a fair amount of analysis with all these lines there.

MR. KOTWICKI: Right. And it's not like we haven't started.

MEMBER BANERJEE: Right.

MR. KOTWICKI: I mean we're not starting today. I mean we've done one of the follow-up steps when we say analysis is this CFD analysis. So this is --

MEMBER BANERJEE: Well I have some concerns about that because when you are looking at things like sharp interfaces, if the CFD analysis isn't being carefully tested against experiments, there are issues with how say it seems like turbulence behave near sharp interfaces.

And most commercial CFD methods are not very good at predicting this. It can give you some qualitative information, but I don't think it can give you some quantitative information.

Now, maybe the French can do it because they've been involved with this problem for a long time, but I don't know if you have access to their codes. You're probably using some standard like FLUENT or STAR-CD or I don't know what.

MR. KOTWICKI: Yes, we're using CFX.

MEMBER BANERJEE: Oh, CFX. So these probably will have potentially problems in what is happening with these interfaces. So I don't think they can be used in a quantitative way. They can indicate qualitative, what's going on.

So your -- my concern would be how much reliance you can place on CFD versus, you know, actual experimental data that exists in these range of sizes and things. And they may be quite a bit, I don't know.

MR. KOTWICKI: And I agree with you. You can do an analysis, and anyone that does an analysis needs to look at it and say do I believe these results.

MEMBER BANERJEE: And I have a problem with CFD.

MR. KOTWICKI: Well, you're not the only one. The one thing that we've committed to do is specifically monitor the surge line for our first plant.

MEMBER BANERJEE: That sounds very robust.

MR. KOTWICKI: And are we able to predict what we're able to measure. So, I mean, if those are night-and-day different, then somebody's got to go back and maybe look at --

MEMBER SHACK: Well just in terms of data, you've been monitoring surge lines --

MEMBER BANERJEE: Yes, that's what I was going to ask.

MR. KOTWICKI: We've got a very unique surge line on this plant.

MEMBER SHACK: No, but as far as verifying the tool.

MEMBER BANERJEE: At least supporting it.

MEMBER SHACK: Supporting the tool. Verifying is a strong word, right.

MR. KOTWICKI: Well, can you simulate or test for everything you can possibly think of? I mean you're really not going to get to that.

MEMBER BANERJEE: What brought this on was your ADS four lines and, you know, things are different in this design. So part of the question is associated with that and the new factors compared to your other plants.

MR. KOTWICKI: We are certainly doing more of this type of analysis than we've done for other plants, so.

MEMBER ABDEL-KHALIK: If you're concerned about this issue for the hot leg, does that translate into some constraints? The hot leg is one of the lines that you will analyze, does that translate into some constraints on correlating patterns?

MR. KOTWICKI: I don't think so. I started out by staying for all intents and purposes, this is for stagnant conditions, so this is not for hot or cold leg during normal conditions, these are shutdown conditions where the hot leg would be involved in something like this.

MEMBER BANERJEE: It has to be significantly stratified.

MR. KOTWICKI: Right. In fact, it's not even full in that particular case that we're talking. And I think the last I heard, and this DCD input is a little dated in the sense that, I think the operating mode that was causing the problem actually went away. So, I'm not even sure it's part of the system design anymore, so.

MEMBER BANERJEE: What was that?

MR. KOTWICKI: I believe it was mid-LOOP operation.

MEMBER BANERJEE: Can you just explain

that a little bit?

MR. KOTWICKI: I think, of course, and I'm not a systems guru, but during shutdown this thing can be half full or whatever and you can have transients that could potentially occur during this condition that you've got a stratified case and you've got some kind of flow coming into or out of that that is potentially giving you something that you want to analyze for.

So that's why it was screened in and why it was there for just initial set of lines that potentially susceptible.

CHAIR RAY: Are you satisfied Sanjoy?

MEMBER BANERJEE: Yes. Well, I'm satisfied by the procedure, I'm just wondering how it's going to close, but that's a separate issue.

CHAIR RAY: Well, he's got a last slide here which doesn't actually use the word close, but it uses the word closure, which is the DAC closure, is when it's satisfied, which you were asking about something much sooner than that I think.

MEMBER BANERJEE: I was just asking about the schedule, what that says is this will be closed in the DAC.

MEMBER SHACK: Yes, but they're going to

get rid of the DAC, that's still the plan isn't it or isn't it?

MR. CUMMINS: Ed Cummins. No, the piping DAC --

MEMBER SHACK: That's the piping of course.

MR. CUMMINS: This is a piping DAC issue and basically Phil's comment that if you finish that around the end of the year, that doesn't support our current licensing schedule. So we've retained our position on the piping DAC in making it not included in the revision to the circ pipe design.

CHAIR RAY: Anything else? Going once, going twice? All right we're a little behind schedule. We're going to go ahead with the last action item because when we come back from lunch, we want to go into a closed session for the shield discussion.

MR. SISK: Mr. Chairman, for that last item, did we resolve the question or is there --

CHAIR RAY: This item is closed.

MR. SISK: This item is closed.

CHAIR RAY: Check it that way, and Rob I'll do the same.

MR. SISK: Thank you. The last item

before we get started I'm going to kind of be a Parrot up here, but is Mark Stella online?

MR. STELLA: Yes, Mark Stella is here.

MR. SISK: Okay. Mark, we're going to get to the high-density polyethylene piping I believe it's item 50 --

MR. WANG: Forty.

MR. SISK: Forty. Thank you.

CHAIR RAY: Go.

MR. SISK: Okay. The purpose of this discussion is to provide information regarding the criteria for use of the high-density polyethylene piping in AP 1000. That's where we use this and summarize a little bit of the advantages of it.

I won't go through the questions on -- the ACRS question on high-density, but what I will do is slip to the fourth slide in the interest of time.

MEMBER RYAN: Oh, no, don't rush.

MR. SISK: Very well. High-density polyethylene piping is not used in safe related fluid system applications in AP 1000, it's Class D or lower. The usage adheres to the requirements of Code Case N-755.

NRC has approved safe related applications at high-density pipe at at least two other operating plants, but I do want to kind of reiterate that we're not using it as the key application at this point.

We're also not using it to transport radioactive process fluids. All the high-density piping applications that we use is low-grade. And generally speaking, we use it in two applications, SWS flowdown alternate make-up lines and the -- I don't see it on here, but I thought the fire lines we also had it used.

HD piping is routed underground to eliminate the possibility of impact damage and material degradation due to UV. Underground installation methodology used to ensure protection of piping for distortion and damage of above ground live loads.

MEMBER SHACK: Are all those spelled out in the Code Case of acceptable methods for doing that or is that your judgment?

MR. SISK: Mark?

MR. STELLA: There are the guidance in the Code Case for use of HDPE in various safety-related applications I don't recall whether all the details are spelled out, but I'm sure that it references acceptable ASTM standards and the use of vendor standards for installation, use of thrust blocks and, you know, supports where necessary.

I can't recall off the top of my head, I haven't looked at that Code Case in a couple of months, so.

MEMBER SHACK: Okay. But it would lead you to other standards I presume?

MR. STELLA: Yes, it would. There are a plethora of other standards ranging from standard-specific for making the heat fusion joints to, you know, the supports and installation of thrust blocks, for example, where the pipe ends and comes up out of the ground and where there are transitions between HDPE and metallic pipe where you need to take into account the different thermal expansion capabilities of the two types of pipe.

So it's not, you know, when these things are being -- the systems are being designed and being installed, this isn't just being done in a way that is unguided. There is substantial guidance for the use of these HDPE pipes.

The largest-bore pipe that I know of right now in AP 1000 is no more than 10 inches for AP 1000. We have probably pipe of that size in the part of the RWS and WWS, but those are all site-specific applications.

And I'm not familiar with exactly what they're using, but the blowdown and alternate make-up lines in SWS are smaller bore piping to begin with.

MEMBER SHACK: Now the staff has approved this for some applications, have they approved the Code Case or just is this still application specific?

MR. MELTON: This is Mike Melton. The staff approved a specific application for Catawba and for Calloway.

MEMBER ARMIJO: What was the application?

MR. MELTON: I can't speak for the stations, but they were Class 3 applications and then they went on and did much extensive pipe replacements with the varied piping.

MEMBER BROWN: What's Class 3, I'm sorry?

MR. MELTON: ASME Class 3?

MEMBER BROWN: Yes, what is Class 3? You said they're Class 3 applications.

MR. MELTON: Oh, I'm sorry. Safety Class 3 applications, NC Systems.

MR. CUMMINS: So things like essential service water, that's the kind of things they're using.

MEMBER BROWN: Support systems?

MR. MELTON: Support systems.

MR. CUMMINS: Yes, they're safety related because they are needed in the whole decay heat removal scheme in an active plant.

MEMBER BROWN: Okay. So there is some safety. And those things have already been approved, this does not have those though according to your charts? It says it's not used in safety applications.

MR. CUMMINS: That's right.

MR. MELTON: That's correct.

MEMBER ARMIJO: But in the AP 1000 application, is it your intent to use it for all varied piping that is?

MR. STELLA: This is Mark Stella again. No, we don't intend to use it for all varied pipe. There are only specific applications we use it for.

I might point out that these applications are all (b)(31)(1) and there is general guidance in (b)(31)(1) for the use of plastic pipe limitations, but we apply the more restrictive Code Case N-755 limits.

For example, pressure 150 pounds or less and temperature no greater than 140 degrees. Those are the pressure temperature conditions above which we do not use HDPE.

MEMBER RYAN: You mentioned the blowdown, you know, might be contained in these pipes is and blowdown can be guaranteed to be radioactive material-free forever?

MR. SISK: I'm going to repeat Mark's viewpoint. The --

MEMBER RYAN: I'm asking can blowdown be radioactive material-free?

MR. SISK: Mark, you had a question?

MR. STELLA: No, I missed it, please repeat.

MR. SISK: Can the blowdown line be guaranteed to be radioactive free for the life --

MEMBER RYAN: Radioactive material-free for the life of the plant or its extended life? Probably not.

MR. STELLA: All right, the service water system cools the Component Cooling System. The Component Cooling System could see some contamination from leaking -- small leaks in heat exchanger tubes that it services; however, with the plate type heat exchanger we have, there really is no pathway other than a plate, leak across the plate or any water from the CCS to enter the SWS.

If there were leaks in the gaskets, for example, they would be leaks to location of the heat exchanger rather than into the other fluid stream.

So, maybe the word guarantee can't be used, but there's a very high probability that there would be little chance of any radiation in the service water system.

We do have a radiation detector on the blowdown line; however, so that we can isolate the blowdown line if there is an indication of carryover of low amounts of radiation in the service water system.

MEMBER RYAN: Well the radioactive material it might be carrying, you know, I guess you'd have to talk about detection limits and all that sort of stuff.

But these kinds of things are the sources of what has been a, you know, pain in the neck kind of problem dealing with, you know, underground piping contamination.

And I'm curious if you can't guarantee it's not going to be present during the life of the plant, is there a monitoring alternative that you thought about, about, you know, having wall-in-wall pipe or some kind of detection program to assess whether it's performing as expected.

MR. SISK: Mark, did you hear the

question?

MR. STELLA: No. I'm having trouble hearing --

MEMBER RYAN: I'm sorry, I guess I'm on the backside or something.

MR. STELLA: -- with the speaker.

MEMBER RYAN: If it's not -- I mean high probability is good, but 100 percent probability is better. But I'm struggling with the fact that small amounts of contamination have caused lots of headaches and how do we avoid that?

Well, we can, you know, beef up the system in some way or we can have improved detection or improved, you know, monitoring systems. And I'm curious if you've thought about improved monitoring systems to identify any small amounts of contamination that may be present.

MR. STELLA: Well, the blowdown line has a radiation detector on it.

MEMBER RYAN: What is it capable of seeing?

MR. STELLA: It's very sensitive, it's sensitivity goes down to about 10 to the eighth microcuries per cc.

MEMBER RYAN: I'm going to guess you mean

10 to the minus eighth microcuries?

MR. STELLA: Minus eight, I'm sorry.

MEMBER RYAN: Okay.

MR. STELLA: I forgot that.

MEMBER RYAN: That would be much better.

That's all right, I just want to make sure the record didn't have 10 to the eighth.

MR. STELLA: Yes, thank you. And to get radiation into the service water system, you would have to first have it in the Component Cooling System, that also has a very sensitive radiation detector and one can detect radiation down to that level as well.

So the, you know, you would be able to identify and terminate the leak into the CCS then clean it up and again, eliminate the potential for any carryover to the service water system.

MEMBER RYAN: Ten to the minus eighth microcuries per cc is a fraction of a picocurie per liter per cc, rather.

MR. STELLA: Yes.

MEMBER RYAN: That's really low. And an in-line system, that's amazing actually.

MR. STELLA: Well, the CCS detector is a side-stream system where we take a small amount of flow off and run it through the detector.

MEMBER RYAN: Oh, I see.

MR. STELLA: So that's the one where we have the money put to be very decisive. I don't know exactly the sensitivity of the SWS detector, but that may be a see-through type detector and in that case it would be slightly less sensitive, we're in the 10 to the minus sixth, 10 to the minus seventh range, then.

We haven't decided on the specific type of detector for that application yet.

MEMBER RYAN: Okay. Let me shift gears just a bit. What's the service life of this piping if exposed to sunlight?

MR. STELLA: It certainly embrittles the piping.

MEMBER RYAN: I know that. But that's the lifetime of it. I mean --

MR. STELLA: The lifetime of the piping is somewhere between 50 and 100 years, up to 100 years according to the manufacturers --

MEMBER RYAN: That's buried.

MR. STELLA: -- without any issues.

MEMBER RYAN: That's buried though, what about if parts of it or joints whatever might be in sunlight or see daylight?

MR. STELLA: Well, we utilized the

underground installation to prevent that from occurring. The only time it would see sunlight would be during the joining process before it were put in the trench or --

MEMBER RYAN: Okay. But there's no inspection locations or any kind of access ports? Nothing comes above ground anywhere?

MR. SISK: It's all below grade.

MEMBER RYAN: All --

MR. STELLA: No the only part of it that comes out of the underground run, it usually comes out into a vault, if we have to transition between the HDPE --

MEMBER RYAN: And the metal.

MR. STELLA: -- and metallic pipe so that we can run the remainder of the line out in the open and that would still be covered. But that would also be available for inspection --

MEMBER RYAN: Got it.

MR. STELLA: -- when that transition occurs.

MEMBER RYAN: Are there any questions about the materials used for the adhesive to join sections?

MR. SISK: They're welded.

MR. STELLA: We don't use adhesive, we expect use the fusion butt weld methodology --

MEMBER RYAN: Okay, great.

MR. STELLA: -- which is basically just melting the two butt ends of the pipe that are put together under controlled conditions, pressure temperature and time.

MEMBER RYAN: One last question. Is there any plan for confirmatory measurements on the buried pipe both with regard to any leakage of fluid, water, whatever it is and then subsequently --

MR. STELLA: I'm sorry, would you repeat that, I didn't get it.

MEMBER RYAN: How are you going to inspect and confirm the performance of the buried underground pipe over time, long times, you know, plant life?

MR. STELLA: It is probably, if we bury it, that would be difficult. If it runs in the trench, or covered trench that's easier to do. The large sections pipes would be in a covered trench.

The smaller ones may just be buried and in that case, to confirm the performance would be a chore. These pipes, though, basically the blowdown line conveys water to the circulating water system cooling tower sump and the other pipe that we use it in is the alternate make-up line to the service water system cooling tower basin.

So, these are not neither radioactive nor super high pressure applications, I mean high pressure in the sense of being near the working pressure of plastic pipe.

So, I guess, you know, it's possible to if they're running in a trench to check and see if there's any leakage.

The ideal, of course, would be to make sure that you have the fusion welds made correctly and if you need further confirmation that they are made correctly besides the use of the approved procedures and perimeters, then there's always an ultrasonic method of evaluating the weld bead that can be used.

The time of flight diffraction type of method has been developed for this kind of pipe.

MEMBER RYAN: Do you have any plans to do more simple pressure tests on the welded pipe to see if they hold pressure for some period of time to verify integrity or anything of that sort or?

MR. STELLA: I don't think we have any plans other than what's required by (b)(31)(1) and N-755 at this time.

MEMBER RYAN: So that would not include a pressure test, is that right?

MR. CUMMINS: This is Ed Cummins. I think that B3011 requires hydrotest at 1.5 times the design pressure.

CHAIRMAN RAY: The initial.

MR. CUMMINS: Yes.

SPEAKER: It's not an ISI requirement.

MEMBER RYAN: That's all I have.

CHAIRMAN RAY: Okay. All right. Rob, do you want to finish up?

Anything more you want to say?

MR. SISK: Well, I think we probably by dialogue went through most of the slides. I can flip through them quickly or -

MEMBER ARMIJO: Just go through quickly, because I think we have covered these things.

MR. SISK: Yes, I'll continue on. I think the one we're supposed to start is the advantages of high-density piping material are essentially inert and are not affected by chemical and galvanic corrosion. The operating lifetime of a properly constructed HDPE piping system is estimated to be up to a hundred years. Joints produced with proper fusion conditions are leak free and not susceptible to degradation caused by exposure to process fluid, groundwater or by surface water infiltration around the exterior of the pipeline.

The HDPE piping sections and associated fittings are joined in the field by fusion, butt welding, we talked about that just a little bit ago, using specialized equipment. I had the picture of the equipment up here just a little bit ago.

The fusion conditions required to produce a strong void-free weld zone between adjacent HDPE pipe sections are well known, Key fusion parameters, the temperature of fusion zone, compression pressure on pipe faces being joined and fusion time.

A nondestructive means for evaluating the fusion joint integrity is available. That was also mentioned by Mark. The time of flight diffraction, an ultrasonic methodology, appropriate installation methods and supports are needed to control stresses and moments in systems using HDPE piping.

ASTM and manufacturing installation standards do exist. Thermal expansion coefficients are higher than for metallic piping and must be accommodated.

MEMBER ABDEL-KHALIK: And would you use this for final protection?

MR. SISK: Mark?

MR. STELLA: Well, we have been discussing using it for the underground portion of the fire protection system. But at this time, we do not have any HDPE in the fire protection system AP1000.

MEMBER ARMIJO: If you didn't use the HDPE, what would you use for those fire protection lines?

Cast iron or coated carbon steel or what?

MR. STELLA: It's an iron pipe that we presently have in the system.

MEMBER ARMIJO: So, all of this could be a potentially superior material. I think you've chosen to stay -

MR. STELLA: Yes, there are arguments both ways, I think. And that's why we haven't gone to HDPE.

MR. SISK: Okay. There's a picture of the butt fusion method used on the HDPE piping, up on the screen.

Generally speaking, we are being very limited in our use of HDPE not using it in safety-related applications, not using it for normally radioactive or treating any type of fluids. And, therefore, we think this is not a significant concern for AP1000.

CHAIRMAN RAY: Charlie, do you have a

question?

MEMBER BROWN: Yes, just that you have - you talked about the required 1.5 times design pressure test, but are you actually - you say you can - there's a test, this time of flight ultrasonic test.

Were you actually going to do that or is it just something that we can, but we may or may not decide?

I mean, it seems like you ought to maximize the utilization and make sure these things are solid and there's not some minor weakness that - minor fusion that may pass the test, but doesn't adequately fuse that may show up in the other test.

And so, sounds like you're doing one test. I'm just curious if you're going to do the other one at the same time.

MR. SISK: Mark, did you hear the question?

MR. STELLA: I did hear the question. I know that we're in the process of developing our - just to finish the first draft or maybe the first real issue of an HDPE piping installation procedure for one of our early AP1000 sites. These are being done on a site-specific basis at this point.

I haven't read it yet to see if it requires the use of the nondestructive evaluation. My understanding is that once you have qualified the joints, the pressure and temperature, etcetera, it's fairly certain that if you use the same parameters each time and make sure that you follow the joining procedures, butting the faces together and making sure they're perfectly aligned, etcetera, that you can rely on a good weld being made.

And I believe the procedure would require before that, before going into production, if you will, that test joints be made by the individuals who are going to run the fusion machine and ensure that they were capable of reliably creating these good joints.

MEMBER BROWN: What you're effectively saying, it's largely a process control as opposed to a test verifier.

MR. STELLA: Correct. And, again, we're not using the HDPE piping in -

MEMBER BROWN: I understand.

MR. STELLA: - high-pressure systems that carry -

MEMBER BROWN: What is the pressure level in those?

MR. STELLA: - well water that's been concentrated a few times by running through the cooling tower.

MEMBER BROWN: Are we talking about a few pounds or are we talking about a few hundred pounds?

MR. STELLA: Oh, we're talking less than 100 psig in either case.

CHAIRMAN RAY: Thank you. Okay. We're a little past 12:00. I'm going to ask that we be back and ready to start at one o'clock in closed session for the shield building.

MEMBER ABDEL-KHALIK: Mr. Chairman, let me just make a comment regarding -

CHAIRMAN RAY: Sure.

MEMBER ABDEL-KHALIK: I still believe that the issue with regard to uncertainty of RCS flow measurement, it's perhaps a little premature to close this item.

I believe the questions raised regarding how the different methods will be reconciled is significant and we should find out how that is going to be resolved.

MEMBER ARMIJO: Well, if I could just add to that. Westinghouse said that they have used this pressure sensor technique in other plants, and also compared it with a calorimetry and other things.

So, if it's already been reconciled in

operating plants, it would be helpful if we could get that information to see how you've actually done it.

MEMBER SIEBER: It basically goes back 50 years.

MEMBER ARMIJO: Well, I think that's the issue. And if you're going to do it the same way if we've seen how you've done it on operating plants, it might resolve the problem.

MEMBER ABDEL-KHALIK: It's finally up to the membership. I mean, it's a personal concern that we haven't really heard enough that would assure us that all these different methods somehow will lead to a closure especially in light of the large temperature variations that you would expect in this case in the hot leg temperature.

CHAIRMAN RAY: Would it be appropriate to frame maybe a - I'm trying to keep these things as clear - as much clarity as possible to word a new action item that has - comes out of this and basically says we want to understand how these multiple millions of -

MEMBER ABDEL-KHALIK: I mean, to put it as sharply as possible, we'd like to see how the uncertainty in-core flow is determined and how much is that uncertainty.

CHAIRMAN RAY: And that would include looking at how these various methods -

MEMBER ABDEL-KHALIK: Right. Is it two percent? Is it five percent?

CHAIRMAN RAY: Okay.

MEMBER ABDEL-KHALIK: We know it's greater than one percent. That's the statement that has been made.

MEMBER SIEBER: I think you need to put that in the framework of how accurate you actually need to know it. If all they use it for is to -

MEMBER ABDEL-KHALIK: I'd be happy with that as well.

MEMBER SIEBER: - indicate the loss of low, you know, you may have tremendous margin there. And if you use it for other safety-related purposes, you have to identify those and justify the accuracy for the application in which it's being used.

CHAIRMAN RAY: Okay. I would like just for bookkeeping purposes again rather than continue that same action item, I'd like to precisely word one that meets the needs of all the members who have an interest here and establish an action item that has got clarity around what it is we're still concerned about.

I think I understand what it is, but I'll ask Weidong to do that. I don't want to just leave this thing unresolved that we came in here with. I'd rather -

MEMBER ABDEL-KHALIK: Right now the issue is pretty focused. What is the uncertainty and how do you go about estimating it?

CHAIRMAN RAY: Weidong, I'd like you to check with Said, Sanjoy and Jack as to the wording of that action item to make sure all of their thoughts are captured. Okay?

MEMBER BROWN: Is Item 40 closed now?

CHAIRMAN RAY: Item 40 is closed, yes. That's right.

Okay. We have now gone on a little bit further. We'll make it five minutes after 1:00 to resume.

(Whereupon, the meeting went off the record at 12:09 p.m. for a lunch recess and went back on the record at 1:02 p.m. in Closed Session to resume in Open Session at 6:41 p.m.)

CHAIR RAY: Let me just say to my colleagues you did get a list of action items. We referred to it in the portion of the meeting before lunch. Before I ask for your input on this afternoon's discussion, let me just say that you're most welcome to identify after the meeting anything pertaining to today's meeting that you'd like to add to the action item list so you don't need to feel like right now you've got to come up with whatever it is that may be nagging at you and that you would like to see us follow-up on. This was an informational briefing. Rev 2 is yet to come in. It will get a lot of review, so this is mostly a time for us to get up to speed and ready to do what we need to do.

Having said all of that, let me go around, though, as we always do and see if there's anything to go on the record as part of this meeting. Let me start with our consultants, and I'll start with you, Tom. Anything you want to . . .

CONSULTANT KRESS: Well, I don't have any real problems. I have some impressions, if you'd like those. It's pretty late. I have some impressions.

CHAIR RAY: Well, it's up to you to decide whether it's, given the hour, it's something you want to put on the record or not.

CONSULTANT KRESS: Well, maybe I'll wait and just put it down in writing.

CHAIR RAY: That's fine. We welcome your reports. We look forward to them. But, again, if you'd like to share with the other members here anything, you're welcome to do so.

MS. MCKENNA: Well, in general, I think the Westinghouse and staff's approach is an appropriate way to do it, given the nature of the threat. And I think they're doing what they can to address it.

CHAIR RAY: You said Westinghouse, but, of course, you meant the COLA applicant, as well.

MS. MCKENNA: Yes, COLA applicant.

CHAIR RAY: I made that mistake.

MS. MCKENNA: I still think there's some issues with respect to the flow measurement that we'll need to resolve.

CHAIR RAY: We now have a new action item that we will follow-up on.

MS. MCKENNA: Good. I'm glad to hear that. There's probably still an open question with respect to the striping issue with respect to the hot leg. I don't think it's been addressed appropriately yet. I think more needs to be done on the striping fatigue analysis of the hot leg.

CHAIR RAY: Sanjoy, do you have any comment on that?

MR. BANERJEE: Well, I agree with Tom, and they are going to, they --

CHAIR RAY: You gentlemen don't need to remain, but if you're comfortable you can sit there.

MR. BANERJEE: They have intentions of dealing with this, but it wasn't entirely clear to me whether it would be done as a part of the certification or part of the COLA. If it's a part of the COLA, I'm not going to worry about it right now. They have time to resolve it, I guess. I better ask Eileen what the situation is there.

MS. MCKENNA: Well, I think when this came up earlier it indicated that this is part of, it would be part of the piping analysis and piping DAC, which is not going to be completed as part of the certification based on the review schedule that we have and the schedule that's in play for completing the analysis.

MR. BANERJEE: Can you give us the schedule for the COLA and the certification, as best as you know.

MS. MCKENNA: No, no, no.

MR. BANERJEE: Okay.

CHAIR RAY: Okay. Well, listen, Tom, what we'll do is, we did close that item, but go ahead and put something in your report that we can then assess to see if there's any more we should do, other than to recognize that this is an issue that needs -- in other words, if there's something that isn't going to be addressed and should be, that, I think, is what we're looking for. Anything else?

CONSULTANT KRESS: Well, I think they pretty much resolved any problems we may have with the buried plastic piping. Oh, I guess I'm really impressed, quite positively, with what they're doing with field design and look forward to the final resolution but certainly think they're approaching it the right way, and I like what I hear and what I see.

CHAIR RAY: Thank you. Bozidar, do you want to say anything?

CONSULTANT STOJADINOVIC: It's in this e-mail queue here I have an action item on the welds for the plates that we discussed. And another action item that I will add, and that is for the pushover analyses that I would like to just wait for Revision 2 data and evaluate that. But I think it's smart to wait for Revision 2 and review that. That will provide a lot more answers than we've already got.

CHAIR RAY: All right. I hope today was a helpful start on --

CONSULTANT STOJADINOVIC: Definitely. I

think that the progress from the previous revisions is obvious, and it is in the right direction. Hopefully, we'll get that in Revision 2.

CHAIR RAY: Bill?

CONSULTANT HINZE: Well, a few comments. Coming into the meeting, I felt that there was a need for demonstration and clarification on a number of the items that I've reviewed and looked at, and I think that this meeting has been very helpful in that regard and also looking forward to the Rev 2. I do think, too, that the large-scale tests, I had some qualms about how useful they would be and how representative they might, but those have been alleviated as a result of this discussion, and that's great. And I think that particularly the cyclic studies are extremely important. I think Bob's kind of summary comments have been very helpful, as well.

To tell you the truth, when I came into the meeting, I had concerns about whether the SB would act as a unit. And I think from a seismic standpoint, that's extremely important. And I have a much better feeling about that now and a much warmer feeling about that. I'm not a structural engineer, but I'm amazed and very pleased with the massive structures that we see at the joint of the roof and the walls.

One of my major concerns was related to the fatigue loading and what we've seen and, thus, the duration problem. And I think that what we've seen today as a result of the large-scale tests is that this may not be a never mind but it's certainly much less than I was anticipating, and I look forward to the additional tests.

I also really want to be supportive of something that Bob said in his summary, and that is the need for the kind of an increased seismic margin. There are a lot of unknowns here, and I think that his advice on this has been very helpful.

CHAIR RAY: Very good. Thank you. Jack?

MEMBER SIEBER: I guess, overall, I'm pretty impressed that the applicant and its partners have laid a pretty good foundation for the seismic analysis of composite structures and the shield building. On the other hand, the analysis isn't complete, and I think a lot of the conceptual problems are resolved at this point in time. But there is still additional work to do, so I await the completion of that work.

CHAIR RAY: Thank you. Sam?

MEMBER ARMIJO: I share Jack's views. I think the work has been very impressive. I think the experimental work was really first class. I'm glad to see it. I still have some concerns about those transition regions. I come from an environment where testing is everything where you can't model from almost first principles, although we do a lot of empirical stuff in the fuel business also.

But the other thing we haven't talked too much about is the welds on the plates. There's going to be maybe thousands of feet of weld, and the quality of those welds is something we haven't discussed. I'd like to hear a little bit more about that sometime in the future. My guess is that it will turn out okay and that even if you have a few defective welds it probably wouldn't make a great big difference, but we ought to understand that.

CHAIR RAY: Would you just make an action item? Because I think that's clearly the case. We need to have something to make sure we get back to the weld process, the inspection, the design, and so on of the --

MEMBER ARMIJO: Yes, because we didn't spend much time on that. But, otherwise, I learned a lot. I'm not a structural guy, I'm not a concrete guy, but I learned a lot. That's all I have.

CHAIR RAY: Sanjoy?

MR. BANERJEE: I don't think I have anything to add to my colleagues here, other than to compliment Westinghouse for an excellent presentation, which I enjoyed very much.

CHAIR RAY: Dennis?

MEMBER BLEY: Yes, same thing. I learned a lot from it, and I felt more confident than I was coming in.

CHAIR RAY: Said?

MEMBER ABDEL-KHALIK: I have no added comments.

CHAIR RAY: Mike?

MEMBER RYAN: No added comments, except I add my thanks and, again, I think it's an impressive body of work to get you to the stage you're at now, and it will get better as time goes on. I look forward to hearing more about it.

MEMBER SHACK: Very helpful and well-done meeting. My thanks.

CHAIR RAY: Harold?

MEMBER BROWN: Very much the same here. I thought the presentations were excellent.

CHAIR RAY: And Mario?

MEMBER BONACA: I was impressed by the work they did and they do. After reading the material in preparation, I expected them to be much behind in the design of the containment, and I was impressed by the progress they've made.

CHAIR RAY: Okay. Thank you very much. We'll go off the record now. And at the risk of being killed, I am going to ask my --

(Whereupon, the foregoing matter went off the record at 6:51 p.m.)

AP1000 Reactor Coolant Pump Flywheel

April 22, 2010

Westinghouse

Purpose

- Respond to ACRS request for information on the reactor coolant pump (RCP) flywheel failure frequency used in the AP1000 Probabilistic Risk Assessment (PRA) model

AP1000 PRA Model Information

- AP1000 PRA does not explicitly model the failure of the RCP flywheel
- A RCP flywheel failure frequency has not been used in the AP1000 PRA model

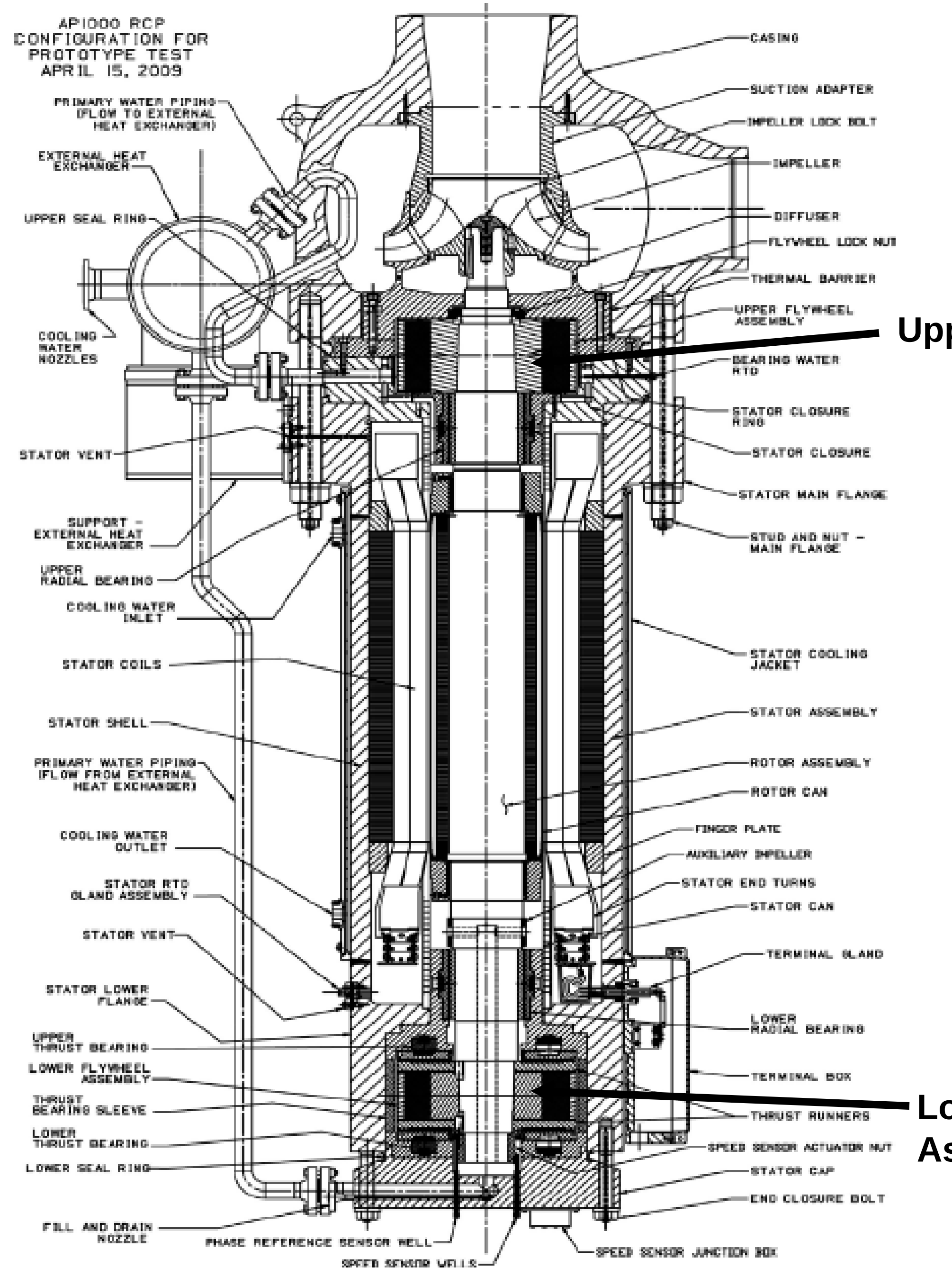
AP1000 PRA Model Information

- RCP flywheel failure could result in a locked rotor initiating event
- The locked rotor initiating event is combined with other single loop loss of reactor coolant flow initiating events
- Single loop loss of reactor coolant flow events are combined with other initiating events in the Transient with Main Feedwater event category

AP1000 PRA Model Information

- Transient with Main Feedwater event frequency is dominated by spurious reactor trip and turbine trip initiating events
- The RCP flywheel failure initiating event is
  - a subset of locked rotor events
    - which are a subset of single loop loss of reactor coolant flow events
      - which are a subset of Transient with Main Feedwater events
- Therefore a RCP flywheel failure frequency has not been used in the PRA model

AP1000 RCP Outline



Upper Flywheel Assembly

Lower Flywheel Assembly

ACRS Meeting

AP1000 RCS Flow Measurement

April 2010

Chuck Brockhoff AP1000 System Design

Westinghouse

Purpose

- Provide information regarding RCS flow measurements and uniformity of flow
- ACRS Question
  - Elbow taps for RCS flow measurement
  - Request additional information including a discussion of the uniformity of flow
  - Please provide additional background information on the Westinghouse change for monitoring RCS flow reflecting an alternate testing method to the precision heat balance
  - The alternate testing method includes utilization of d/p measurements on both hot and cold legs

AP1000 RCS Flow Measurement

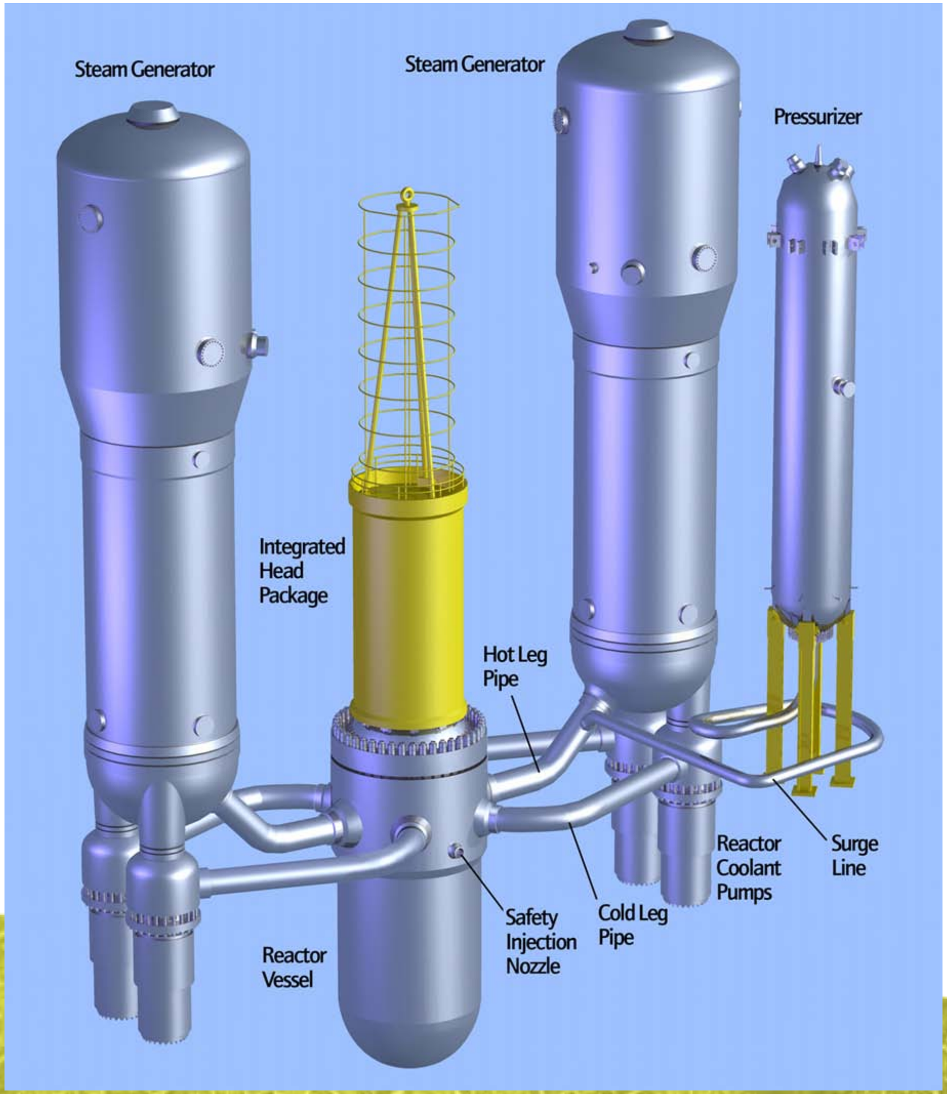
- Westinghouse Improved Standard Tech Specs (ISTS) prescribes ‘precision calorimetrics’ as the method to measure RCS flow.
- The feedwater calorimetric measures reactor power and then uses delta-T (T-hot to T-cold) to calculate the RCS flow
- Accuracy is impacted by hot leg temperature streaming (non-uniform temperatures in hot leg)
  - AP1000 geometry and low leakage loading pattern may contribute to hot leg streaming
- Technical Specification SR 3.4.1.4 <u>allows the use of alternative precision flow methods</u> in addition to the traditional calorimetric
  - This alternate approach is to use in-situ calibration of the hot leg elbow and cold leg bend d/p channels
  - Precedent exists for this method – Farley / South Texas / Diablo Canyon / Seabrook / Watts Bar

Westinghouse

AP1000 Plant Application DCD Rev 17

- Baseline RCS Measurement of RCS flow at the time of plant startup utilizing multiple sources
- Use that flow determination for in-situ calibration of the RCS flow elements
  - Hot leg elbows and cold leg bends
- Use those flow elements for all further RCS flow measurements

AP1000 Reactor Coolant Piping



Requirements for Plant startup

- The following reactor plant startup requirements apply:
  - DCD 14.2.10.1.17: “The estimated reactor coolant flow rate from data taken PRIOR to initial criticality equals or exceeds 90 percent of the minimum value required by the plant Technical Specifications for full power operation.”
  - DCD 14.2.10.4.11: “The reactor coolant system flow determined from the measurements at approximately 100 percent rated thermal power equals or exceeds the minimum value required by the plant Technical Specifications.”
- Westinghouse expects that:
  - The “precision calorimetrics” method will be adequate to meet this requirement
  - Better accuracy can be achieved by evaluating data available from multiple test sources

Westinghouse

Baseline Flow Measurement

- The Baseline Flow Measurement will be documented in an engineering report based on all measurements available of RCS flow at time of plant startup

- These measurements and tests include:
  - RCS pump d/p (compared to factory tests)*
  - RCS pump motor power (compared to factory tests)*
  - Hot leg elbow and cold leg bend d/p*
  - All other RCS d/p measurements available*
  - ΔT and calorimetric during power escalation
  - Core exit T/C, T-cold, calorimetric power

- The engineering report will reconcile all measurements and report the determined flow (X ± Y gpm) at specified conditions

* = Used for pre-criticality test flow confirmation

Westinghouse

Baseline Flow Measurement

- Baseline Flow Measurement will be used to calibrate the RCS elements (hot leg elbow and cold leg bend d/p channels)

- All future RCS flow measurements will be based on measurements of d/p channels in hot leg elbows and cold leg bends
  - The observed d/p will be converted to a measured flow based on the d/p corresponding to the baseline flow measurement
  - Instruments used to measure d/p will be calibrated at refueling intervals

- Uncertainty will include allowances for:
  - Uncertainty in baseline flow measurements
  - Uncertainty in d/p measurement channels in hot leg elbows and cold leg bends

Baseline Flow Measurement

- The 12-hour RCS flow check (SR 3.4.1.3) will be made with installed process instrumentation (consistent with operating plants)
  - The current licensing basis is determination of gross change in indicated RCS flow on a relative basis

- The refueling interval RCS flow check (now SR 3.4.1.5) will be performed to measure flow based on calibrated loop differential pressures with consideration of appropriate instrument uncertainties in the error allowance

Uncertainties

- Both the hot leg elbow and cold leg bend d/p channels are expected to have uncertainties that cannot be resolved until as-built plant startup measurements are performed
  - The hot leg elbows have nearby piping connections that may introduce d/p measurement uncertainties
  - The cold leg bends (with taps at the end of the bend) have a large bend radius that causes a low d/p signal

- Therefore Westinghouse has taken the precaution of using either or both as an alternate to the “precision calorimetric” method of RCS flow determination

Summary

- The RCS flow measurement strategy provides an accurate and verifiable method of demonstrating that RCS flow meets requirements

- The accuracy (and value) of measured RCS flow will be established in the Reactor Coolant Flow Measurement Report following plant startup

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Questions

Screening Criteria for Thermal Stratification, Cycling and Striping (TASCS) in AP1000

April 2010

AP1000™

Westinghouse

Screening Criteria Document

Materials Reliability Program: Management of Thermal Fatigue in Normally Stagnant Non-Isolable Reactor Coolant System Branch Lines (MRP-146), EPRI, Palo Alto, CA, June 2005, 1011955

MRP-146 Screening

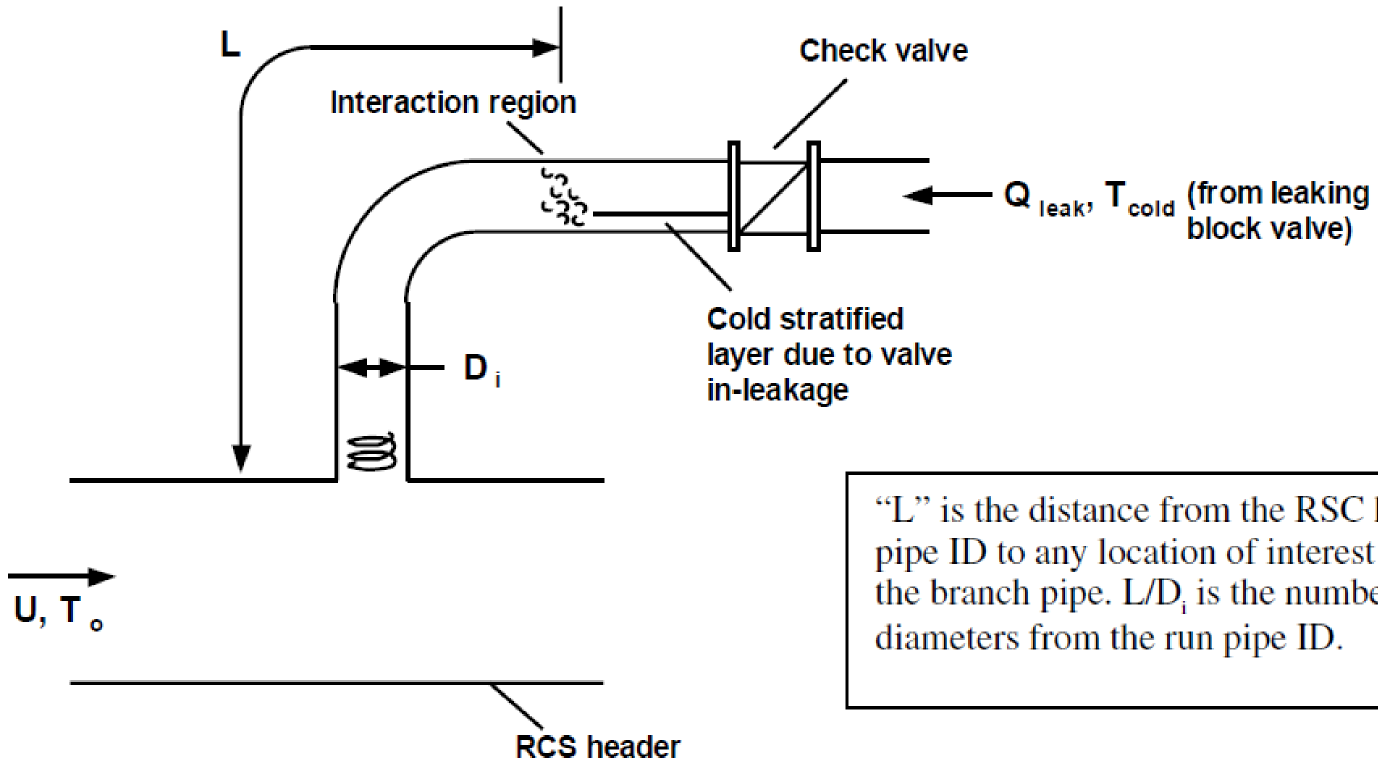
Identify all normally stagnant branch lines connected to the RCS piping with a potential for:

- In-leakage via valves from a high-pressure source toward the RCS header piping
- Potential for turbulence/swirl penetration

Piping and instrumentation diagrams (P&IDs) are used to identify these paths

Lines with Potential for Valve Inleakage

Example of an up-horizontal (UH) branch line piping configuration



"L" is the distance from the RSC header pipe ID to any location of interest along the branch pipe. L/D_i is the number of diameters from the run pipe ID.

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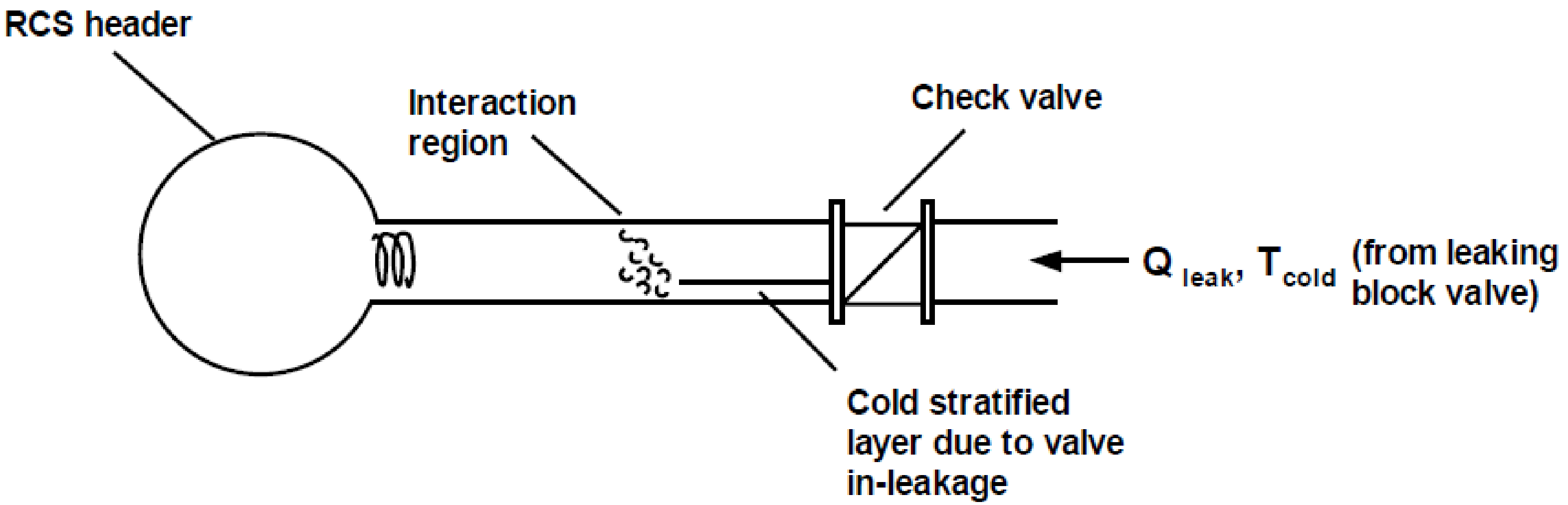
Lines with Potential for Valve Inleakage

Example of a horizontal (H) branch line piping configuration



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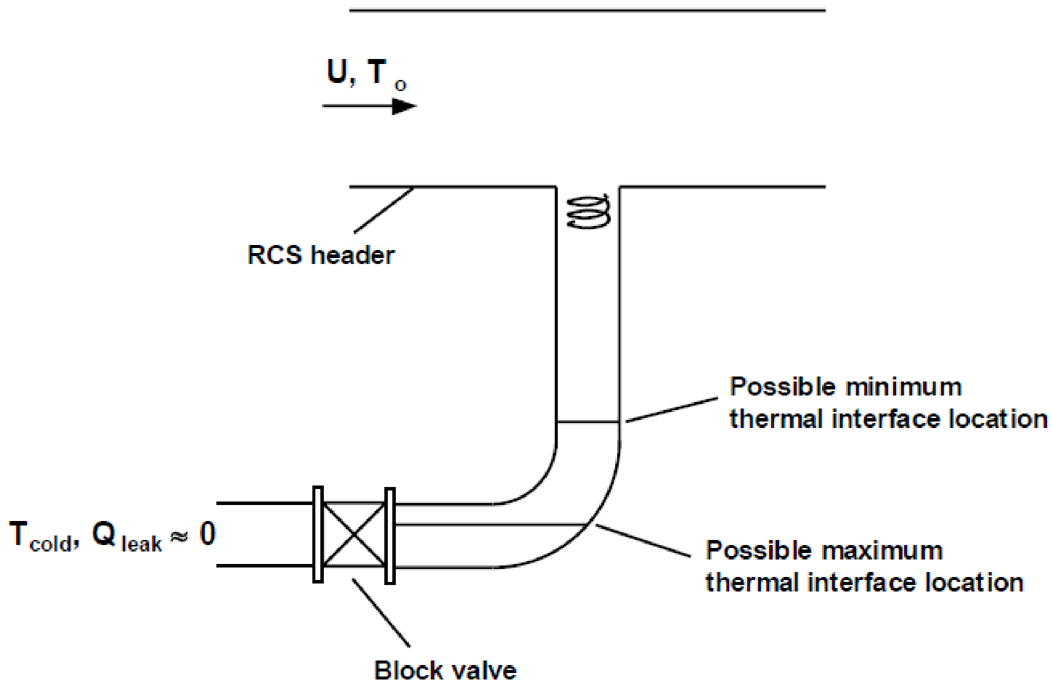
Lines with Potential for Turbulence/Swirl Penetration

Example of a down-horizontal (DH) branch line piping configuration



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MRP-146 Screening

Significant Temperature Threshold

For steady stratification during normal operation, a guideline of 50°F measured metal top-to-bottom temperature difference is provided.

As long as this limit is not exceeded, no further action is required (Section 2.1.5)

MRP-146 Screening

No further evaluation required if any of the following conditions are met:

- For UH lines, piping from RCS nozzle to first check valve is ≤ 2 inch nominal pipe size
- In-leakage path includes pressure relief or other pressure control devices
- For top connected piping, the vertical section is sufficiently long such that swirl penetration cannot reach the upper horizontal sections
- For bottom connected piping, vertical length between RCS piping and horizontal section is greater than the maximum, or less than the minimum specified in MRP-146, Sec. 2.2.3

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AP1000 Lines Susceptible to TASCS

- PRHR supply line from RCS hot leg to PRHR heat exchanger
- Passive residual heat removal (PRHR) return line from PRHR heat exchanger to steam generator channel head
- Automatic Depressurization System (ADS) stage 4 lines from RCS hot legs to the stage 4 depressurization valves
- RCS hot leg lines
- RCS cold leg lines
- Pressurizer surge line
- Normal residual heat removal suction lines from the hot legs to the isolation valves
- Direct Vessel Injection (DVI) lines
- Chemical and Volume Control System (CVS) purification return line

(Reference DCD 3.9.3.1.2)

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Evaluation and Further Actions

1. For susceptible lines, a CFD analysis is performed to study the flow mechanism and determine the temperature distribution
   - Thermal gradients used to obtain bending stresses
   - Thermal gradients also included in fatigue analysis

2. Recommendations are provided to avoid the potential for thermal fatigue degradation

Evaluation and Further Actions

- Results will be available during piping DAC closure/audit

AP1000 HDPE Follow-up Questions

April 22, 2010

Westinghouse

Purpose

- Provide information regarding the criteria for use of high density polyethylene (HDPE) piping in AP1000 applications
- List all AP1000 systems using HDPE piping
- Summarize advantages of HDPE piping

HDPE Use in AP1000

- ACRS Question
  - HDPE - Underground piping (fluids) and conduit (electrical) and how they perform with regard to groundwater intrusion and surface water infiltration. The concern includes the pipe, connections and material performance at the connections (joint adhesives "welding" materials, etc.). A related question are any of the tritium task force results and recent experiences reported for Vermont Yankee and Indian Point raising issues for such piping. (Mike Ryan)

AP1000 HDPE Application Criteria

- HDPE piping is <u>not</u> used in safety-related fluid systems applications in AP1000
  - usage adheres to requirements of Code Case N-755
  - NRC has approved safety-related applications of HDPE piping in at least two operating plants
- HDPE piping is used in underground applications only
- HDPE piping is not used in systems that carry normally radioactive process fluids
  - complies with RG 1.143 restriction

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AP1000 HDPE Application Criteria

- HDPE piping is used only for
  - SWS blowdown and alternate makeup lines
  - May be used in certain site-specific RWS and WWS applications
- HDPE piping is routed underground to eliminate the possibility of impact damage and material degradation (embrittlement) due to UV exposure
- Underground installation methods used ensure protection of piping from distortion and damage by above-ground live loads

Advantages of HDPE Piping

- HDPE pipe materials are essentially inert and are not affected by chemical or galvanic corrosion
- The operating lifetime of properly constructed HDPE piping systems is estimated to be up to 100 years
- Joints produced with proper fusion conditions are leak-free and not susceptible to degradation caused by exposure to process fluid or ground water, or by surface water infiltration around the exterior of the pipeline

Ensuring Long-Term Leak-Free Performance of HDPE Piping

- HDPE pipe sections and associated fittings are joined in the field by fusion (butt welding) using specialized equipment [SLIDE 9]
- The fusion conditions required to produce a strong, void-free weld zone between adjacent HDPE pipe sections are well-known
- Key fusion parameters
  - temperature of fusion zone
  - compression pressure on pipe faces being joined
  - fusion time

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Ensuring Long-Term Leak-Free Performance of HDPE Piping

- A non-destructive means of evaluating fusion joint integrity is available
  - Time of Flight Diffraction (TOFD) - ultrasonic
- Appropriate installation methods and supports are needed to control stresses and moments in systems using HDPE piping
  - ASTM and manufacturer installation standards exist
  - thermal expansion coefficients are higher than for metallic piping and must be accommodated

Butt Fusion of HDPE Piping

Conclusion

HDPE piping use is not a regulatory issue for AP1000

Questions