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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

US-APWR SUBCOMMITTEE

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OPEN SESSION

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THURSDAY,

FEBRUARY 19TH, 2009

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The Subcommittee met at the Mitsubishi Building of 547 Keystone Drive in Warrendale, Pennsylvania, at 8:30 a.m., Otto L. Maynard, Chairman, presiding.

MEMBERS PRESENT:

OTTO L. MAYNARD, Chairman

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR., Member

JOHN D. SIEBER, Member

JOHN W. STETKAR, Member

SANJOY BANERJEE, Member

SAID ADBEL-KHALIK, Member

MIKE RYAN, Member

STAFF PRESENT:

NEIL COLEMAN, Designated Federal Official
JEFF CIOCCO
MICHAEL TAKACS
JEFF SCHMIDT
DAN PRELEWICZ

ALSO PRESENT FROM MITSUBISHI HEAVY INDUSTRIES AMERICA, INC.:

KEITH PAULSON
ATSUSHI KUMAKI
DOUG WOOD
AKIRA OONUKI
HIROSHI HAMAMOTO
HADID SUBKI
MICHITAKA KIKUTA
TETSUYA TERAMAE
YEON-JONG YOO
RURIKO TAKAMASKI
KAZUYUKI KATSURAGI
HIDEAKI IKEDA
JUNTO OGAWA
HISANAGA TAKAHASHI
YASUHI MAKINO
HIROSHI FUJISHIRO

T A B L E O F C O N T E N T S

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

(8:30 a.m.)

CHAIRMAN MAYNARD: Good morning. This is a meeting of the US-APWR Subcommittee. My name is Otto Maynard. I'm the Chairman for this subcommittee. Other members in attendance, we have Said Adbel-Khalik, Sanjoy Banerjee, Dennis Bley, who will be here in just a few moments, Charlie Brown, Mike Ryan, who will also be here in just a few minutes, Jack Sieber and John Stetkar.

Neil Coleman of the ACRS Staff to my left is the designated Federal Official for the meeting. And the purpose of today's meeting is an informational briefing and an opportunity to discuss topical reports related to the LOCA assessment and non-LOCA methodologies.

We'll hear presentation from the NRC Office of New Reactors and Mitsubishi Heavy Industries and their subsidiaries. Again, this is an information briefing at this point. There's no action required at this point by the ACRS.

Once the Staff has completed their reviews, then at that point the ACRS will decide to what level we get engaged and start a more formal review of the topical reports to the extent that we believe is necessary.

So, again, today's meeting is primarily informational and an opportunity to exchange questions and discuss things, and basically get more familiar with the methodologies and the analyses that are being used by Mitsubishi.

The rules for participation in today's meeting have been announced as part of the Notice previously published in the Federal Register. And portions of the meeting may be closed for the discussion of un-classified safeguards and proprietary information.

We've received no written comments or requests for time to make oral statements from members of the public regarding today's meeting. 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 the meeting use the microphones in the meeting room when addressing the subcommittee. And participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

We'll proceed with the meeting here in just a moment. Before we actually get into the formal part I'd like to ask Gil Remley to make a couple of logistical announcements here.

MR. REMLEY: I'm right here.

CHAIRMAN MAYNARD: Oh, there you are.

MR. REMLEY: I moved. My name is Gil Remley. I'm the Nuclear Department Manager here at Mitsubishi Electric Power Products. I just want to go over the arrangements for today. For your breaks we have coffee and refreshments just outside the door.

For lunch we are going to provide boxed lunches in the area for your convenience. For those who have to pay for their lunch, the charge is five dollars, we'll collect the money.

The facilities, the restrooms are right down the hall to your right, just past the door that you picked up your badge at. If you just go to the next door to the right there's a ladies and a men's room. I guess that covers everything.

CHAIRMAN MAYNARD: All right. Thank you very much. Now I'd like to turn it over to Mike.

MR. MORADO: I'm Mike Morado. I'm the Acting Chief of the US-APWR Project Branch in the Office of New Reactors in the Nuclear Regulatory Commission.

I'd like to thank everyone for coming

today and to welcome them. We are pleased to have this opportunity for interaction between my staff and the staff here at Mitsubishi and ACRS.

The topical reports that are currently under review related to Chapter 15 of the document for the US-APWR -- and my staff, the Project Manager working with Chapter 15 is Mike Takacs.

MR. TAKACS: Good morning everybody. My name is Mike Takacs. I'm the Chapter 15 Project Manager for the accident analysis. Do I need to be near a microphone when I speak?

CHAIRMAN MAYNARD: Yes.

MR. TAKACS: Can you hear me?

CHAIRMAN MAYNARD: It's the Court Reporter that should.

MR. TAKACS: Okay. Very good. The purpose of this meeting, to reiterate, is to provide an overview, at least this presentation, of the NRC'S status for the three topical reports that support Chapter 15.

And that's the Large Break LOCA code applicability, Small Break LOCA methodology and the non-LOCA methodology. And, of course, we're here to address any questions from the Committee as well.

The first topical report is the Large

Break LOCA Code Applicability. This topical report is provided to us for review of the methodology and the analysis used to determine the thermal hydraulic behavior of the US-APWR design for Large Break LOCA.

The methodology and the code used here is WCOBRA/TRAC and ASTRUM, the Automated Statistical Treatment of Uncertainty Method. A key here for our review involves verifying this applicability to US-APWR which, by the way, has been previously approved for current designs, AP1000, AP600.

RAIs for this topical report have not yet been issued. But they will be issued within, I believe, a week from now. They are being finalized by the technical staff.

The safety evaluation report for this topical report is expected in January of 2010.

CHAIRMAN MAYNARD: A question for you. This topical report and review, is this to be able to be used on a generic basis for other reactors, or is this specifically for the US-APWR?

MR. TAKACS: I believe it's other reactors. And I'd like to verify that with Jeff Schmidt.

MR. SCHMIDT: This is Jeff Schmidt from the NRC. We're reviewing any context with just the

APWR right now.

MR. TAKACS: Thank you. The second topical report, Small Break LOCA Methodology, the report's provided to us for review of the methodology and analysis to determine or evaluation the emergency core cooling system performance during a Small Break LOCA for the US-APWR design.

M-RELAP5 is the computer code used for this analysis. The key here is now M-RELAP5 is a code based on RELAP5-3D, a three dimensional computer code.

The concern here is that the NRC has not previously approved a three dimensional code such as RELAP5-3D. Therefore, on the third bullet, as it points out, the NRC staff finds it necessary to perform a validation code review of M-RELAP5.

MEMBER BANERJEE: Is this just for the code part? Or what's the 3D part? Is it just for the code?

MR. TAKACS: It's for the code review of M-RELAP5.

MEMBER BANERJEE: What do they need the 3D part for?

MR. SCHMIDT: They're not. This is Jeff Schmidt from the NRC again. It starts from RELAP-3D. They're not using the 3D aspect of RELAP-3D.

MEMBER BANERJEE: Oh, okay. So just the name of it?

MR. SCHMIDT: Right.

MEMBER BANERJEE: They're not using a 3D module in it.

MR. SCHMIDT: That is correct.

MEMBER BANERJEE: So how are they doing the code?

MR. SCHMIDT: They're doing it in one dimensional.

MEMBER BANERJEE: Okay.

MR. SCHMIDT: Similar to RELAP5, mod 3.3, for example.

MR. TAKACS: Any other questions? For this topical report Small Break LOCA, RAIs were recently issued in December of 2008. The safety evaluation report for this topical report is expected or planned for June of 2010, the reason being is the work required to do the code review for M-RELAP5 as opposed to Large Break LOCA, which was January of 2010. Any questions on this topical?

Finally, the third topical report is the non-LOCA methodology provided by our review of the methodology and analysis used for the non-LOCA events.

There are three principal computer codes used in this topical report, VIPRE-01M, TWINKLE and MARVEL-M. A key interest for us, the MARVEL-M computer code.

MARVEL-M is a 4-loop computer code. However, it is based on a 2-loop version of MARVEL from 1971. Unfortunately, that was not approved by the NRC as well.

So, much like the MARVEL -- rather, the RELAP, the Staff finds it necessary to perform validation code review of MARVEL-M. RAIs have been issued for this topical report in July of 2008, October of 2008 and as recent as this month, February of 2009.

The safety evaluation report for this topical report will be or planned on being issued in June of 2010. Any questions on this?

MEMBER BANERJEE: So, you have three codes there. What are they primarily being used for or will be used for? Say MARVEL-M, are these for anticipated transients? Or what type of events are we talking about?

MR. SCHMIDT: Again, this is Jeff Schmidt from the NRC. Yes, your basic Chapter 15 accidents, other than the LOCAS.

CHAIRMAN MAYNARD: And I think that MHI is going to be getting into it in their discussion of what they will be using them for.

MR. SCHMIDT: Yes.

MR. TAKACS: Okay, in summary of course, the three topical reports are currently in review. RAIs have been issued for all except Large Break LOCA, which are coming due or being issued next week.

And the safety evaluation reports for two of the topical reports will be June of 2010, Large Break LOCA January of 2010..

CHAIRMAN MAYNARD: Are all three of these basically the same as far as being reviewed specifically for the US-APWR? Or are any of them being requested for generic applicability?

MR. SCHMIDT: Right now we're just reviewing them relative to the APWR.

MR. TAKACS: And that's all I have. Are there any questions? Chairman?

CHAIRMAN MAYNARD: Okay. Go ahead. Is that completed for by the Staff, I believe? So go ahead and turn it over to Mitsubishi and start their presentation.

MR. KUMAKI: Good morning. My name is Atsushi Kumaki from Mitsubishi Heavy Industries. Last year on October and November we held meeting regarding the design, and advanced accumulator and also the ECC system.

At this time we will provide presentation for the safety in our area to include Large Break LOCA, Small Break LOCA and non-LOCA. I think last year's meeting was very excellent and very exciting.

And I believe this meeting should also be good progress and the members can understand our design methodology for our design, safety analysis results and also our US-APWR plant is safe. Thank you for your time.

CHAIRMAN MAYNARD: One thing I should have mentioned while we're transitioning here is that the first part of this meeting is an open meeting and will be a general overview and that we will be going in to closed session and going back in to more detail on some of these.

So, in the beginning it's a general overview here.

MR. PAULSON: Thanks very much. My name is Keith Paulson. Is this mike on?

CHAIRMAN MAYNARD: Ask her if she can hear you.

COURT REPORTER: It doesn't amplify.

MR. PAULSON: It doesn't amplify, okay.

CHAIRMAN MAYNARD: The main purpose of the microphones is for the recorder.

MR. PAULSON: Oh, okay.

CHAIRMAN MAYNARD: It's not so much for the speakers.

MR. PAULSON: I'll hang in close to one of these microphones.

CHAIRMAN MAYNARD: Okay.

MR. PAULSON: Rather than have the voice come in and out for her. We do appreciate the opportunity to talk about our computer codes. We've done extensive reviews of these codes.

I want to point out early on that these codes, although they've been modified by Mitsubishi, our source codes in one way or another have been reviewed by the NRC in years past.

And that's an important point because we're not in general writing new codes, we're actually using codes that were applicable to a certain extent and needed some modification in order to meet the requirements of the design or the analysis capability of the codes.

MEMBER BANERJEE: So you're talking mainly about applicability or are you talking about the codes themselves?

MR. PAULSON: Both. The topical reports go into significant level of detail. They look at all aspects of the code, the basis of the code, the analysis being performed, the nodalization within the code, modifications being made.

And so, as you look at the topical reports, although it follows pretty much, I think, 1.203, many of the pieces of information have been seen generically on other codes.

But the codes have been specifically tailed for US-APWR because of some unique features in the code or because we believe in order to use the codes effectively we have to make some modifications to generate results that we were satisfied with.

MEMBER BANERJEE: So the aspects of them which are sort of unique compared to versions of the code, you had them validated against some experiments that you've done and things like that.

MR. PAULSON: And that's all -- that will be presented in these later sessions in more detail. But it's part of the -- all identified what those changes are.

MEMBER BANERJEE: Thank you.

MR. PAULSON: As Mike mentioned, the three areas we're going to look at today specifically deal with large break, small break and everything else, so to speak, in Chapter 15 accident analysis.

Let me start out with the Large Break LOCA applicability. But, as a general comment, Mitsubishi recognized when they decided to move forward with the submittal for approval of the US-APWR designs that there were going to be issues of analysis methodologies that were necessary in order for the Chapter 15 accident analysis to be accepted.

And, rather than trying to do that all as part of the SER, we went into a significant topical report submittal schedule during 2007, which involved more than just computer codes.

But the focus was to put the computer codes and methodologies and document them prior to submittal of the DCD to the NRC so that the availability of information that would be necessary in order to pass judgement on the analysis was available prior to the actual analyses appearing to the NRC.

That doesn't mean we don't do analyses in the topical reports. It just means that we wanted the DCD to be not a discussion of methodologies, but a discussion of the results.

So, we have these topical reports in primarily during the middle of 2007. We had three meetings with the NRC to discuss the content of the reports.

And in some cases we actually had some meetings or questions that we answered following the submittal of the topical reports in 2007. This report is going to highlight the status of how we see it.

I think Mike did a pretty good job of identifying the status. But we kind of come at it more -- rather than from the RAI approach we come at it from the responses to the RAIs, which is our responsibility.

And I'll give you a little bit of that. And then a little bit on the methodology and then summary of how we see the current status and events that have occurred so far.

Just the highlights of our topical report. First of all, the objective is to present a comprehensive assessment of the applicability of WCOBRA/TRAC Mitsubishi 1.0 and ASTRUM methodology to the US-APWR design for Large Break LOCA.

The specific subjects that we identify are US-APWR design features. As I've mentioned, there are some unique design features or features that are somewhat new to other plant discussions and therefore there had to be some characterization of those specifically within the codes.

And that has been done. The topical report does identify those specifically and discuss them as to how they were integrated into the computer codes and supports the basis for the integration and validation.

And the applicability of the code and methodology for the US-APWR has been examined based on the CSAU approach.

MEMBER BANERJEE: So you've done a full CSAU type analysis?

MR. PAULSON: Well yes. Some of the things, like I said, there are some places where we use methodologies that have been reviewed already, the basic methodologies.

But wherever there was a change of methodology, whether it was due to data supporting a specific design, integration of that design feature into the code, nodalization is necessary, all of those are defended within the topical report.

Relationship with the DCD, in each case you'll see the relationship with the DCD is the codes that are being used for analysis and are referenced in our DCD.

But the specific topical report is only

referenced. And the information provided in the topical report is not reproduced in the DCD. As I mentioned, and Mike mentioned also, we submitted this report in 2007 to provide an opportunity for early review of the code.

And it was docketed by the NRC in January of 2008. As Mike mentioned, today we don't have RAIs under design. But we are anxiously awaiting, maybe next week or shortly here, some RAIs specifically dealing with the large break.

MEMBER BANERJEE: Are we going to in closed session talk a little bit about some of the unique features?

MR. PAULSON: Absolutely. I'm going to talk a little bit in the next two slides on that. But there will be much more detail with respect to data and so forth that will be in the closed session.

And anything we don't present that you have questions on we can certainly address it with answers to questions that come up. So that's kind of a segway into this.

This is a slide some of you have seen already. But I wanted to remind you a little bit about, not unique features, because some of these features are being used in one way or another in the industry, but features that have not been used in classical form of plants that have been done in the past, specifically in the emergency core cooling system that we model.

One thing that has changed is the advanced accumulator design. I'll give a little more on that in the next slide. But the point is that there is an elimination in low head pumps because of the capability of our current system, which is the high head pumps and advanced accumulators.

It's a four train system, so that has to be nodalized. You'll notice in the figure here if I can make this happen, the accumulators here, four of them, one in each quadrant basically.

And you'll notice that they supply cooling directly into the cold legs downstream of the reactor cooling vessel. The other feature is, once again, a four train system for the safety injection, the high head safety injection pumps.

In this case all of these pumps take suction from the fuel water storage pit inside of the container. The emergency diesels are illuminated in this design and substituted for by gas turbines.

There's an extensive program in place right now that Mitsubishi and the NRC are participating in qualifying the gas turbines for application to this sort of design.

MEMBER BANERJEE: Undoubtedly Mitsubishi gas turbines.

MR. PAULSON: No, they're not, actually.

MEMBER BANERJEE: They're not?

MR. PAULSON: Kawasaki.

(Laughter.)

CHAIRMAN MAYNARD: Now, you still have the low head injection but you don't use it for the LOCA, it's used primarily for RHR or shut-dow, stuff like that. But it is still capable of being lined up.

MR. BROWN: Those ASTRUM generators, those are specifically for the safety injection pumps only. That's the pump for --

CHAIRMAN MAYNARD: All the safety loads.

MR. PAULSON: All the safe head systems.

MR. BROWN: Okay. So all loads come off of that, not just --

MR. PAULSON: That's right. This is just --

MEMBER BANERJEE: Just in place of the diesels, is that correct?

MR. PAULSON: That is correct.

MEMBER BLEY: Are you planning to tell us anything about the qualification program today or --

MR. PAULSON: Not today. But that certainly is a subject that is hot and heavy in our discussions. We will keep you updated on that if you want.

CHAIRMAN MAYNARD: It might be worthwhile, the accumulators, and we had a full session discussing those last fall. One of the reasons is to be able to use the gas turbine for the generators.

They don't start as fast as the diesel. So we needed a little bit more time there. And that's what the advanced accumulator really does, is give you that time.

But, other than that, once it starts up the gas turbine generators are the same as the diesel generators, provides power to the safety busses.

MEMBER BROWN: I guess I have one question on that, because experience -- I come from a Navy background. Gas turbine generators are used extensively in a lot of ships.

And they have a low indulgence of having heavy load applied to them. You normally have to load them in a more small increment, not real small, you understand, you can't just slam a full weighted loader or a half weighted loader on them.

They don't like it. Everything just goes to pot. And so that's why it's the question about what the loads are and how the load profile is to maintain.

I presume that's being taken into consideration.

MR. PAULSON: We're doing a significant testing program.

MEMBER BROWN: To show that it will meet that profile?

MR. PAULSON: Well, another key issue, of course, is the startup time and the reliability. We have a number of issues we're dealing with.

CHAIRMAN MAYNARD: We haven't got into this in that stage of the review. But, for the existing plants, even with the diesel generators, they don't just slam a full load.

They sequence loads on five seconds apart or so so you don't just slam it on there.

MEMBER BROWN: Okay.

CHAIRMAN MAYNARD: I'm not sure how they're going to be doing it. But, typically you handle that in your load sequence.

MR. PAULSON: That's part of the evaluation that goes on for the sequence.

MEMBER ADBEL-KHALIK: The high head safety injection pumps inject directly into the vessel. But there is a parallel path here going to the hot legs. What is the purpose of that?

MR. PAULSON: That's just for long-term cooling benefits. If you'll notice in the chart here you can see that the path directly to the hot leg is closed off and not in operation.

It's only the open path is directed to the vessel, which is the direct path early on to provide enough cooling for the early part of it. I think that shows up in the next slide.

Some of the issue here we've been dealing with in the discussions here, you can see where the need for the high head pumps comes later on in terms of -- it becomes more than that.

But, it has to be maintained for a long time because it provides long-term cooling capability. It's not the advanced accumulator that does that.

If you look here in the US-APWR -- the yellow part is high head flow availability flow from the high head pumps as the source of water for long term cooling.

MEMBER BLEY: When we look at this curve I'm assuming the flows you show on there are the flows from a single pump.

MR. PAULSON: Two pumps.

MEMBER BLEY: So you're assuming two pumps --

MR. PAULSON: Two pumps are operating.

MEMBER BLEY: Two high head.

MR. PAULSON: Now, for long term cooling, I want to check this because I'm not sure myself. I think maybe we only need one pump.

MEMBER BLEY: That's why I was asking. But early on you need two?

MR. PAULSON: Early on we need two.

MEMBER BLEY: So that should be what we've seen here.

MR. PAULSON: And the presumption is one is shut down and indicates a single failure.

MEMBER BLEY: Yes, okay.

MR. PAULSON: Just a comparison, because you may have seen something like this for the current flow of plants. You see the sum of the high head and low head pumps here.

And you see the impact of the accumulator flow, the standard accumulator flow from a current flow of the plants. And the net effect is, of course, once you've drained that system it goes to zero and the flow goes to zero.

The difference between it and the advanced accumulators is this shifted of the flow from a high head or a high flow to a lower flow and longer term availability of flow from the advanced accumulator, which allows this difference.

You can see the startup time here that's assumed for the advanced -- for the gas turbines as opposed to here over for the diesel generators.

See there's a difference in that startup time that was assumed in our accident analysis, it was actually much longer than when we think the actual startup time is.

It was very conservative. I think it was 100 seconds or something. Correct me if I'm wrong. But we think that startup time is more like 40 or 50 seconds.

So there's a lot of margin that we've put into those startup times. In any case, you can see that the secondary flow from the advanced accumulator supports the water requirements for the reflood stage during the time that the startup of the gas turbines is assumed.

The difference is though, between the two, is that because we're able to substitute with the advanced accumulator flow during the reflood stage, we're able to eliminate the low head safety injection floods that exist in prior designs.

And, to a certain extent, it was meant to be a passive system. There is some interest by the NRC to look where passivity makes sense to put passivity in.

And this does that because the advanced accumulator is not an active system.

MEMBER BANERJEE: For long term cooling, do you realign also to have hot leg injection?

MR. PAULSON: Yes.

MEMBER BANERJEE: About what stage does that happen?

CHAIRMAN MAYNARD: Come to a microphone.

MR. HAMAMOTO: My name is Hiroshi Hamamoto. We plan to switch over, if four train is available, we try to two train to switch over directly to hot leg injection.

If only two train is available we switch from one train to hot leg injection of the four areas.

MEMBER BANERJEE: Okay.

MR. PAULSON: Okay. So, the code's being used for the analysis COBRA/TRAC and ASTRUM being used for the analysis of the uncertainties. And it's been used for, I think, these are familiar codes.

There are some modifications that have been made, but they're preliminary minor modifications that you may expect. And I'll mention in a little bit some of those modifications.

HOTSPOT is used for the analysis of looking peak temperatures. This is the same fuel rod analysis model that's used for the fuel rod analysis capability.

I think you reviewed some of that in the last set of meetings. We went over our fuel computer folks. Calculation the effect of uncertainties at the axial location of the fuel rod is provided by HOTSPOT also.

And the simulation of clad burst, metal-water reaction and fuel relocation following the burst phenomena is calculated with HOTSPOT. ASTRUM is used for statistical methodology.

It does not assume the peak clad temperature distribution, that's part of HOTSPOT calculation. Statistical methods used to acquire 124 cases in order to meet the 95 percent -- the 95/95 criteria in order to fulfill on the obligation of that 95/95.

And it assumes that it meets the 95/95

peak clad temperature for local maximum oxidation and for the core-wide oxidation requirements in those calculations.

The applicability of the WCOBRA/TRAC to US-APWR has been evaluated and confirmed, especially in simulating the high-ranked phenomena going on.

And when the high ranked phenomena come up, of course, in the PIRT evaluation. The features that were incorporated into this model that I mentioned before that are necessary to adapt it to the US-APWR code specifically, is the advanced accumulator and two other design features, the direct vessel injection and the neutron reflector that has been incorporated into the design also.

MEMBER BANERJEE: How large is the DVI line? Is it about eight inches?

MR. PAULSON: The direct vessel injection line? From where to where?

MEMBER BANERJEE: Going into the -- diameter, yes.

CHAIRMAN MAYNARD: Where it penetrates the vessel itself.

MR. PAULSON: Yes, the diameter of the line?

MR. SUBKI: Three point four.

MR. PAULSON: Yes, 3.4. It's nice to have the detail man. So those were a key feature that we had the codes for. The applicability of the code anything methodology for the US-APWR has been examined and confirmed based, once again, on the CSAU approach and includes the following.

As I mentioned, the PIRT evaluation, looking at code applicability based on the modifications. Nodalization requirements for the calculations, we did a nodalization study.

That was performed and the results are provided in the topical report. We had to perform sample analyses also. That was done. As I mentioned, the results of the computer codes for Chapter 15 are done in Chapter 15 and provide the back-up and sample calculations and validation using the sample calculations are done as part of the document.

MEMBER BANERJEE: You may come to this later, but were there any experiments done on a medium scale facility like the size of ROSA or something taking into account --

MR. PAULSON: We'll get into that this afternoon.

MEMBER BANERJEE: You will? Okay. So there were some experiments done.

MR. PAULSON: Yes. There are a number of experiments that have been built into the calculation.

MEMBER BANERJEE: Full integral experiments.

MR. PAULSON: Well, I can't say what you consider fully. But we have done a significant number of validations.

MEMBER BANERJEE: With accumulators with the high pressure injection, all sort of mocking up what you have.

MR. PAULSON: The accumulators, right. The accumulators, we've done our own extensive analysis. We did three different scale operations.

MEMBER BANERJEE: But, as part of an integral test, the accumulators all separately?

MR. PAULSON: All -- the accumulators were done separately, but they looked at with different phenomena when we're actually looking at -- we had one test that was full height, so the effects of all the height --

MEMBER BANERJEE: Let me rephrase my question to make it clear. Were there integral tests done with full height accumulators or were only separate effects tests done with accumulators?

MR. PAULSON: Separate effects.

MEMBER BANERJEE: There's been no integral tests done?

MR. PAULSON: No, but there were tests that looked at the expected phenomena that it would be dealing with if it were an integral test. Like, for example, we looked at different pressures for the low, for the accumulator going into different pressures.

And that provided somewhat a separate effects the equivalent of an integral test because it looked at different back pressures.

MEMBER BANERJEE: So you looked at semi-integral tests.

MR. PAULSON: That's good, I like that. Separate integral tests.

MEMBER BANERJEE: All right.

MEMBER BROWN: Question on the PIRT. In the report you invoke the small. But again, if you make statements like all the branchings, the high, medium and low and whatever it was in one of your reports.

They were all done based on judgements, I think five or six, something like that. So I got the impression there were no sensitivity studies done relative to the analysis or other to see if some of these systems or applications would require a high, medium or low.

This is strictly based on human judgement. Is that a correct assumption based on an understanding of what was in the report?

MR. PAULSON: Pretty much. It was based on expert evaluations off the PIRT. Now, there were sensitivity studies that were done in the topical report.

But I'm not sure to the extent that you're looking for. The PIRT charts don't -- are somewhat different than what you would see in the standard plan because we have the advanced accumulator and so forth and variations.

But, in general, you would anticipate that it would look very similar. The starting point actually for PIRT charts was the standard for the plant, which has been well evaluated, I think, over the years in terms of sensitivity.

In summary on the large break and WCOBRA/TRAC, ASTRUM methodologies being used, new or improved US-APWR design features have been evaluated for code applicability.

And there have been sensitivity studies, of course, done on those. Applicability of COBRA/TRAC and ASTRUM methodology to the US-APWR has been examined and confirmed using the CSAU approach.

WCOBRA/TRAC has been applied to sample US-APWR plant analysis and its capability to simulate the US-APWR large break transient was demonstrated.

The US-APWR LOCA analysis has been reported in the DCD Section 15.6.5. And the results of the ECCS performance satisfies the Acceptance Criteria of 10 CFR 50.46.

MEMBER BANERJEE: Could I just ask a quick question of the Staff? Do we have confirmatory capability to do independent analyses of these accumulator, like TRACE or something, right now?

MR. SCHMIDT: This is Jeff Schmidt from the NRC. We are actually just starting to set up for large -- talking about large breaks. We're doing a bunch of confirmatory runs in a bunch of areas.

We're trying to set up a RELAP5 model that will give us some idea of what the system response is, including the advanced accumulators. While we don't expect the results to match, you know, the WCOBRA/TRAC results, but we're trying to get some feel for it.

We're trying to do some sensitivities looking more for deltas and not necessarily absolute values. But we are starting that process now to set up models for confirmatory runs.

MEMBER BANERJEE: And this is going to be primarily RELAP5, there is no effort to be using TRACE?

MR. SCHMIDT: Yes, there is. Research is doing one and we are doing one, and NRO.

MEMBER BANERJEE: So they are going to set up a TRACE model as well?

MR. SCHMIDT: That is correct.

MEMBER BANERJEE: Would we get a look at whether -- regarding the applicability of these confirmatory analyses to this? Because the accumulator behavior is fairly unusual compared to what we calculate with ours.

MR. SCHMIDT: I guess I'm not sure exactly what you're asking.

MEMBER BANERJEE: So typically, let's say TRACE, if it's going to be used for US-APWR, I mean, that's a big figure.

MR. SCHMIDT: Right.

MEMBER BANERJEE: You come to us to review the applicability of TRACE for US-APWR. I don't know whether that's necessary here or not. But is something like that planned?

So we need to put it in our schedule. Because it --

MR. SCHMIDT: I'm not sure we really address that for the APWR yet. I mean, we're setting up a model. But now we have to address whether the -- are you thinking like the momentum equation issue for whether it affects --

MEMBER BANERJEE: Well, not just the momentum. I mean --

MR. SCHMIDT: -- the APWR. I know research is looking at that and basically trying to figure out where that affects what design to what degree. I'm not sure if -- I haven't really talked to research about whether they are considering the applicability of TRACE to the APWR yet.

I think right now the assumption that I'm going under that, you know, it is applicable to the APWR. But once we get a model up and running we'll have some --

CHAIRMAN MAYNARD: First of all, this is for information at this point. But, once we get to a draft SER or the Staff is much closer to finalizing their review, we would be taking a look at it and probably having a subcommittee meeting to focus on either specific topical report or analysis and what chapter, depending on what the SER is really addressing.

And then at that time we would have an opportunity to --

MEMBER BANERJEE: Well, the SERs for these codes are clear, they're going to come whenever they're going to come, 2009 or whenever.

MR. SCHMIDT: In 2010.

MEMBER BANERJEE: Then we, of course, review that in the normal way. I'm just wondering about confirmatory calculations, how that is being done and the applicability of the codes that are being used for the confirmatory calculations for the US-APWR.

MR. PRELEWICZ: This is Dan Prelewicz from the ISL. Research has a project called TRACE Applicability where TRACE is being used for the test.

There's extensive testing that was done by MHI on the new accumulator. And TRACE is being used there to predict those results.

MEMBER BANERJEE: And what about RELAP5 or RELAP? Are you doing the applicability study against those experiments too?

MR. PRELEWICZ: We're doing confirmatory calculations with RELAP5.

MEMBER BANERJEE: But is it being compared to the accumulator experiments?

MR. PRELEWICZ: We have the opportunity to do that. ISL is a contractor on the TRACE Applicability project. So we have all the models. And, of course, to be able to do the confirmatory calculations we nee to be able to show that the accumulator response is reasonable, matches the --

MEMBER BANERJEE: I'm talking about RELAP.

MR. PRELEWICZ: Yes, RELAP.

MEMBER BANERJEE: You're also looking at RELAP?

MR. PRELEWICZ: We are doing confirmatory calculations for the small break and for the large break with RELAP mod 3.3, the NRC version, yes.

MEMBER BANERJEE: Yes.

MEMBER ADBEL-KHALIK: The empirical model for the accumulator that's embedded into this code is based on those scaled experiments.

MR. PAULSON: Well, it's based on the full height half scale.

MEMBER ADBEL-KHALIK: Right, full height half scale. And then the code is used to check against the experimental data. This seems like a circular argument.

You're using an experiment to come up with an empirical model that you embed in a code and then use the code to check if you're predicting the same experiment.

Of course you would. So I just want to understand how you're doing this independently. What do you mean by validating the code? If you're using an experiment to come up with an empirical model that you embed within a code and then use the code with that empirical model to check the results of the experiment, isn't that a circular argument?

MR. PAULSON: Well, only to a certain extent because the test data is independent of what the code -- the code has to perform in a certain way given the integrated test type effects.

And you have to look at it to see how those effects result in acceptable results as you test it. So, it is confirmatory in that sense. But the test results from the full height half scale test are independent and are accurate over a range of back pressures and a range of time distribution.

So, in theory, the results are independent. You would hope that -- are you saying you need another independent validation?

MEMBER ADBEL-KHALIK: Correct. It's a circular argument. I'm using one experiment to create a model I embed in a computer code and use the same computer code after I have embedded that empirical model to check the experiment.

Well, what do you expect? I mean, it's just like --

MR. PAULSON: I would expect it to come out the same.

MEMBER ADBEL-KHALIK: Well, but at any rate, we'll probably get to this in more detail later one.

MR. PAULSON: I think the results are being checked independently by some of the evaluation teams before the Staff.

MR. SCHMIDT: Again, this is Jeff Schmidt with the NRC. Since it's like the advanced accumulator we're trying to do some CFD work that's totally independent of the Mitsubishi testing and scaling.

MEMBER ADBEL-KHALIK: That would be comforting.

MR. SCHMIDT: To try to predict the same flow rates versus different back pressures and things like that.

MEMBER ADBEL-KHALIK: Right.

MR. SCHMIDT: That is ongoing. We're working on that.

MEMBER BANERJEE: To what extent is this empirical. Is it truly just empirical or does it have some physical basis like the CFD calculations you are doing? I mean, maybe I should address that to Mitsubishi.

MR. SCHMIDT: Yes, you should probably address that to Mitsubishi.

MEMBER BANERJEE: It is truly empirical because they --

MR. PAULSON: It was based over a wide range of testing. And the formal that was developed that developed the empirical algorithms were very consistent with what we were getting from the testing.

MEMBER BANERJEE: But, built into this then, maybe you get to it. There must be some scaling parameter which allows you to scale from half scale, to full scale, to one quarter scale.

I mean, did you conduct tests at various scales and then build that in.

MR. PAULSON: Three different scales. In fact, I think the --

MEMBER BANERJEE: Will you talk about this model today?

MR. PAULSON: I think the correlations looked at both the fifth scale and the full height half scale. And the correlation worked well for both.

MEMBER BANERJEE: Will you talk about this later today?

CHAIRMAN MAYNARD: What I'd like to do is go ahead and move on. Because we'll have another opportunity. And I'll also remind us that we did have a discussion on the accumulator in another meeting.

MEMBER RYAN: One question we had for future discussions, I understand Said's point. I guess I'd like to suggest that there's a difference between a quality control check of the code against an experiment and a validation of the code's ability to predict over a wider range of events.

MEMBER ADBEL-KHALIK: It's a verification rather than a validation.

MEMBER RYAN: And I would call that quality control rather than quality assurance.

MEMBER SIEBER: For that specific case.

MEMBER RYAN: Exactly.

CHAIRMAN MAYNARD: Let's go ahead and move on.

MR. PAULSON: Okay. Going on to the small break. We've heard some comments on the small break already. Because we're in detailed discussion on RELAP5 3D applications and the derivative code that we have to utilize that Mitsubishi uses is MRELAP5.

The summary of the code is that the highlights and status will be provided. I'm giving you a little more information on that. This identifies the -- I'm not going to read through this list because it's something you can do at your leisure.

We did identify the following areas specifically addressed in the topical report so that there is a lot of detail. And a lot of it you'll be getting later on this afternoon.

And you can ask questions. And if there's something else, questions that we haven't answered in the topical or don't answer in the presentation, feel free to ask us to address that for you.

But we wanted to show you the level of information that's been presented in our topical reports in the hopes that it's seen as a good representation of all of the parts of 1.203 that are necessary to do a code evaluation, and also that the testing that's going on and what has been factored into the designs representing the current evaluation model requirements have been done consistently with the model requirements.

Small break is to present the

comprehensive methodology that's used for Small Break LOCA. Key issues that we have addressed in the topical report include the identification of US-APWR design features that are relevant for small break analysis.

That's part of our requirement in our PIRT evaluation and a later on assessment matrix that's used for small breaks and for small break analysis code.

The development of RELAP5, which has been mentioned several times, is a version of the code that was developed at Idaho to incorporate and that we've modified to incorporate the 10CFR50 Appendix K requirements for that design.

And then to assess the evaluation model to determine the adequacy of M-RELAP5 with those results included. The relationship to the DCD is, once again, that this report is in support of the DCD calculations and not reproduced in the DCD.

What's in the DCD specifically are the results and the support evaluation would be found in the topical report.

The report was submitted, once again, in 2007, the middle of 2007, docketed in January of 2008. As was mentioned, we've received responses to RAIs from the Staff.

And we have responded to those RAIs both in January and February of this year. So we've been doing our best to keep up with the RAIs as they relate to the specific code and then the application for small break analysis.

The base code, the 3-link version, as I mentioned, is a best estimate code developed by Idaho based on a complete two-fluid model applicable to various thermal hydraulic phenomenon.

RELAP5 has a long history of verification and validation for small break applications. So where you need to start your evaluation is, I think -- I don't want to call it problematic, but it kind of is a call that could be said that many of the earlier parts of an evaluation of a new computer code have it done because the RELAP5 model has been validated over a number of prior time periods by numerous organizations.

From an Appendix K point of view, we believe it's in conformance with Appendix K requirements. It's in a high ranked phenomena. The following conservative models have been built in.

I think we're very familiar with all of these. But, just to mention a few and what we've included, the 1971 decay heat model, fuel gap conductance model equivalent to the design codes that MHI uses for fuel.

The Baker-Just correlation for metal-water reaction. Clad swelling and rupture model based on ZIRLO. The Moody critical flow model and the critical heat flux and fuel heat transfer models in conformance with Appendix K requirements, an example being no return to nucleate boiling.

And, of course, we also make sure that our model is correct for the Appendix K evaluation being incorporated the advanced accumulator model.

MEMBER BANERJEE: What are you doing about reflux condensation? Do you have a flooding criteria or does it come in through a change in the friction?

MR. PAULSON: We may be answering that this afternoon. I don't want to mention something if it's proprietary in nature. Maybe just an answer to that --

MEMBER BANERJEE: For RELAP5, what do they do?

MR. PAULSON: What does RELAP use?

CHAIRMAN MAYNARD: Can you come to a microphone or use one right over there. And identify yourself.

MR. KIKUTA: We use CCFL model in RELAP5 and the parameter was determined by test analyses.

MEMBER BANERJEE: So you're using a flooding criteria at the steam generator tubes?

MR. KIKUTA: Yes.

MEMBER BANERJEE: What about in the line leading into the steam generator? Do you put a flooding criteria there as well? You know the 45 degree bend to the plenum?

MR. KIKUTA: Yes, we use a CCFL criteria for plenum, we've categorized that base parameter.

MEMBER BANERJEE: For the elbow?

MR. KIKUTA: Yes. We will discuss later.

MR. PAULSON: We've mentioned this several times, but I think it's worth highlighting again. And that is that we've had our experts and independent experts look at our PIRT charts, which are, I think, a critical starting point for these.

And we have used in general as a starting point, would be your standard four-loop plant PIRT chart, but variability based on the changes have been made in the design.

Afterwards MHI enhanced the PIRT identifying the phenomena occurring due to the specific design features that are different from the design, the prior 4-loop designs.

The ranking levels, I'm sure you're familiar with. The important thing is that in both the high and the medium they're modeled. And in the high important phenomena that our process is not only modeled but are validated.

And, for low importance we still model them, but the high accuracy requirements are not required there. That's why the PIRT chart becomes correctly, especially in the high and medium categories.

The US-APWR Small Break LOCA PIRT has been reviewed by international LOCA experts and independent of MHI and validated independently. I think that's covered in the topical report also.

There will be more detail this afternoon. But, just to summarize the results of the topical report, where we're at with it. I think we've mentioned there is an independent review going on by the NRC now in the RELAP model. It's being utilized. And there are a number of ways of doing, I think, that validation and exploring that as time goes on. And there have been a series of meetings with the NRC to do that.

The US-APWR Small Break LOCA phenomena

have been identified and RELAP modeling capability has been assessed in conformance with EMDAP. And RELAP5 applicability to the US-APWR Small Break LOCA analysis have been verified using small break separate effects and integral testing.

And I think some of that we'll cover this afternoon. And, in conclusion, we believe M-RELAP5 is adequately applicable to the Chapter 15 small break analysis and of small break and 10CFR part 50.46 Acceptance Criteria for Emergency Core Cooling System for Light-Water Nuclear power Reactors as designed by the US-APWR.

MEMBER BANERJEE: What is being used to look at boron dilution. Is it RELAP?

MR. PAULSON: In Chapter 15, is it MARVEL?

MEMBER BANERJEE: Is it MARVEL?

CHAIRMAN MAYNARD: Again, you have to come to a microphone.

MR. WOOD: This is Doug Wood speaking, MHI non-LOCA consultant. We use simplified hand calculations for the boron dilution event for a non-LOCA.

If your question is directed toward boron dilution during a LOCA event you need to ask that specifically.

MEMBER BANERJEE: I need to ask that specifically? Yes, okay. Tell me what happens.

MR. PAULSON: Was it during a LOCA event scenario?

MEMBER BANERJEE: Yes. So let's say you get water and refluxing in the loop seal. You can use pumps. I don't know exactly what you're doing.

I'll give you a scenario. How do you do that calculation? I don't know if it's a credible thing. Do they restart pumps? I mean, I don't know what you are doing exactly. So I have to look at these accidents.

MR. PAULSON: Well, the specific phenomena for each large break and small break will be discussed today.

MEMBER BANERJEE: Okay. Maybe we'll defer it until that point.

MR. PAULSON: I think that's the place to do that. It's an interesting question. You may be posing an event that hasn't been modeled. But we'll discuss that this afternoon.

MEMBER BANERJEE: Well I don't know. Maybe it's a not-credible event. I mean, I don't know exactly what you do in this plant.

CHAIRMAN MAYNARD: I do think it would

probably be better to bring this up again this afternoon that way we'll probably have the right people at the microphones too.

MR. PAULSON: Right, we'll have people that have done the calculations that are familiar with the phenomena that can address those questions.

Okay. For the non-LOCA transients we'll provide technical information to support the DCD for Chapter 15, Section 6.2. This is for all events other than the LOCA and dose calculations.

There are three primary codes that were used. There's the MARVEL-M, TWINKLE-M that seems to be modified by Mitsubishi. And I'll talk more about the modification as we go through.

And VIPRE, which is used for fuel calculations. The methodology of how these codes are used in the analysis is discussed in the topical report.

But we'll provide a little of that as part of this overview summary. And we'll get into more detail later on today as part of the Chapter 15 non-LOCA accident discussion.

And we provide sample results of analyses prior to DCD submission so that there was a certain validation of the computer codes as part of the topical report that are revealed we had supplied and the validation based on some actual test results that we've had.

And that is in the topical report to validate the computer code. We have a little longer history here in terms of topical reports. As I mentioned, once again, our topical reports were submitted in 2007, about the middle of 2007.

RAIs were issued by the NRC in July of 2008, October of 2008 and February of 2009. And we've provided responses essentially in all cases. I'm not sure all the February ones are answered.

They are? So we've provided responses already for all of the RAIs to date that we've had on computer codes for the non-LOCA accident. I'm not going to go through this.

This is just to give you an indication of, once again, we tried to be complete in our evaluation of the code. We looked at both comparisons of the code to other codes that have been approved and also specific support information that validates it independent of its comparison to other codes.

And those are all included in the sample analyses that I mentioned, and they're all included in the topical report. The objectives of the non-LOCA codes are to fulfill the obligation of doing a credible job of Chapter 15 for the DCD Section 6.2.

The three codes specifically deal with -- are used differently depending on which accident we're looking at, which non-LOCA accident we're looking at.

MARVEL-M is used as a system transient code. TWINKLE looks at multi-dimensional neutron kinetic issues. And VIPRE looks at subchannel thermal hydraulic analyses and fuel transients.

Typically it's utilized in combination with MARVEL or some other transients in Chapter 15. All three codes are MHI enhanced versions of codes that have already been reviewed by the NRC for licensing analyses of PWRs in the USA.

As we go through them I'll make a few comments on that. MARVEL is based on the Westinghouse MARVEL that was developed in the 1970's.

I think actually a few submittals to the NRC, one in `71 and one in, I think, `77. The models did not change much. The base models for those computer codes did not change much between `71 and `77.

They were both 2-loop models. There were some enhancements that were added to it. But the basic algorithms and methodologies were maintained.

The `71 version was the one that was utilized as the basis for MHI to expand the design capability of it, specifically expanded from a 2-loop code to a 4-loop code.

The reactor coolant system modeling, the mixing and the secondary steam systems were all upgraded, the models in MARVEL, the version that we used, were all upgraded to make them better -- a better evaluation tool for events that are being analyzed for Chapter 15.

A reactor coolant pump model was included. Som other small refinements that were made.

MEMBER ADBEL-KHALIK: I did not see how you stored energy in the neutron shield in your MARVEL-M model. And that's a lot of energy.

MR. PAULSON: You mean in the shield or the --

MEMBER ADBEL-KHALIK: Right, you have 150,000 pound neutron shield that, you know, at the beginning of the transient probably has enough stored energy comparable to one percent decay heat for half an hour.

And that is nowhere included in your MARVEL-M calculations.

MR. PAULSON: A lot of the transients that we utilize really don't -- the stored energy would not affect them because they're over so quickly.

MEMBER ADBEL-KHALIK: Well, how about pressurization transients?

MR. PAULSON: Well, pressurization transients, that's an issue. I think we can address that this afternoon. But, even in those cases, the over-pressurization transients are fairly short term.

MEMBER ADBEL-KHALIK: But that's not the point. In a sense that, you know, you have a significant difference and yet you need to account for that in your calculations. Otherwise they are not conservative.

MR. PAULSON: I think things are in equilibrium at the start of those transients. And if they're over quickly the impact of the stored energy is relatively low.

MEMBER ADBEL-KHALIK: I do not agree.

MR. PAULSON: I don't think you would see a big change in the over-pressurization transient. It's just based on stored energy.

MEMBER ADBEL-KHALIK: You would see as much change as you would if you were to change the amount of the decayed heat.

MR. PAULSON: But it's not a decay heat

issue. I mean, it's a long-term cooling issue.

MEMBER ADBEL-KHALIK: We'll get to that in the afternoon perhaps when we see that, the details of some of these transients. But the point is, you know, even though the code may be quite similar to the old MARVEL code, when you apply it to the US-APWR, you need to take into account the differences in the design of the machine.

MR. PAULSON: I think it would be interesting to have PIRT evaluation because that could be an issue that would come up as part of the PIRT evaluation that doesn't come up as part of the evaluation here.

CHAIRMAN MAYNARD: I think this is something we can maybe discuss more this afternoon.

MR. PAULSON: Right.

CHAIRMAN MAYNARD: Also, I think a heads-up to the Staff in their review to make sure that this gets reviewed.

MR. SCHMIDT: Agreed. I was just saying I was looking at that last night for Small Break LOCA, actually decayed heat versus stored energy in the RCS, basically for metal mass.

I can't remember off the top of my head if we looked at it relative to MARVEL though. But we have been looking at it relative to LOCAs. I think you raised a good point. We need to make sure we look at that.

MR. PAULSON: I think it involves -- and I would expect if this is looked at in some ways, and that's the effect long-term on heat removal based on a situation where you're dealing with both decay heat and energy from metal.

So, removal of that should be incorporated into the design of the heat removal systems.

CHAIRMAN MAYNARD: I think at a minimum it can't be something we just don't think it's going to be an affect. There should be some justification.

MR. PAULSON: Right. And I presume that's taken into account. But I think we can discuss that this afternoon. And, if we don't have a direct answer we'll give you one.

TWINKLE code was based on the Westinghouse design --

CHAIRMAN MAYNARD: I'm sorry, I just want to go back. I might have misunderstood something that the Staff said earlier. I thought they said one of these codes had not been approved.

He said that the MARVEL code had been approved.

MR. PAULSON: No, MARVEL in the `71 version was not approved. The one that was approved was the `77 version.

CHAIRMAN MAYNARD: Okay.

MR. PAULSON: What I said was the algorithms did not change significantly between `71. But we used the `71 version of it to go from 2-loop to 4-loop MARVEL.

CHAIRMAN MAYNARD: Okay.

MR. PAULSON: I'm glad you made that distinction. I didn't want to counter what the NRC said, because the NRC said it correctly. But I just wanted to point out that there were a lot of similarities between what they approved and what we started as a base.

MEMBER SIEBER: The one that you used was the `71 code?

MR. PAULSON: It was the one that I think Mitsubishi was most familiar with and had available to them. Right. Mitsubishi was a very active participant in the design of the MARVEL code -- in the `71 version of the MARVEL code.

MEMBER SIEBER: Thank you.

MR. PAULSON: TWINKLE, as I said was based on the Westinghouse TWINKLE. There were some modifications made, fairly significant one is identified here in the spatial mesh expansion. And 2,000 points was increased over 80,000 points for the 3D version.

Introduction of the discontinuity factor, this was input data made to make homogeneous diffusion solutions more closely agree with the transport solution.

And no change in the diffusion equation in TWINKLE was included. This is the changes to make the diffusion calculations consistent with the transport equation.

And there were some other minor refinements. But those were the biggest ones. VIPRE refers to the Thermal Design Methodology in the Topical Report and is familiar to the Staff.

The 2-loop version of MARVEL was reviewed and approved. That's what we were talking about with respect to the `77 version. Modifications of a key benefit to the code were both inclusion of a 2-loop to 4-loop simulation and the addition of the built-in reactor coolant pump model, and other minor. Did I do something?

MEMBER BANERJEE: Just so we can read it better.

MR. PAULSON: It's in the handouts.

MEMBER BANERJEE: Oh, okay.

MR. PAULSON: I was mentioning some of the changes that have been made or some other minor refinements. But I wanted to point out here the number of validation steps that we had, or verification steps maybe is a better way of saying it.

Because we have used the MARVEL-M and compared both the two and the 4-loop version for consistency, which is incestuous to a certain extent.

But, at least it shows that there was a valid transition from 2-loops to 4-loops. The results were compared to operating plant data. MARVEL-M results were also compared to an independent code developed by Westinghouse, their 4-loop version of LOFTRAN, which has been approved by the NRC.

MEMBER ADBEL-KHALIK: The logic of this process has been, okay, MARVEL has a simplified model. It is similar, if not identical to LOFTRAN. LOFTRAN has been approved, therefore NRC please approve MARVEL.

To me this is sort of looking at the old technology where at one time the NRC didn't have the tools to check to a great extent the validity of those simplified models and therefore approve them.

But now we do have much more sophisticated tools. And the question is, should independent calculations be done to compare these simplified codes against more advanced code predictions as a justification to approve MARVEL-M or whatever, rather than hanging your hat on the fact that this is similar to LOFTRAN.

LOFTRAN has been approved so MARVEL-M should be approved.

MR. SCHMIDT: I think you raise a good point. We are also doing confirmatory runs in this area with RELAP5 Mod 3.3 to try to address basically your concern.

MEMBER ADBEL-KHALIK: Okay.

MR. SCHMIDT: The big picture.

MR. PAULSON: And, as the slide says. We've had excellent agreement with all comparisons we've used with MARVEL, so far anyway. Hopefully it will show in the RELAP5 comparison also.

I think it will in general. Because, like I said, most of these Chapter 15 AOOs are over fairly quickly. I think some of the effects we've been talking here are longer term effects.

TWINKLE validation, modifications were made by MHI for, as I mentioned, the spatial expansion and introduction of the discontinuity factor and other minor refinements.

Verification and validation studies were performed using 3D steady-state validation. There was actually an agreement with ANC assembly power and operating plant data.

And the 3D kinetics validation, there was also excellent agreement with industry benchmark problems. I don't know if that goes quite to the extent that you're looking for.

But it's clear that there was an attempt here at using independent sources of information, both experimental and calculational methodologies to compare the results.

And the sensitivity mesh size we looked at also, and concluded that a 2x2 mesh per assembly was adequate for the licensing analysis. But there were studies performed as part of the topical report that address this issue of mesh size and node size.

And VIPRE validation is described in the methodology of the topical report also.

MEMBER BANERJEE: Is there any significant change made to VIPRE?

MR. PAULSON: No. Maybe I shouldn't speak. But I'm not aware. We would have mentioned it.

MEMBER BANERJEE: so why is an M there?

MR. PAULSON: Well, there are some adjustments for Mitsubishi Fuel.

MEMBER BANERJEE: Oh, I see. You're just a CHF correlation or whatever. And are these correlations based on full scale experiments? Or are they based on some other?

MR. PAULSON: I think we'll get into that this afternoon. That's a good question.

MEMBER BANERJEE: Yes.

MR. PAULSON: Current SRPs and 1.206 classify events, as you know, as anticipated occurrences and postulated accidents. Events are organized in the standard review plan and categorized that way.

For each specific event there is classification event. Codes used to analyze these events were identified. The acceptance criteria are identified in the topical report.

And exceptions to the SRP are noted also.

MEMBER STETKAR: Are you going to talk more about the selection of events this afternoon.

MR. PAULSON: We will. We provide detailed descriptions of the methodology relevant to applicable events in the topical report. Sample events are selected and cover the range of event categories and parameter ranges associated with the events.

There are events that use MARVEL only. Typically the uncontrolled control rod bank withdrawal at power, some of the over-power pressurization events, for example.

MARVEL-M and VIPRE are used typically for DNV calculations where you're looking at total loss and flow. TWINKLE is used for the rod injection looking at the spectrum of rod injection events.

And for those requiring special treatment also MARVEL is effective because it does have the capability of looking at four loops as opposed to just two loops.

The original development of it was for looking at 1-loop doing something and 3-loops doing something else, or 2-loops doing something else. This provides the opportunity of looking at all loops.

MEMBER SIEBER: Did you have a loss of force in reactor coolant flows?

MR. PAULSON: No, the one that's referred to here is loss of flow. So, in summary, Mitsubishi uses codes and methodologies for non-LOCA events that use algorithms similar to those approved by the NRC.

And we think that that is of some benefit to these codes. We're not trying to bias, but we are trying to say that we haven't changed anything.

And, at the point of entry into the evaluation, hopefully, is affected by the fact that we have these algorithms that we presume have been reviewed.

Changes in the codes previously approved by the NRC have been described, justified and validated in the topical report and associated RAI responses, we think.

Of course, that evaluation is ongoing right now. Verification and validation comparisons show excellent agreement with other codes, plant data, and industry benchmark problems, as I pointed out, as part of the evaluation.

And last, codes and methodologies are applicable to the Chapter 15 events as identified as part of the topical report, which events they are specifically identified for.

So, the justification of the codes and the comparison -- the validation and verification of the code is in the topical report, as opposed to being in the design control document.

MEMBER ADBEL-KHALIK: Is there a separate topical to be submitted for ATWAS events.

MR. PAULSON: It was addressed, I think, is it in -- where is it addressed in the DCD?

MR. WOOD: This is Doug Wood. ATWAS is addressed in Section 15.8 of the DCD. The transient analyses for the ATWAS events, however, are not included in Section 15.8.

The ATWAS transient performance really is part of the plant PRA and is used for determining the event sequences for acceptable versus unacceptable results in the PRA and, as a result, is part of the PRA.

MEMBER ADBEL-KHALIK: So Mitsubishi does not plan to submit calculations showing plant response for various ATWAS events? Is that what you're telling me?

MR. WOOD: At this point in time that is true. The ATWAS analyses, to the extent that they are performed, are a backup to the PRA split fractions.

MEMBER ADBEL-KHALIK: Will we have the opportunity to review these calculations as part of this review process? Or is this going to be a part of the COL review process?

MR. CIOCCO: This is Jeff Ciocco with the

NRC. You'll have a chance to review the safety evaluation report. Chapter 15 A is the ATWAS section of the design control documents.

The Staff is reviewing it. We will be issuing RAIs on the ATWAS probably by the end of February or early March this year.

MEMBER ADBEL-KHALIK: Okay.

MR. CIOCCO: So, whenever you get the safety evaluation report with open items you will have an opportunity to look at the ATWAS. And, as he said, it is in Chapter 19 as well, the PRA is.

MEMBER ADBEL-KHALIK: Thank you.

MEMBER SIEBER: That's not a licensing basis, right? On the other hand the plant has answers to cope with that.

MR. SCHMIDT: It falls into a different category on the regulation, LOCAs and stuff like that.

CHAIRMAN MAYNARD: We're coming to the end of the open session. I'd like to ask right now whether there's any members of the public. We didn't get any for comment.

But if there's anybody from the public that has a comment they'd like to make, I'd entertain that right now. If not, this is going to conclude the open portion of the meeting.

And, since this is an informational brief and no conclusions are really going to be drawn, we're not going to come back in to open session.

So the afternoon, the end of this morning and this afternoon will all be closed session. And we'll basically end in closed session.

So this is the public's last opportunity to make comments and stuff here. With that, we're going to take a break and we'll come back at 10:15.

And at that time we'll come back in session in closed session. Let's take a break.

(Whereupon, the above-entitled matter went off the record at 9:56 a.m. for a closed session, adjourning the open session)

ACRS Subcommittee Meeting on US-APWR Topical Reports

February 19, 2009

Mitsubishi Heavy Industries, Ltd.

Topical Reports

1. Large Break LOCA Code Applicability Report for US-APWR
2. Small Break LOCA Methodology for US-APWR
3. Non-LOCA Methodology

Overview of
"Large Break LOCA Code Applicability Report for US-APWR"

Summary

- Highlights and Status of the Topical Report
- LBLOCA Code and Methodology
- Summary

Highlights and Status of the Topical Report

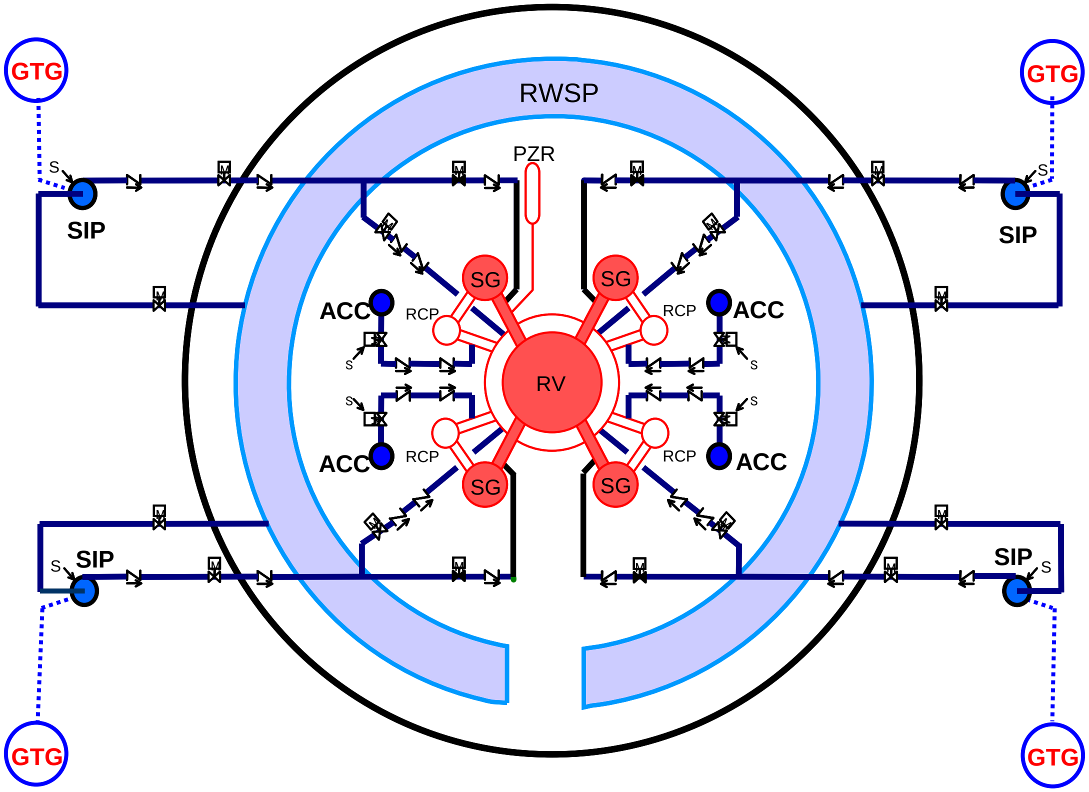
- Highlights of the Topical Report
  - ✓ Objective
    - To present comprehensive assessment of the applicability of WCOBRA/TRAC(M1.0) code with ASTRUM methodology to US-APWR LBLOCA analysis
  - ✓ Subjects
    - US-APWR design features to be evaluated for the code applicability have been identified and discussed
    - Applicability of the code and methodology for US-APWR has been examined based on CSAU approach
  - ✓ Relationship with DCD for US-APWR
    - The Topical Report is referenced in Section 15.6.5 of US-APWR Design Control Document (DCD)

Status of the Topical Report

- Submitted (Rev. 0) in July 2007
- Docketed in January 2008
- No RAIs received to date

US-APWR Plant Design and Features (1/2)

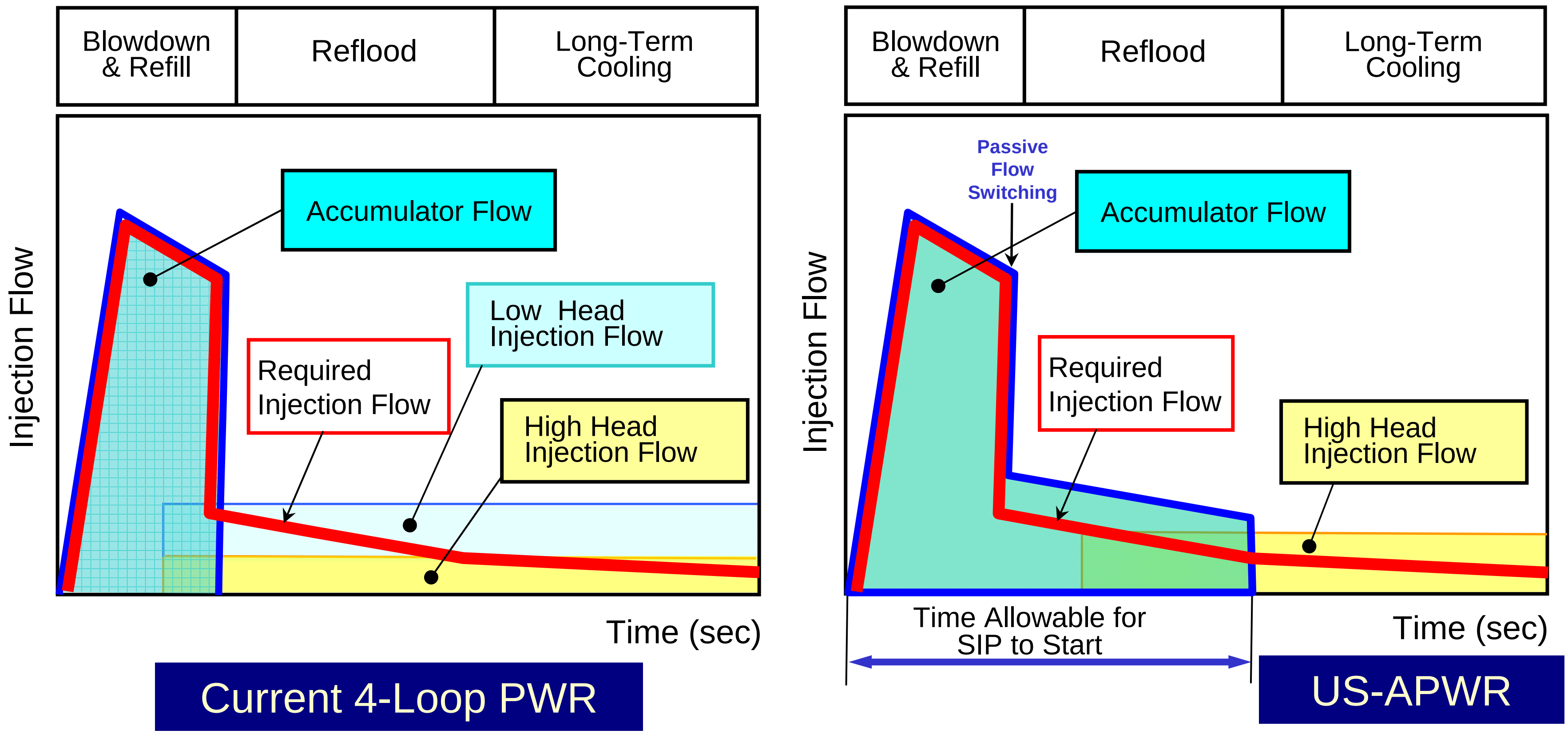
- Emergency Core Cooling System (ECCS)
  - ✓ Four (4) ACCs: Cold Leg Injection
  - ✓ Four (4) SIPs for High Head Injection System (HHIS): Direct Vessel Injection (DVI)



RV:	Reactor Vessel
SG:	Steam Generator
RCP:	Reactor Coolant Pump
PZR:	Pressurizer
S:	Safety Injection Signal
ACC:	Advanced Accumulator
SIP:	Safety Injection Pump
RWSP:	Refueling Water Storage Pit
GTG:	Gas Turbine Generator

US-APWR Plant Design and Features (2/2)

- Improved Features of ECCS
  - ✓ Passive switching of injection flow rate by flow damper
  - ✓ Low head injection system eliminated
  - ✓ Extended ACC injection allows more time for SIP to start
    → Gas Turbine Generator (GTG) adopted



LBLOCA Code and Methodology (1/2)

- WCOBRA/TRAC(M1.0) code with ASTRUM methodology has been used for US-APWR Large Break LOCA (LBLOCA) analysis for design certification application
  - ✓ WCOBRA/TRAC(M1.0)
    - Modified version of the WCOBRA/TRAC code (Mod.7A Rev.6)
    - Calculation of thermal-hydraulic behavior during a large break LOCA
  - ✓ HOTSPOT
    - Same fuel rod analysis model as that used in WCOBRA/TRAC
    - Calculation of the effect of uncertainties at axial location of the fuel rod
    - Simulation of cladding burst, metal-water reaction, and fuel relocation following burst phenomena
  - ✓ ASTRUM (Automated Statistical TReatment of Uncertainty Method)
    - Non-parametric order statistical methodology that does not assume Peak Cladding Temperature (PCT) distribution
    - Statistical method determines that 124 cases must be run to assure 95/95 PCT, Local Maximum Oxidation (LMO), and Core-Wide Oxidation (CWO)

LBLOCA Code and Methodology (2/2)

- Applicability of WCOBRA/TRAC to US-APWR has been evaluated and confirmed especially in simulating high-ranked LBLOCA phenomena and new or improved design features
  - ✓ New Design
    - Advanced Accumulator (ACC)
  - ✓ Improved Designs
    - Direct Vessel Injection (DVI) for Safety Injection Pump (SIP)
    - Neutron Reflector (NR)
- Applicability of the code and methodology to US-APWR has been examined and confirmed based on CSAU approach, which includes the following:
  - ✓ Identify and Rank Phenomena (PIRT)
  - ✓ Determine Code Applicability
  - ✓ Define Nodalization for Nuclear Power Plant (NPP) Calculations
  - ✓ Perform Sample Plant Analysis

Summary

- WCOBRA/TRAC(M1.0) code with ASTRUM methodology is being used for US-APWR LBLOCA analysis
- New or improved US-APWR design features have been evaluated for the code applicability
- Applicability of WCOBRA/TRAC(M1.0) code and ASTRUM methodology to US-APWR has been examined and confirmed based on the CSAU approach
- WCOBRA/TRAC(M1.0) has been applied to sample US-APWR plant analysis and its capability to simulate US-APWR LBLOCA transient was demonstrated
- The US-APWR LBLOCA analysis is reported in the DCD Section 15.6.5
- Results of ECCS performance analysis satisfies the Acceptance Criteria 10 CFR 50.46

Overview of
"Small Break LOCA Methodology for US-APWR"

Summary

- Highlights and Status of the Topical Report
- Contents of the Topical Report
  - ✓ Introduction
  - ✓ Compliance with 10CFR50.46
  - ✓ Systems, Components, Phases, Geometries, Fields, and Processes that must be modeled
  - ✓ Identify and rank Key Phenomena and Processes
  - ✓ Assessment Base
  - ✓ Development and Assessment of the RELAP5-3D-Based Framework of the M-RELAP5 Evaluation Model
  - ✓ Evaluation Model structure
  - ✓ Assessment of EM Adequacy
  - ✓ Conclusions

Small Break LOCA Methodology

- Objective
  - ✓ To present MHI's comprehensive methodology for US-APWR small break LOCA (SBLOCA) analyses
- Key Issues
  - ✓ Identification of US-APWR design features relevant to SBLOCA
  - ✓ Development of Phenomena Identification Ranking Table (PIRT) and assessment matrix for SBLOCA analysis code
  - ✓ Development of M-RELAP5, a modified version of RELAP5-3D to incorporate 10CFR50 'Appendix K' Evaluation Model (EM)
  - ✓ Assessment for EM adequacy of the M-RELAP5
- Relationship with DCD for US-APWR
  - ✓ The present topical report is referenced in Chapter 15.6.5 of the US-APWR DCD.

Status of the Topical Report

- Submitted (Rev. 0) in July 2007
- Docketed in January 2008
- NRC RAIs issued December 2008
- Responses to RAIs submitted in January and February 2009

M-RELAP5 Evaluation Models

- Base Code (RELAP5-3D)
  - ✓ A best-estimate code developed by INL
  - ✓ Based on the complete two-fluid model applicable to various thermal-hydraulic phenomena
  - ✓ RELAP5 has a long history of verification and validation for SBLOCA application
- Appendix K Model Implementation
  - ✓ In conformance to Appendix K requirements to the high-ranked phenomena, the following conservative models have been implemented into RELAP5-3D by MHI.
    - ANS-1971 decay heat model
    - Fuel gap conductance model equivalent to MHI design code
    - Baker-Just metal-water reaction model
    - Cladding swelling and rupture model applicable to ZIRLO™
    - Moody critical flow model
    - Modified CHF and fuel heat transfer models in conformance to Appendix K requirements (No return to nucleate boiling, etc.)
    - Advanced accumulator model

Phenomena Identification and Ranking Table (PIRT)

- As a starting point, a generic SBLOCA PIRT for current PWRs was examined by MHI experts
- Afterwards, MHI has enhanced the SBLOCA PIRT by identifying the phenomena occurring in the specific features and components of US-APWR (US-APWR SBLOCA PIRT)
- Three ranking levels are applied to each phenomenon to determine its importance in US-APWR SBLOCA
  - ✓ H: The process is considered to have high importance and the relevant analysis models and processes must be validated
  - ✓ M: The process has medium importance and must be modeled in the analyses
  - ✓ L: The process has low importance and needs to be modeled although a high accuracy of modeling is unnecessary
- The US-APWR SBLOCA PIRT has been reviewed by international LOCA experts independent from MHI

Summary

- US-APWR SBLOCA important phenomena have been identified and M-RELAP5 modeling capability has been assessed in conformance to EMDAP
- M-RELAP5 applicability to US-APWR SBLOCA analysis has been verified using small-break separate and integral effects test data
- In conclusion, M-RELAP5 is adequately applicable to the Chapter 15 Small Break LOCA analysis of the US-APWR against the Acceptance Criteria specified in 10 CFR Part 50 Section 50.46, ” Acceptance Criteria for Emergency Core Cooling System for Light-Water Nuclear power Reactors ”

Overview of
“Non-LOCA Methodology”

Objectives and Status of the Topical Report

- Objectives of the Non-LOCA Topical Report
  - ✓ Provide technical information to support DCD Ch. 15 and Sec. 6.2 (all events except LOCA and dose evaluation)
    - Non-LOCA computer codes used by MHI
      - *MARVEL-M*
      - *TWINKLE-M*
      - *VIPRE-01M*
    - Methodology of how these codes are used in analyses
  - ✓ Provide sample results of analyses prior to DCD submission

Status of the Topical Report

- ➢ Submitted (Rev. 0) in July 2007
- ➢ NRC RAIs issued
  - ✓July 2008
  - ✓October 2008
  - ✓February 2009
- ➢ Responses to RAIs submitted
  - ✓August 2008
  - ✓September 2008
  - ✓November 2008
  - ✓February 2009

Contents of the Non-LOCA Topical Report

1. Introduction
2. Computer Code Description
3. Code Validation
4. Acceptance Criteria for SRP Chapter 15 Non-LOCA Events
5. Event-Specific Methodology
6. Sample Transient Analysis
7. Conclusions
8. References

Appendices A-F

1.0 Introduction

- Non-LOCA codes used for DCD Chapter 15 and DCD Section 6.2
  - ✓ *MARVEL-M*: plant system and transient analysis code
  - ✓ *TWINKLE-M*: multi-dimensional neutron kinetics code
  - ✓ *VIPRE-01M*: subchannel thermal hydraulics analysis and fuel transient code
- All 3 codes are MHI enhanced versions of codes that have been reviewed by the NRC for licensing analyses of PWRs in the USA

2.0 Computer Code Description (1/2)

- MARVEL-M
  - ✓ Based on Westinghouse MARVEL code developed in the 1970s and later approved by the NRC
  - ✓ MHI made several improvements to original MARVEL
    - Models expanded from 2-loops to 4-loops
      - Reactor coolant system
      - Reactor vessel mixing
      - Secondary steam system
    - Built-in reactor coolant pump (RCP) model
    - Other minor refinements

2.0 Computer Code Description (2/2)

- TWINKLE-M
  - ✓ Based on Westinghouse TWINKLE code developed in the 1970s and later approved by the NRC
  - ✓ MHI made several improvements to original TWINKLE
    - Spatial mesh expansion
      - Original 2,000 points increased (US-APWR uses over 80,000 points for 3D analysis)
    - Introduction of a discontinuity factor
      - Input data to make homogeneous diffusion solution more closely agree with transport solution
      - No change to the diffusion equation in TWINKLE
    - Other minor refinements
- VIPRE-01M
  - ✓ Refer to Thermal Design Methodology Topical Report

3.0 Code Validation (1/2)

- MARVEL-M validation
  - ✓2-Loop version reviewed and approved by NRC
  - ✓Modifications by MHI
    - Expansion from 2-loop to 4-loop simulation
    - Addition of built-in RCP model
    - Other minor refinements
  - ✓Verification and validation of modifications provided in topical report and RAI responses
    - MARVEL-M results compared to 2-loop MARVEL results
    - MARVEL-M results compared to operating plant data
    - MARVEL-M results compared with 4-loop LOFTRAN results (NRC approved WCAP-7907-P-A) for selected events in DCD Chapter 15
    - Excellent agreement for all comparisons

3.0 Code Validation (2/2)

- TWINKLE-M validation
  - ✓ Modifications by MHI
    - Spatial mesh expansion
    - Introduction of a discontinuity factor
    - Other minor refinements
  - ✓ Verification and validation of modifications provided in topical report and RAI responses
    - 3D steady state validation – excellent agreement with ANC assembly power and operating plant data
    - 3D kinetics validation – excellent agreement with industry benchmark problem solution
  - ✓ Sensitivity study of mesh size – concluded that 2x2 meshes per assembly is adequate for DCD licensing analysis
- VIPRE-01M validation
  - ✓ Described in Thermal Design Methodology Topical Report

4.0 Acceptance Criteria for SRP Ch. 15 (1/2)

- Current SRPs and RG 1.206 classify events by
  - ✓Anticipated operational occurrence (AOO)
  - ✓Postulated accident (PA)
- Events are organized into SRP categories based on effect on the plant
- For each specific event, topical report gives
  - ✓Classification of event (AOO, PA)
  - ✓Code(s) used to analyze event (MARVEL-M, etc.)
  - ✓Acceptance criteria specific to event
  - ✓Exceptions to SRP are noted

5.0 Event-Specific Methodology

- Provide detailed description of analysis methodology relevant to applicable events
- Sample events selected cover range of event categories and parameter ranges associated with events
  - ✓ MARVEL-M only
    - Uncontrolled RCCA bank withdrawal at power
  - ✓ MARVEL-M and VIPRE-01M sequence
    - Complete loss of forced reactor coolant flow
  - ✓ TWINKLE-M and VIPRE-01M sequence
    - Spectrum of RCCA ejection
  - ✓ Requiring special treatment
    - Steam system piping failure
    - Feedwater system pipe break
    - Steam generator tube rupture (SGTR)

Summary

- MHI uses codes and methodologies for non-LOCA events that use algorithms similar to those approved by the NRC for existing US PWRs
- Changes to codes previously approved by NRC have been described, justified, and validated in the topical report and associated RAI responses
- Verification and validation comparisons show excellent agreement with other codes, plant data, and industry benchmark problem solutions
- Codes and methodologies are applicable and valid to analyzed events for US-APWR DCD Chapter 15 and DCD Section 6.2 analyses