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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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US-APWR SUBCOMMITTEE

OPEN SESSION

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TUESDAY

JANUARY 15, 2013

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ROCKVILLE, MARYLAND

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

SUBCOMMITTEE MEMBERS:

JOHN W. STETKAR, Chairman

J. SAM ARMIJO, Member

DENNIS C. BLEY, Member

CHARLES H. BROWN, JR. Member

HAROLD B. RAY, Member

JOY REMPE, Member

WILLIAM J. SHACK, Member

NRC STAFF PRESENT:

GIRIJA SHUKLA, Designated Federal Official

JAMES GILMER, NRO

HOSSEIN HAMZEHEE, NRO

JOSHUA KAIZER, NRO

RUTH REYES, NRO

JEFF SCHMIDT, NRO

ALSO PRESENT:

YUKO FUJITA, MNES

MASAYA HOSHI, MNES

DAN HUGHES, Information System Laboratories

ATSUSHI KUMAKI, MNES

YUTA MARUYAMA, MNES

MASATOSHI NAGAI, MNES

MASAMORI ONOZUKA, MNES

KEITH PAULSON, MNES

DAVID SEEL, MNES

RYAN SPRENGEL, MNES

TAKAYUKI SUEMURA, MHI

JUNICHI TAKEUCHI, MHI

KURT WALTER, MNES

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P R O C E E D I N G S

(8:32 a.m.)

CHAIR STETKAR: The meeting will now come to order. This is a meeting of the United States Advanced Pressurized Water Reactor Subcommittee. I am John Stetkar, Chairman of the subcommittee meeting.

ACRS members in attendance or Harold Ray, Dennis Bley, Sam Armijo, Bill Shack, Charlie Brown, and Joy Rempe. Mr. Girija Shukla of the ACRS Staff is the Designated Federal Official.

The subcommittee will discuss the VIPRE Code Topical Report MUAP-07009-P, Revision 0, "Mitsubishi Thermal Design Methodology" and the staff's SER associated with the topical report.

The subcommittee will also receive an informational briefing on the FINDS Topical Report MUAP-07034-P, Revision 3, "FINDS: Mitsubishi PWR Fuel Assemblies Seismic Analysis Code." We will hear presentations from Mitsubishi Heavy Industries and the NRC Staff. We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

The subcommittee will gather information, analyze relevant issues and facts and formulate 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 this meeting previously published in the Federal Register.

Parts of this meeting may need to be closed to the public to protect information proprietary to MHI or other parties. I would ask the NRC Staff and the Applicant to identify the need for closing the meeting before we enter into such discussions and to verify that only people with the required clearance and need to know are present.

A transcript of the meeting is being kept and will be made available, as stated in the Federal Register notice. Therefore, we request that the 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 they may be readily heard.

A telephone bridge line has also been established for this meeting. To preclude interruption of the meeting, the phone will be placed in a listen-in mode during the presentations and committee discussions.

Please silence your cell phones during the

meeting.

We also have an item on the agenda at the end of our discussions that we are going to review some preliminary answers, responses for thermal hydraulics, questions from our July and October subcommittee meeting. So I just wanted to alert everyone to that item on the agenda.

And with that, --

MR. HAMZEHEE: I'll take it from here.

CHAIR STETKAR: Hossein has spoken up. I will ask Hossein Hamzehee to start to the meeting.

MR. HAMZEHEE: Thank you, sir. I don't have a lot to say. I just want to thank John and the ACRS Subcommittee members for the opportunities to discuss these topical reports with you this morning. And we have all the staff sitting in the back and we will be here to present and also they are SCF. They are sitting outside, a lot of them.

With that, Ruth, anything you would like to add? Back to John.

CHAIR STETKAR: Thanks, Hossein. And with that, we will turn it over to Mitsubishi.

MR. SPRENGEL: Good morning. This is Ryan Sprengel with MNES. I would like to echo Hossein's thank you for this meeting. And we are looking forward

to a productive year and especially the next couple of months, I think, the first half of this year with productive interactions, hopefully. So, I will go ahead and turn it over to Takeuchi-san.

MR. TAKEUCHI: Yes.

CHAIR STETKAR: Also, just again to warn you, I know that you have some information that is open. Just be aware of anything that we tread upon in the open session that might be proprietary. Just alert us to that and we will cover it in closed session after you close the meeting. Okay, thank you.

MR. TAKEUCHI: Okay. Good morning, everyone. Thank you for giving me the opportunity to present this material.

I have the open session material and the closed session material. So first thing, the open session, I will briefly explain the outline of the Topical Report. And in the closed session, I will go into the detail of the Topical Report.

Okay, so in my presentation, I will introduce the contents of the Topical Report MUAP-07009, thermal design methodology.

And I am lead presenter, Junichi Takeuchi. I am a senior engineer in Mitsubishi Heavy Industries, MHI, and in charge of thermal-hydraulic design. And

we have two technical experts here. Mr. Takayuki Suemura, he is an engineering manager, MHI and he is in charge of thermal-hydraulic methodology and software development. And Mr. Masaya Hoshi is senior technical advisor with Mitsubishi Nuclear Energy Systems, MNES, and he is charge of thermal hydraulic design also.

Okay. So basically our Topical Report presents the comprehensive description of the thermal design methodology utilized by MHI, which is based on already approved code and methodology for other vendors and currently used in the United States, which is the VIPRE-01 subchannel analysis code which is approved for EPRI and for DNB correlations WRB-1 and WRB-2, which are approved for Westinghouse. And we also supplementary use W-3 correlation which is a very classical correlation just for low pressure events. And for the design procedure we use Revised Thermal Design Procedure RTDP which is already approved for Westinghouse.

And our Topical Report addresses that all this methodology applicable to DNB analysis and transient fuel temperature analysis for MHI-designed PWR cores.

Okay. So the main part of our Topical Report is the VIPRE-01M, which is MHI version of

VIPRE-01.

So the VIPRE-01M is essentially identical to VIPRE-01 in essential thought which constitutive equations and numerical schemes but we incorporated additional functions shown here, which is DNB correlations for design applications WRB and WRB-2. And fuel thermal properties for design applications actually VIPRE-01 has its own thermal properties but we incorporate our own thermal properties which is consistent to our fuel design code.

And the important part of the change --

MEMBER SHACK: Is that an option or you have actually replaced them?

MR. TAKEUCHI: It is an option.

MEMBER SHACK: It is an option.

MR. TAKEUCHI: Correct. So the important part of our thermal property is that it accounts for the degradation effect of thermal conductivity of the fuel, depending on burnup.

And we also added some options to perform the hot spot peak cladding temperature analysis for after DNB and some user interfaces are more defined.

MEMBER ARMIJO: I just want to make sure I understood. Since the thermal degradation is a fuel property and function of burnup, why would that be an

option in your analysis? Why wouldn't it be just a standard input?

MR. TAKEUCHI: Well it is added as option but we use it as a standard.

MEMBER ARMIJO: Okay, so you never would use an -- do an analysis without thermal conductivity degradation?

MR. TAKEUCHI: Yes, for design application we always use the thermal conductivity accounting for the degradation effect.

MEMBER REMPE: If a person that picks an option that is inappropriate, are there warnings that show up in the code? Does the code stop? Does it check to see that you picked the right option? Does it stop or how does this work?

MR. TAKEUCHI: We can choose different options I we intend to do so. But the input are always checked before it runs. So --

MEMBER REMPE: Checked by the code or checked by another engineer?

MR. TAKEUCHI: Checked by engineers.

MEMBER REMPE: Okay. Also, and I don't know if this goes in the open session or the closed session, but there was an issue about a frozen version of the code and when the staff was reviewing it, they

found that multiple versions had been used and could you clarify how that happened and how that won't happen again?

MR. TAKEUCHI: Yes, we basically -- can you explain that frozen version issue? So your question is that we clarified that. This issue is addressed properly.

MEMBER REMPE: Well there was a point in some of the documentation we were provided that said that Mitsubishi has a frozen version of the code. You have a lot of good quality assurance to keep you using that frozen version but yet the staff found that you had used multiple versions of the code in some of the information they were checking. And so I would like to understand how that even occurred with your quality assurance system. And then apparently, there was some sort of flaw in the quality assurance and how do you know that won't happen again?

MR. TAKEUCHI: Okay, our code development started before our quality assurance program is actually finalized. So it actually happened before that, the final quality assurance program was fixed.

So over the course of the development, the first part of the code development was not be under the current final version of the quality assurance program.

So that was the start of the issue.

We basically confirmed that our code changes are acceptable in quality assurance program and we performed the -- we re-preformed the calculation that was done in the old version.

MR. SPRENGEL: Let me clarify a little a bit. Because what Takeuchi-san is talking about is more tied to the implementation of the US-APWR Quality Assurance Program. So there was a transition period.

But what Joy is asking about is actually it is tied more to our licensing documentation, where we had used different versions over time --

MEMBER REMPE: Despite that you were supposed to have one version that was frozen.

MR. SPRENGEL: There is always one version that is frozen and up-to-date. But it had been revised and we had not gone back and redone the previous submittals. And so that was the kind of gap in the internal procedures. So that was fixed.

And we did go back and look at the different submittals that were made the results that were found using the code. So and then that was fixed.

So that was the problem was aligning the most current code to also match up with all you submittals for the licensing.

MEMBER ARMIJO: All the previous analyses were done with frozen code, which at the time was the reference code?

MR. SPRENGEL: At the time, yes.

MEMBER ARMIJO: Right, so it wasn't something that was just out of control. But you then had to go back and update it with the newest version.

MR. SPRENGEL: To line up with licensing documentation with a version of the code, yes.

MEMBER ARMIJO: Okay.

MR. SPRENGEL: So it was all controlled.

MEMBER REMPE: So this won't happen again.

MR. SPRENGEL: The only missing link was to make sure that you had alignment between the most recent version in the QA process and the licensing submittals.

MEMBER REMPE: So this wouldn't happen again, --

MR. SPRENGEL: Correct.

MEMBER REMPE: -- as to either issue.

MR. SPRENGEL: Correct, yes.

MEMBER REMPE: But I wanted to have some confidence.

MR. SPRENGEL: So it was a change in the licensing procedures within MHI.

So as an additional step to look at the code that you are using and if there was changes in the QA-controlled code, that you also then have to update all of your licensing submittals or do a review to confirm that there is no impact.

MEMBER REMPE: Thank you.

MR. TAKEUCHI: Can I move on? Okay, so VIPRE-01 is already approved by NRC for EPRI, which is approved as a generic code. So when each vendor applies it for their own calculation, each vendor has to justify their own -- their way of using it, and justify the model option that they use. So that is the condition in the VIPRE-01 SER. So we basically discussed the SER conditions in Topical Report and addressed that how we complied with the VIPRE-01 SER. And these are the main topic of the Topical Report.

And so I picked two examples of the most important parts of the SER conditions here, which is model used for licensing analysis must be justified. And in the topical report, we justify our model options by sensitivity analysis and benchmark with other NRC-approved codes.

And the second point here is newly introduced CHF correlations must be validated. Since we incorporated WRB-1 and WRB-2 correlations, we

qualified these correlations by analyzing DNB test data with VIPRE-01M. And eventually we show that the original DNBR correlation limit of 1.17, which is approved for WRB-1 and WRB-2 are conservative for VIPRE-01M analysis of Mitsubishi fuel.

Another important part of this Topical Report is that since we incorporate these model options into VIPRE-01, we qualify that our models works properly in VIPRE-01M by showing that DNBR is also similar or slightly conservative in comparison with other NRC-approved codes.

And for safety -- for steady state analysis, the results are compared against THINC code results for various plant conditions. And for transient analysis, typical locked rotor analysis were performed and results were compared against FACTRAN and THINC code results.

Okay, so in conclusion, we summarize the Topical Report by saying MHI thermal design methodology consists of RTDP, VIPRE-01M and WRB-1 and WRB-2 correlation. And VIPRE-01M is an extension of VIPRE-01. And the VIPRE-01M model options selected for licensing analysis are well-accepted and conservative.

WRB-1 and WRB-2 correlations and their

original DNBR correlation limit of 1.17 are conservative for Mitsubishi fuel in conjunction with VIPRE-01M.

And in summary, we say we conclude that the MHI's methodology is applicable to the core thermal hydraulic design analysis and all non-LOCA safety analysis relevant to DNB. So this is our conclusion of the Topical Report.

So this is the end of the open session presentation.

CHAIR STETKAR: Any question for MHI, at least for the open material?

MEMBER REMPE: Before we get into the closed material, could I ask the Staff a question just to give some perspective of what we are going to hear herein the closed part?

CHAIR STETKAR: Sure.

MEMBER REMPE: In your documentation, you regularly have said small changes to VIPRE can give big changes to the results. And they said well, we have only made a few small changes, although frankly to me they look kind of substantial.

What kind of small changes can give big changes to VIPRE results and so as you go through the closed session, could you give some examples from the other things you have done with VIPRE or you saw some

big changes?

MR. KAIZER: Josh Kaizer, NRC staff. What we are personally concerned about is anytime you make a change to a code, you never really know what your result is. So when they made small changes to VIPRE-01 I think a better way to say that would be they actually continued -- finished VIPRE-01. VIPRE-01 as it sits in the SER says you can't use this. EPRI has a lot of different models in it. There is a lot of two-phases flow, a lot of CHF models. And in the SER we said you have to choose which two-phase flow model, which pressure drop model, void quality. You select that and then you justify that and that is what MHI did.

So I don't consider VIPRE-01M so much an extension of VIPRE-01. I consider VIPRE-01 incomplete and VIPRE-01M is the complete version, like VIPRE-01D, which is Dominion, and VIPRE-01W, which is a Westinghouse version.

And then they had to not only justify why they selected that model, but ultimately, and this is what you will hear probably over and over again, they had to validate that and they validated with their CHF data.

So if they were to have quote-unquote, "made a change" that would give them erroneous results, we

would not expect to see them to be able to predict CHF data anywhere near as well as they predicted it.

MEMBER REMPE: Okay.

MR. KAIZER: Does that answer your question?

MEMBER REMPE: Yes, sir. Thank you.

CHAIR STETKAR: Anything else? With that, we will go onto closed session and I will ask the Staff and MHI to verify whether or not anyone needs to leave the room.

(Pause.)

CHAIR STETKAR: Seeing no one heading for the doors, I am assuming we are all okay. So we are now in closed session and we can begin the closed session discussion.

Actually, let's hold off. We need to check the bridge line to see who might be out there on the bridge line. Let me ask this. Ryan, is anyone who is out there from MHI needed to possibly answer questions? Because we can just close the bridge line.

MR. SPRENGEL: We don't need the bridge line.

CHAIR STETKAR: Why don't we do that? Just close the bridge line. Because if they don't need any technical resources to answer questions, it is just a

lot safer if we just close it.

(Whereupon, the foregoing meeting went off the record at 8:54 a.m. for a closed session and went back on the record at 10:42 a.m., continuing the open session.)

CHAIR STETKAR: We're back in session and we will hear from the Staff. I guess we probably just for interest should reopen the bridge line, if there were people.

MR. SHUKLA: There is only one consultant from the Staff that should be on the bridge line. He is here?

MR. SCHMIDT: Yes, we don't need a bridge line.

CHAIR STETKAR: You may not need it but according to our public process, we normally keep it open. Did we have anybody --

MR. SHUKLA: Not really until somebody requests it.

CHAIR STETKAR: Did we have anybody on it before?

MR. SHUKLA: No.

CHAIR STETKAR: Oh, there was nobody? I just wanted to check. Thank you.

MS. REYES: Okay, thank you very much.

Good morning everyone. My name is Ruth Reyes. I am the project manager for the review of the VIPRE Topical Report. Here with me are part of the technical staff involved in the review. From NRO, we have Jeff Schmidt and from NRR Josh Kaizer. We also had Anthony Attard. He was a senior technical reviewer from NRR who was involved in the review but he retired last year. So he is not here with us today. And also we have ISL, which is here with us, who helped the staff in the review.

So having said that, I am going to let the staff start with their presentation of the ACRS review.

MR. KAIZER: To perform this review, the staff used the guidance in SRP 15.0.2, which is actually very good guidance. And that is why you will notice that there are a couple rounds of RAIs and round three was when we really started using this SRP guidance. So we asked a lot of questions specifically dealing with what the SRP said you should ask.

We also looked at previous reviews for VIPRE-01, Westinghouse's VIPRE-W, Duke and Dominion each have their own versions of VIPRE as well. We issued five rounds of RAIs, which MHI each answered and we performed two quality assurance audits. We also went

to Germany and observed the DNB testing in their KATHY loop.

MEMBER BLEY: Okay. The way you began this, is that a new section of the SRP?

MR. KAIZER: It is not. This is the first time that I am aware of that the Staff has used an SRP as much as I did in writing the SER.

MEMBER BLEY: Okay.

MR. KAIZER: Like I mean, all my sections and criteria come right from there. I am hoping that we are going to continue it because I think it works really nicely but that part was different.

MEMBER REMPE: Were the number of RAIs considerably more than what you had like say with AREVA or Westinghouse or some other place?

MR. KAIZER: For a lot of cases, I think there were more RAIs. I think that was really two reasons. First, was the number of reviewers that had a hand in the pot. It started with Ed Throm and Ralph Landry. It then switched from Ed Throm to Tony Attard and then came from Tony Attard and myself who it finally landed with. And it was also the fact that MHI was a new vendor to the NRC. The way I tried to treat it in my mind is Toys "R" Us is coming in and asking and they

want to use this nuclear code. And so I understand MHI has significant more experience than Toys "R" Us but it was just something that I had to say in my mind because we didn't have any real experience or relationship with them like we have with Westinghouse and AREVA and GE.

The Topical itself describes VIPRE-01M and its applicability to PWRs. This -- I just want to show you guys. This is one of the reports that the Topical is based on. This is actually Volume 1 of VIPRE-01 by EPRI. And this is just the mathematical modeling. There is about five volumes of VIPRE-01M. This is the most interesting because it goes through all the derivations. So VIPRE-01M is heavily based on this because they used the same modeling. They just choose which of the closure models they are going to use.

As you have already heard, it is used to perform non-LOCA transient and accident analysis for the US-APWR. So in the Topical Report they talked about their core modeling, their transient fuel rod modeling, the thermal-hydraulics used. And it is consistent with previous approved versions of VIPRE-01.

VIPRE-01M is a subchannel code. I get to break out my toys. This is what a subchannel looks like. I don't know if you actually have kind of seen one.

I made one just so I knew what it looks like. This is six rods and you can see the subchannels between them. So they are modeling the heat transfer and fluid flow inside this little subchannel. They are actually -- you model the hot assembly, which when you move stuff -- because I made the model I get to show it.

This is the hot assembly.

CHAIR STETKAR: You actually made that?

MR. KAIZER: Yes. This is not prototypical of what they are doing because that is proprietary. This is another one I had from my subchannel notes from Dr. Hochreiter.

But you can kind of see how you have individual subchannels where you would have the hot channel. Then you start lumping things. This is one-eighth of a hot channel. It is placed in the center of the core. That is typically done but it is also a conservatism because your hot assembly is usually not in the center of the core. And then you would start to lump the other assemblies and calculate the heat transfer and fluid flow through those.

So they typically use subchannel models to predict design margin for DNB. They can also use it for peak clad temperature analysis. For example,

locked rotor. I believe the only other transient they use it for is rod ejection. When they do the locked rotor transient, because they can't -- the code itself can't change the fuel properties like you would need to, they automatically assume certain things. I believe they closed the gap or they increased the gap heat transfer tremendously. They assumed DNB at the beginning of the transient. Those type of things.

US-APWR, one of the questions we asked and this is what we have seen in previous reviews. It is very similar to our current PWR. We just wanted to make sure okay there is no new phenomenon, no new mechanism that isn't really accounted for here. Again, VIPRE-01 was generically approved. Each vendor must justify the use of the specific models. MHI told us what models they were going to use. They are proprietary. We do have a closed slide if you really want to see those. They are the models we would expect them to use. And ultimately, and I would say this is the message from the staff, the justification, the selection of these, the selection of pretty much all of their parameters rests on their CHF test data because that is where everything comes together. And they demonstrated through their CHF test data that they had adequate models

to predict DNB.

The validation, again, they used their, I believe Z2 and Z3 grids, tested them at KATHY. The test range spanned the range of applicability of WRB-1 and WRB-2. It was on 14-foot data because that is what their data was. I think both WRB-1 and WRB-2 have also been approved for 14-foot data. I am almost positive that that was in the range for those.

But they have demonstrated it and this was something that we kind of -- Tony and I talked a little bit about. They didn't give us enough data to I would say come up with their own CHF correlation because that is not what they were after. I mean, it was a couple hundred points but we weren't really thinking of it in terms of okay, can this data stand alone and say we can make our own CHF correlation just from the data we gave us. What we kind of considered it was okay, is this data enough to show that their fuel assembly behaves like the other fuel assemblies and behaves well considering how much we know about WRB-1 and WRB-2. And from that aspect, we definitely believe that the test range was more than adequate.

Yes, and the testing confirmed that they can use the WRB-1 and WRB-2 correlations with VIPRE.

MEMBER REMPE: You mentioned you went over there to visit KATHY and observe it. It does adhere to NQA-1 because of AREVA already having that certification. But what exactly did you do to give yourself confidence that they were doing a good job on the testing?

MR. KAIZER: I wasn't able to go.

MEMBER REMPE: You didn't go?

MR. SCHMIDT: No, actually it was Tony Attard, myself, and Jim Gilmer went. You know, the main thing we were considering the repeatability tests. We didn't do anything more as far as like looking at the qualification of the --

MEMBER REMPE: You didn't go check the instrumentation to see it was calibrated or whatever?

MR. SCHMIDT: No, no, no, we didn't. You know, I was really relying on Tony Attard, who had been there many times and was very knowledgeable on the facility. But we did not or I did not do anything additional to make sure that the measurements were, the measurement uncertainty was any different than what had typically been performed.

So the Staff was more in a, I would say, an observer role than a QA role over there.

MR. KAIZER: From my understanding with talking with Tony, when we have a chance to go look at CHF test data and testing, we usually take it but it is more of a learning experience for us, as opposed to an actual audit experience.

We did perform QA audits for MHI because we needed to treat them again as a new vendor. We performed two QA audits. The first one where we looked at the RELAP and VIPRE-01 and we kind of looked at okay, how did you modify the code? What were the aspects at work there. And then because of some RAIs we needed to resolve and also because of the confusion about the frozen code issue, we went back and we looked specifically at okay, VIPRE-01 give us, let us -- we went through two of their transients.

I know we looked -- well, we looked in detail at locked rotor and also just basically how would an analyst perform this review. Where would they go and get that stuff from, that kind of thing. We didn't discover any significant issues. And we did make, as we have already discussed that condition limitation just based on the confusion with the frozen code issue earlier.

That is, for the open portion, I do have

closed slides, but there are just more details about the CHF test data. The Staff found that MHI's thermal design methodology is acceptable licensing analysis. We are familiar with how they are doing their subchannel code. We are familiar with how they are doing their meshing, why they chose the radial nodes they chose, why they chose the axial nodes they chose. We do believe VIPRE-01M is acceptable for performing AOO and accident analysis and ultimately, we believe that the WRB-1 and WRB-2 are acceptable for predicting CHF behavior based on the DNB test data.

It is brief. It is quick. That is my last slide. I am more than happy to take any more questions for comments.

MEMBER REMPE: I am curious. Maybe I am mis-remembering but I thought they had submitted something to the staff on their hopes to have a transition core. And maybe I misread something.

MR. KAIZER: This came down to an issue of the documentation MIH had access to versus what they did not have access to. Like they had for the fuel rod bow, they had access to the previously approved fuel rod bow topical. So they submitted that to us. They did not have access to the transition core topical.

And so when they could not submit that, the Staff then wrote a conditional limitation just to be clear. It is okay, you cannot use, you have to submit an approved transition core methodology, whether they want to come up with one of their own or if they want to find a way to get access to an approved one. That was that issue.

MEMBER REMPE: Okay.

CHAIR STETKAR: Oftentimes it requires people need a little time to collect their thoughts. Any other questions for the staff?

MR. KAIZER: I guess as you are thinking, I will try to give you more interesting things.

CHAIR STETKAR: I was going to say, you have toys.

MR. KAIZER: I have more toys. One of the interesting things MHI did in their CHF test report, which I am very grateful to them for and I think is very good work, is since they have started using CHF tests, they use a five by five grid assembly and they have these little things and they are called -- well they are support grids. And it is basically to show that -- to stop the buckling that would occur from the large magnetic forces. And these were brought up in the review of WRB-1, which I want to say was 1979, briefly

addressed, the staff looked at it and said oh yes, they will be fine and then nothing really was ever done. And MHI actually went back and demonstrated how the support grid does not really add to the CHI performance of you fuel.

So that is pretty much what a support grid looks like. This is about the size of a CHF test bundle. I have a real grid spacer, if anybody wants to see it. These are all just all my cool toys.

This is 17 by 17.

MEMBER ARMIJO: Is that the new Z?

MR. KAIZER: This is not. This was a junk grid spacer AREVA was getting rid of. And because it has no monetary value -- I have a letter right here.

(Laughter.)

CHAIR STETKAR: You buried that in your luggage.

MR. KAIZER: No, I mean it is nice -- I am actually not even sure if it is -- for all I know it could be a Westinghouse grid spacer. They are like here, take this.

This one I got off of eBay.

(Laughter.)

MR. KAIZER: But so this is about the size

of -- I am sure that theirs is going to be similar. But I have all these things if anybody wants to look at it.

CHAIR STETKAR: Those little touches.

MR. KAIZER: Yes, the vein design, the vein angle. How these little nubs, that has been a big deal because those prevent their grid-to-rod fretting. I think that is it for all my cool toys.

CHAIR STETKAR: That's great. Any other questions for the Staff? Hearing none, thank you very much. That was efficient.

What I would like to do is first of all, because this is the end of the discussion of the thermal design methodology, just ask if there are any public questions, comments.

Hearing none, we will end this session. And now, in terms of logistics, we need to end promptly at noon. I will ask MHI whether you would like to start the briefing on FINDS code.

MR. SPRENGEL: Yes.

CHAIR STETKAR: Okay, that is a good answer. We will do that, then. We will get as far as we can. As I said, we have another conflicting meeting.

MR. SPRENGEL: Right. So this is a closed

session as well.

CHAIR STETKAR: We do need to end promptly at noon. So we will just adjust the time.

MR. GILMER: Jim Gilmer with Staff. We had arranged for --

CHAIR STETKAR: Hold on, Jim. Sorry.

MR. GILMER: We had arranged for our contractor at Pacific Northwest to be on the bridge line at one. So if I can take a few minutes, I can probably get them to call in now.

CHAIR STETKAR: Yes, if that will help.

MR. GILMER: Yes, I think it will.

CHAIR STETKAR: Give them a call. We will go into recess while we reorganize here.

(Whereupon, the foregoing meeting went off the record at 11:07 a.m. for a closed session and went back on the record at 1:36 p.m., continuing the open session.)

CHAIR STETKAR: I don't think there is anyone on the bridge line but as of this time, the meeting is open.

What we would like to do, I think, we had a couple of items. And if Joy can bear with me, Joy and Sanjoy Banerjee have been working diligently over

the last couple of months and I would like to publicly, since we are on the record now, thank you very much for the amount of effort that you folks and Girija has been supporting them. There has been a lot of communications on these topics over the last couple of months and I really appreciate the effort that everybody has put in.

What I would like to do is go through those items pretty much one by one, so we have clarity where we are. And if there is any open issues that need further evaluation that we are real clear on what needs to be done. We are going to hand out a table so that you all have it.

MEMBER REMPE: But we are going to -- may I suggest something Mr. Subcommittee chairman? Why don't you start with the October one, because it is a good example that will be fairly quick and then let's go through the July ones, okay? And we will get the table out in a bit.

CHAIR STETKAR: Yes, there is only one from October.

MEMBER REMPE: Right. And let's go through it.

CHAIR STETKAR: It is a two out of four thing, if that is what you are talking about.

MEMBER REMPE: Yes, because it is, I think, a good response where they gave us sufficient information and it would be a good example to go through first.

CHAIR STETKAR: That is not on your table.

MEMBER REMPE: It's not on my table, right.

CHAIR STETKAR: You are right. That is what I was going to suggest.

MEMBER REMPE: Okay.

CHAIR STETKAR: Thank you, it is an excellent suggestion.

MEMBER REMPE: I thought you were going the other way.

CHAIR STETKAR: No, I wasn't.

MEMBER REMPE: Okay.

CHAIR STETKAR: I wanted to get that one out of the way first. And we don't have this in writing. Let me pull up my file here so I can refresh my memory on the specifics.

There was one -- I will give you, kind of orient you. There was one question that we had, there were statements in the SER and in responses to RAIs, and in fact in your response to us, regarding this notion of if you have a single failure in the reactor protector

system, any one of the remaining four channel -- any one -- I think the way it is phrased is any of the remaining channels will trip the reactor.

And a question that, according to the tech specs and your response, was something of the order of according to the tech specs, if a channel is inoperable, we need to put the channel in test -- or I am sorry -- we need to trip the channel. And, therefore, successful operation of any of the remaining channels will trip the reactor.

The problem is, the way I read the tech specs, and this might be my misinterpretation of the tech specs is the tech specs require by law, require that three channels of the reactor protection system shall be operable. Three not four.

If during a real event now, if I have one channel inoperable, I am operating my nuclear power plant and a channel becomes inoperable, normally I have four. The tech specs don't tell me that I need to trip that channel that becomes inoperable because I only need three to be operable. So I am in a gray area now. What happens in the real world if that channel becomes inoperable?

According to the tech specs, I don't find

anything that says I must place that channel in trip. So I am operating under the presumption that I will not trip that channel. That leaves me three channels.

If now I have an event and I take my single failure as one of those three channels, I need a trip signal from the remaining two. That was the genesis of my question. And it all hinges on this fact that the tech specs require three channels to be operable and they are silent on what happens if one of the four channels in the real world becomes inoperable. I can't find a requirement that says place that channel in a trip condition. If one of the required channels is inoperable, it clearly says trip it. Follow me?

MEMBER BROWN: The point is it could be out of service without a trip.

CHAIR STETKAR: The point is that during normal operation I have four channels. What happens in the real plant if one of those four channels becomes inoperable? My reading of the tech specs are that they are silent. They do not require me by law, by license, by anything, to place that one channel in the trip condition because I still satisfy my operability requirements. I still have three operable channels.

So in principle, according to my reading

of the tech specs, I can be operating 365 days out of the year. I am going to push maintenance rule and those sorts of issues off to the side but I can be operating 365 days in the year with three and only three operable channels and the remaining channel not in trip. In other words, bypassed, basically. And if that is the case, if that is allowed by the tech specs, then I still -- I am not arguing with the notion that you don't meet the single failure criterion. You certainly do meet the single failure criterion because no single failure will prevent you from tripping that reactor but the way that all the responses and the wording in the SER has been stated, it is implied that any one of the remaining channels is sufficient to trip the reactor. And I don't think that is necessarily true in the context of the logical relationships that fall out of those tech spec requirements.

MR. SPRENGEL: So the question what is the control to put the one inoperable channel with the trip.

CHAIR STETKAR: Well, it is how the tech specs are interpreted. And having operate a nuclear power plant in a previous life and I always have to admit that that was a very long ago previous life, most people who operate nuclear power plants, unless they are told

explicitly do X will not do X, especially if by doing X it makes them more vulnerable to tripping the plant, which putting one of your channels in trip would do.

MEMBER BROWN: I would take a slightly different tack and that it could be out of service and it could not be possible to put that in trip due to the nature of the failure. And, therefore, you are operating on three and you will have to require simple failure in the other. I'm just saying that is another aspect of having one channel, whether it has been put in trip or whether it is out of service and you can't put it in trip, or whether it is being repaired or what are those circumstances.

So I would not be comfortable if somebody says the only way this plant is protected is if a channel is out of service and it is placed in trip and that is the only requirement. I think that is nuts. You ought to be able to operate with three channels and then have two out of three be their protection mode.

And the implication from what you went through is that that is almost well no, while you may only need one, we are still going to have people place that discrepant channel in trip. And I just don't think --

CHAIR STETKAR: I think we might be talking of different purposes here.

MEMBER BROWN: I don't know.

CHAIR STETKAR: Ryan, do you understand sort of my logical arguments?

MR. SPRENGEL: Now I understand two arguments. Because the second argument is to maintain that two out of three.

MEMBER BROWN: Well, if you have got four channels, the whole idea, I mean I have lived with four channels my whole life. If one is out of service for whatever reason, you don't necessarily put a trip into it. If I have got -- now I am down to three and two out of three will trip me.

CHAIR STETKAR: And indeed that is --

MEMBER BROWN: I don't require a manual trip in that out of service channel.

CHAIR STETKAR: No, we are saying the same thing. The tech specs are very clear to me. Now maybe I am misinterpreting them. The tech specs say that you need three operable channels. And if a required channel is inoperable, you place that channel in trip. That is my reading of the tech specs and if I am not reading them correctly, please help me. Which essentially

leaves you, in some sense, half-primed for a trip because a trip signal from either of the remaining two channels will trip you. That is why people don't like to put the channels in trip but that is okay. That is the way the tech specs seem to be written to me.

But now if I have three operable channels, no channels in trip, and I have a real event, now we are in design basis space, so I have a real event and I must presume a single failure. And the single failure that I take is one of those three channels. And that failure does not trip me because it is a failure. Then I need a legitimate valid trip signal from the remaining two channels, essentially a trip from two out of the three channels.

And I said, it is not a single -- you meet all of the single failure criteria. I am just trying to make sure that I understand how the plant will be operated and make sure that the decisions are made in licensing space for the plant are not based on words that may be logically optimistic.

MR. SPRENGEL: So the problem is we are focusing on being in the condition of having three channels operable and we are assuming that we have the fourth one tripped, where you are saying that may not

be --

CHAIR STETKAR: The way I read your response was it presumed that any of the four channels, if they became inoperable, would be placed in trip because that is the way that the response was basically worded. But my reading of the tech specs would not require that they put it in trip and there may be many, many operational considerations where they would not want to put it in trip because you don't like sitting in a place where a trip signal from another channel will bring the plant down.

MR. SPRENGEL: But I guess to be clear, though, it is not necessarily -- is it mostly a wording concern?

CHAIR STETKAR: It is absolutely, Ryan, a wording concern.

MR. SPRENGEL: So we have two, that it may be this or we could be in a situation of having three operable channels, have the one channel failure and then we would require two.

CHAIR STETKAR: Require two, that's right. I am not raising this as a fundamental licensing single failure issue. I'm raising it as wording that is pervasive through both the MHI documentation and the

staff's SER that implies that any one of the remaining channels, and that is sort of the way that it is cast, will give you the safety thing.

MR. SPRENGEL: Okay, because it is built up presuming one.

Okay, so we back up and have the two different scenarios are covered but they just need to be acknowledged.

CHAIR STETKAR: You are covered. You are absolutely covered. I have absolutely no question about single failure vulnerability at all. I just want to make sure that the licensing basis for the failure --

MEMBER BLEY: If in fact there was a good reason for that, the tech specs ought to probably be different. And if there is not, the first licensee that comes in will probably come in with a change to get rid of that.

MR. SPRENGEL: Okay, so we need to confirm the scenarios and then I understand.

CHAIR STETKAR: Okay. It all hinges on what people will or are required to do when the first of the four channels become inoperable.

MR. SPRENGEL: Okay. So we will confirm,

I guess, not only what they will but what are they able to do. Because if they are able, to as you say, continue operating with the one inoperable channel but not in trip, we need to acknowledge that scenario.

CHAIR STETKAR: Able, you mean, legally able.

MR. SPRENGEL: Yes.

CHAIR STETKAR: Yes, I mean they are certainly able.

MR. MARUYAMA: Yuta Maruyama. I understand. I will check with our engineers and get back to you by in Region IV.

CHAIR STETKAR: Great. Sorry to drag you through this. It is just sometimes the words are important, even though we all agree that the technology is okay because we don't want to give people the impression that there might be some misinterpretation of the way the plant actually works or the way the operators will indeed operate the plant. That is the only reason why I am sort of --

MR. SPRENGEL: Okay, now that was the July meeting. Right?

CHAIR STETKAR: That was actually the October meeting. I believe that was October.

MR. SPRENGEL: Okay, we will move on. It is not important, I don't think.

CHAIR STETKAR: Okay. I think that was October.

MR. SPRENGEL: We have July, so --

UNIDENTIFIED SPEAKER: It was actually July's meeting.

CHAIR STETKAR: Was it July's meeting? Okay.

MR. HAMZEHEE: Just make sure that --

CHAIR STETKAR: Speak and identify yourself. We are on the record. This is Hossein Hamzehee from NRC.

CHAIR STETKAR: Thank you.

MR. HAMZEHEE: I just want to make sure this is not a two-way communication between you and MHI and the Staff is not taking any action on this except, if necessary, clarification on the wording of the SE.

CHAIR STETKAR: That is exactly right, Hossein. I was trying to understand it. This is a question that we had to MHI. They have given us some feedback on it.

It does have implications on the wording in the SE because the SE reproduces that notion of

failure or under a single failure condition a valid single from any one of the remaining channels will give you a trip. But at the moment, we are talking MHI.

You probably need to clean up the wording in the SER but we will --

MR. SCHMIDT: This is Jeff Schmidt from the NRC. Yes, we will clean up the wording in the SE.

CHAIR STETKAR: Now regardless of whether that was October or July because I have lost complete track of time, that was the only one that I had. And I think the remaining items that we communicated with you last week or the week before, I don't remember when the emails were flying around, all have to do with the table of thermal hydraulic questions. There are five or six or eight, depending on how you count them or split them.

MEMBER REMPE: There is one that Sam had about the fuel.

CHAIR STETKAR: But that is postponed, I think, until -- unless you have something. You have something on the PCI?

MR. SPRENGEL: We would like to discuss it.

CHAIR STETKAR: Oh okay, good. The last note I saw was you wouldn't necessarily be ready to do

that. So if you are, that is good.

MR. SPRENGEL: We do not have results or analysis to present but we do want to discuss this.

CHAIR STETKAR: Okay, good. Let's do that.

MR. SPRENGEL: I think we can stay on our previous topic and we will save PCI to the end.

MEMBER REMPE: Okay.

CHAIR STETKAR: Okay.

MEMBER REMPE: So in October there was a question which we don't need to discuss but it was about the nodalization in MARVEL. And you guys went through and did sensitivity studies. And they did a very nice response back. And that is why we don't need to discuss it. But there was this other table of questions that we provided to you.

CHAIR STETKAR: Now, before you do that, let's hand out the table. I want to make sure everybody has it --

MEMBER REMPE: Can we go through the first one first?

CHAIR STETKAR: No, because I want to have the table -- you wrote it up.

MEMBER REMPE: Okay.

CHAIR STETKAR: Everybody put it together. I'm not --

MEMBER REMPE: Okay.

MEMBER ARMIJO: Do we have copies of that?

CHAIR STETKAR: Yes we do. If we can distribute that Girija.

It is just a lot easier for people to read the words and take notes. That is the reason I want to make sure that we have it.

MEMBER REMPE: I agree that it is going to be eventually needed.

CHAIR STETKAR: And as long as we are going to discuss all of them, we will discuss it.

I think pretty much anybody except Joy, Girija and I need a copy of the table.

MR. HAMZEHEE: Hi, this is Hossein Hamzehee again from NRC. John, does the staff have a copy of this table? Did you ever communicate this to the Staff?

CHAIR STETKAR: No, not at the moment. Right at the moment, this is another thing that we are talking to the Applicant about.

MEMBER REMPE: The first table didn't -- this is a table that --

MR. SPRENGEL: The Staff are aware of the

topics.

MEMBER REMPE: The topics, the questions, did they not get a copy? I don't know but there were like some questions we documented from the meeting. Did the Staff have a copy of that? Then MHI came back with some --

CHAIR STETKAR: That I don't know. The first iteration you may have received.

MEMBER REMPE: Girija, did they not -- the staff -- the history of this is there was a meeting and there were a lot of questions raised and we were asked to come up with documented questions. And did the Staff see those documented questions?

MR. SHUKLA: The Staff was given a hard copy.

MEMBER REMPE: Of the table. So you have seen the original ones.

MR. SCHMIDT: Yes, we have seen the table.

MEMBER REMPE: Okay and then we got an email in the last couple of months that were like for draft responses, which I have included in this revised table. And then we went through those draft responses. And if we go through the first one, for example, the question was on refluxing. And we would ask about during what

phases of the small-break LOCA does the reflux condensation occur? What are the rates for steam and counter-current flow rates? We would like a ratio of the hot leg and steam generator flow areas to the core power and compare with the conventional four-loop plant and clarify the logic for selecting the hot leg sizing. And then the response was that MHI believed that the requested information had already been provided in RAI questions 15.0605 and RAI CA1.

And so we went back and looked at those documents and we couldn't find the response to our questions to put it briefly. I mean we guessed what pages of those documents you were referencing and maybe we guessed wrong but we thought we had it right. But we didn't see a clear, concise response to our questions. Are we missing something on that one?

MR. SPRENGEL: I missed the question.

MEMBER REMPE: You can see our ACRS response. We didn't see a response to our question Did you have a particular place in those documents you wanted to point out to us that responded to our question?

MR. MARUYAMA: This is Yuta Maruyama from MNES. I saw the ACRS response here. We do not have special LOCA engineer from MHI today. So I would like

to bring those answers back to MHI then talk to MHI.

Then we will get you back what is our intention or we modify our response to your question.

MEMBER REMPE: Okay because it is my understanding you never really issued your response. It was just a draft.

CHAIR STETKAR: No, no. It is my understanding that you were targeting roughly the end of January for a submittal that addresses these things. The reason I wanted to get them out at the table at this meeting is we have the opportunity to at least discuss the items face to face and if there is any need for clarification or if it would have any effect on your plans, it is good to get those issues resolved here. It is a lot more efficient than trying to do a round robin by emails or sending tables back and forth.

MR. SPRENGEL: I agree.

CHAIR STETKAR: So that is the whole idea of having of this discussion.

MR. SPRENGEL: Okay.

CHAIR STETKAR: And I recognize you don't necessarily have the right people here today to answer these things.

MR. SPRENGEL: Yes, that's okay. And the

other key piece of feedback which we are also going to incorporate in to the VIPRE table will be to pull more information into this with a reference for more detail.

MEMBER REMPE: That is, I think, the point of the discussion today.

MR. SPRENGEL: But give you once place to just look at the information.

CHAIR STETKAR: That helps an awful lot. I mean, we get -- I hate to keep whining. But we get so much information that we need to plow through, thousands and thousands of pages a month, literally, that it is really difficult for us to organize our time and wade through large documents.

MEMBER REMPE: But in this particular case, I didn't see numeric answers.

MR. SPRENGEL: Okay.

MEMBER REMPE: I saw more hand-waving discussions or whatever and we really do want to see the answers to the questions. Okay?

MR. SPRENGEL: Okay.

MEMBER REMPE: And I think actually, I mean we can go through the rest of these but that is basically the bottom line. There were some where you did address things but a lot of places there needs to be more detailed

responses back to the questions raised.

CHAIR STETKAR: Does it make sense, Joy, to actually just go through them? I mean, this is the first chance MHI has had to see --

MR. SPRENGEL: No, it's okay. But looking through it, some of this is additional analyses and you are just basically recognizing that that is --

MEMBER REMPE: And that can come later in your response back. I think one of the reasons we have put this in this table today and we have brought this back to John ahead of time was to hopefully not have another round of this back and forth to request that you do provide more information on the cases that you are or wait and say we are going to get that analysis later.

CHAIR STETKAR: And I think the other from your perspective, I know you are trying to read through this in real time but at least from my perspective, this table now represents both necessary and sufficient answers, which kind of gives you a target for closure. At least it is a subcommittee -- full committee can raise issues later but at least as far as issues that have been raised in the subcommittee, this should help to draw us to closure.

MR. SPRENGEL: That is good to hear. If we could look at number four, specifically it looks like, maybe it is a wording clarification of the request to see additional analyses but we are not performing additional analysis. There is additional explanation but I don't know if it is just the terminology.

MEMBER REMPE: I think that is a wording -- that is a wording thing.

MR. SPRENGEL: Okay.

MEMBER REMPE: I'm sorry for that. But you are right, it is just the additional explanation which could be an assessment or an analysis but yes. Okay?

MR. SPRENGEL: Okay.

MEMBER REMPE: But we would like --

CHAIR STETKAR: You start thinking running codes, don't you?

MEMBER REMPE: Yes, you don't need to run a code but you will have to give us the detailed explanation.

MR. SPRENGEL: Okay. Okay and then number five, the date for the subcommittee meeting for the accumulator has not been defined.

CHAIR STETKAR: Right.

MR. SPRENGEL: So that -- I won't say

anything more but so I guess that though will be taken off in terms of the LOCA connection and discussion. Is that what I am getting?

CHAIR STETKAR: Yes, I think that is fair to -- we will try to pull that together whenever the subcommittee meeting on the accumulator. So just push that one.

MR. SPRENGEL: Okay.

CHAIR STETKAR: Just make sure you address it whenever we have that meeting.

MR. SPRENGEL: Okay and then number six is tied to the discussion we need to have today.

Seven is the same wording, explanation versus analysis.

CHAIR STETKAR: Right.

MR. SPRENGEL: And it looks like number eight is similar to one where we will need to pull together some information to present it better, as well as include some of the feedback there. Okay.

Okay, I don't think we need to have any more discussion now on this. This was helpful.

CHAIR STETKAR: Is that pretty clear?

MR. SPRENGEL: Yes.

CHAIR STETKAR: Okay.

MR. SPRENGEL: I do not want to necessarily maintain our end of the month commitment. But if there is a change, we will let you know.

CHAIR STETKAR: You know, Ryan, I still come back to where we are in the whole review process. These are issues that we are raising to send out a flag to MHI that there are issues that we need to have resolved, at least to our satisfaction by the time the final safety evaluation is issued with the certified design. The sooner we get them resolved, the better for everybody. You know, we are where we are in terms of the design certification process.

MR. SPRENGEL: Okay.

CHAIR STETKAR: There is nothing magic about an end of January date.

MR. SPRENGEL: Agreed but I just want to be clear.

CHAIR STETKAR: I think, you know, in both of our interests, the sooner the better is fine. But that is your, obviously your call.

MR. SPRENGEL: Yes and if we need to split it up or something, we will do that. We will communicate any change from end of January.

CHAIR STETKAR: Okay, Hossein.

MR. HAMZEHEE: Hossein Hamzehee from NRC again. I just want to make sure just for clarification and also for admin control, in the future I would like to make sure that any of these questions are worked through by the Staff so that if there are any impact on the Staff's conclusions, SER, they are adequately reflected and reviewed. So in the future, please make sure that we are kept in the loop. Because none of these things are on the docket yet. And if something comes out, the Staff has to be ready to respond and take the appropriate action.

CHAIR STETKAR: Okay, thank you. Point taken.

MR. HAMZEHEE: Yes, thank you.

MR. SPRENGEL: PCI.

CHAIR STETKAR: PCI. Dr. Armijo.

MEMBER ARMIJO: I have asked my questions several times as clearly as I can.

MR. SHUKLA: Let me ask one question. How are you going to respond to us, through the Staff or through us?

MR. SPRENGEL: The same way we have done with all of our other responses. We send a letter to the staff.

MEMBER ARMIJO: Okay, that's fine.

MEMBER REMPE: The letter from Rebecca came to the Staff with the preliminary response, so the Staff has seen that part. It was just this table.

CHAIR STETKAR: The problem is this table has undergone numerous iterations over the last 30 to 45 days and it has been hard enough for the two people iterating on it to keep it straight.

MEMBER REMPE: And actually I guess I thought it was, if you had come back and said well you missed this on the first item, that there was that type of information, that is why I thought --

CHAIR STETKAR: That was one the reasons why I wanted to bring it up in the meeting with it in front of us. Because if there had been some miscommunication or misinterpretation, it was good to get it out.

MR. SPRENGEL: Okay.

CHAIR STETKAR: PCI.

MR. SPRENGEL: Okay, we are at a little bit of a loss for the requested PCI evaluation. I guess we went looking. We went back and looked at Mitsubishi's experience with it. And I guess we have had 19,000 assemblies and 500 cores and we have never

had any issue with PCI.

We understand there is a request for evaluation but it is difficult because --

MEMBER ARMIJO: You know, in the case of normal operation, and I am not disagreeing with you, in normal operation you have the benefit of a 2,000 psi external pressure. PWR is notorious -- not notoriously -- fortunately don't have the same PCI vulnerability as BWRs. Okay? But it does, it has happened in PWR fuel. Most recently in several BWRs, your competitor's fuel is related to defective pellets. And it is well known in the industry, that is in the last several years. So PCI can occur in PWR fuel but it is rare.

In the transients, anticipated operational occurrences, you are going to much higher powers than you normally would operate. And in those events, you can be susceptible to PCI fuel failures and you do not address them in your fuel design methodology. You make some statements that there is no specific PCI design criterion and don't have to worry about it because we meet the cladding strain criteria and the fuel melting temperature criteria and neither of those will protect you from PCI because PCI occurs at much lower strains than the one percent and that is demonstrated in a number

of Studsvik power ramp test programs.

So what I am looking for is just a set of charts that says these are all the AOOs that our US-APWR is susceptible to. This set, the transient is so fast that it is over before anything can happen. The power may go up and down in a few microseconds or seconds and so that is not a concern. But there is some where the power goes up a considerable amount and I am talking nodal power, peak nodal power. I am not talking averages or anything else. The power goes up a substantial amount and it holds for a period of time. And that can be as short as a few minutes and you are in a range for experimental work has demonstrated that you can have PCI fuel failures. And depending on the number of fuel assemblies and fuel rods that are exposed to that transient, you could see a lot of fuel.

Now it may be that you have really good answers to these things but you can't do it just by making a statement. You have got to show these are the AOOs. This is the power that we start out with. This is the power we end up with. So that is the delta power. The duration of the transient is so many seconds or minutes, at which time it is either terminated by automatic systems or terminated by operator action or something.

And so there will be a certain class of events that you may be susceptible to PCI.

It may be you have a good answer to all of these things. Maybe you are not susceptible to anything but you haven't provided anything in your documentation to demonstrate that.

MR. SPRENGEL: All right, there is no regulatory basis, though, for us to follow. I mean we don't have any guidance to do this analysis. And I understand in general terms what the request is but when we get to specifics I don't know how to define what is analyzed.

MEMBER ARMIJO: You can't make it any clearer. You know if you are saying that as long as I am below one percent cladding strain I am okay, I don't have to do anything, I don't find that an acceptable answer.

Your job is to design the fuel so it addresses all fuel failure mechanisms, not just the ones that are cited in the regulations.

So you know, I just think you are ducking the issue and I don't see why. You have got the analytical tools to tell you what the strains will be. For example, we said calculate what the localized

stresses and strains are on the cladding ID'd during these transients. And I am not talking about every transient because there is a whole class of them that are so fast and they are over before anything can happen. I am talking about the ones that there is a significant time at which you are at high power during the transient.

MR. SPRENGEL: Is there other guidance that other vendors have followed to do this analysis?

MEMBER ARMIJO: I know of one vendor who has a very specific good answer because they have tested their fuel to powers much, much higher than normal operation and demonstrated their fuel is resistant. Now that is a different cladding design than you have. It was designed to be resistant to PCI even under operational transients.

Now that was a BWR. BWR's are more susceptible. But you are going under the assumption, Ryan, that the PWR fuel is not susceptible to this problem and I disagree with that.

MR. SPRENGEL: Based on our vast experience, we are confident that we are not susceptible. But we have found it tough to comply with the request because we do not have a complete document telling us what analysis to do and how to define our

starting points and what to compare it to. There is not enough there for us to go on.

So, I am looking if there is any guidance that other vendors have followed and maybe that the Staff has approved.

MEMBER ARMIJO: Well I am not sure if the Staff can provide other vendors' approaches. I don't know if that is appropriate or not.

MR. SCHMIDT: This is Jeff Schmidt. I am sorry to interrupt but we are having the same problems, in some senses. For PWR fuel, the Staff is having problems defining what a success criteria or acceptable criteria are.

I understand that there is information for BWRs but obviously, BWRs seem to be having more of a problem than PWRs. And I am not aware of a PWR vendor who has established any criteria for PCI.

MEMBER ARMIJO: Well you know, let me give you a good example. Let's say you had a particular transient that went from a normal operating power, let's pick a number, six kilowatts a foot up to 12 kilowatts a foot in this transient in a very short time frame and the transient lasted for -- pick a number -- five minutes before it was terminated either by operator action or

some device.

Well the specific test results are very clear. During that time, fuel cladding will fail and it is based on strain. And the strains at which these failures occur are small, much, much smaller than one percent to the order of a tenth of a percent. And so that would be a criteria.

If you calculate your strains are trivial, then you would say hey, I don't have this problem because I don't -- you should be able to calculate localized strain during these transients. That is available with your codes. You should be able to calculate that routinely. It is the same code that calculates the one percent cladding stream. It only takes a chemical effect into account, rather than just a pure mechanical.

MR. SCHMIDT: Right, but we don't -- we can calculate the local strains but we don't know for PWR fuel what the value we should be comparing to. That is kind of the crux is we can do the comparison that you are requesting but I don't know if there is a way that I am aware of to say you know, yes or now we are susceptible to PCI based on that Studsvik data.

And the other problem with the Studsvik data is, a lot of that data is proprietary.

MEMBER ARMIJO: No, it isn't. It is published. Yes, I have got to correct you on that.

MR. SCHMIDT: Okay.

MEMBER ARMIJO: That is all open literature and published. There may be some proprietary data that some vendors have squirreled away but this is all well-known data.

MR. SCHMIDT: And it is relevant to PWR?

MEMBER ARMIJO: Sure. It is just -- PCI is a stress corrosion cracking problem. You get a certain amount of strain. You got the chemical environment of fission products cladding on the cladding ID. You get that strain occurs. It is localized and you can form a crack. It doesn't care whether it is a Zircaloy-2 or Zircaloy-4. Stress relief, re-crystalize, all of this has been addressed in the past.

And so normal operation isn't a predictor that you are protected in a transient. It is much higher power than you normally operate. The question is --

MEMBER SHACK: But Sam, how about the argument with so many thousands of hours of operation, I mean these plants have seen transients.

MEMBER ARMIJO: Well if they have, that is

part of the answer.

MEMBER SHACK: But I mean statistically you sort of know that you have years and years of operating experience without this happening and yet --

MEMBER ARMIJO: You know if somebody can say look, here is the only transient that lasts more than a few seconds. Okay, we had it last year or in previous years several times and nothing happened. That is a good answer. I wouldn't be too upset about that. But I don't think you have the operation.

You know, these anticipated occurrences don't always happen. But if they do, how have you analyzed it against this fuel failure mechanism? And there is no analysis here. There is just a bald statement that says hey, we meet the one percent criteria, the melting temperature, and therefore, they are okay.

MEMBER SHACK: Well you know, everybody knows that one percent isn't aiming at the mechanism you are talking about. It is looking at a different mechanism.

MEMBER ARMIJO: Right. And what I am trying to get across to the MHI and to the Staff is that you have a much more aggressive mechanism operating at

lower strains.

So you know, that is where I am at. Maybe the rest of the committee isn't in sync but I have asked a very specific request for an analysis.

MR. SPRENGEL: And I guess I want to make clear that we are prepared to do analysis but without the analysis being clearly defined and an acceptability criteria, we don't feel comfortable moving forward on that.

MR. HAMZEHEE: John?

CHAIR STETKAR: Yes.

MR. HAMZEHEE: Hossein Hamzehee from NRC. At least for my educational purpose, is this something you need for new reactors or is this something that is for all of the reactors as well?

MEMBER ARMIJO: It is generic. It is not a new reactor thing but in the case of a new reactor, you have -- you know, this is a very conservatively designed core. I want to make that clear. I am not saying you are on the edge.

You may have probably the best way to answer this than anybody the way you have designed this core but it hasn't been addressed. It hasn't been addressed in any way. It has just been ignored. And you say

Mitsubishi does not apply a PCI-specific design criteria. PCI is addressed by two criteria, cladding remaining below one percent strain, and fuel centerline melting will not occur. I mean, that is just inadequate.

It may be adequate for the Staff but I believe it is inadequate.

MR. HAMZEHEE: Okay, I have some follow-up questions. I think because you want to make sure that if there are some areas that we need to spend some time and maybe include it in our regulatory requirements, we do so. As of now, I don't believe this issue has been included in --

MEMBER ARMIJO: It is not in your regulatory requirements.

MR. HAMZEHEE: -- or any of our reg guides.

MEMBER ARMIJO: It is not in your regulatory requirements.

MR. HAMZEHEE: So I don't blame MHI if they don't have adequate guidance as to what to do and how to document it. So I would like to go back and talk about this among our technical staff and see if there is some follow-up that the Staff should act on.

CHAIR STETKAR: In the sense, Hossein, of

it is a generic concern, so in some sense it is not necessarily strictly related to this particular design certification. However, I can cast it in a question related to this design as is there anything in this design, the AOO transient response of this design or anything in the design of the fuel itself that would indicate a different vulnerability.

MR. HAMZEHEE: I see.

CHAIR STETKAR: You know, so you could ask the question that way and remove the genericism from it --

MR. HAMZEHEE: Yes.

CHAIR STETKAR: -- and still say well, can MHI go through their list of AOOs and see if there are any, based on their plant design, their automatic trip set points, their assumed manual actions and so forth, is there any part of this particular design, coupled with their specific fuel design that would leave them more vulnerable to this issue than let's say a generic plant.

MR. HAMZEHEE: I see.

CHAIR STETKAR: And I don't want to speculate. There may not be but I think one of the things that Sam is asking for is is that type of information.

For example, if the core could remain at, pick an absurd, 150 percent power for 30 minutes because of some specific element of this particular plant design, I think we would have a real problem. You know, and that has to do with the specific response to AOOs on this design.

MEMBER ARMIJO: I think John brought up a key point. You know, in the case of the BWRs, people always thought that this PCI problem would not exist during transients because they would be over so quickly and stress corrosion is a time-dependent failure mechanism, until they did the experiments. And they did power ramp tests that lasted from 30 seconds to three minutes. And almost all of the fuel rods that were tested that way had PCI cracks either all the way through or partially through. And that is documented. We can provide information on that.

So the problem is, this is a much more aggressive failure mechanism and we don't even talk about it. We don't even say hey look, these are the only transients that have a certain duration that have a sufficient, a significant increase in power above our normal operating power but we have had them before and nothing has happened. That would be a good answer.

But if it has never happened, how can you say you are safe? That is really my point.

MEMBER BLEY: Did the guys who did those experiments map those ramps they did on any AOOs or these really severe accident conditions?

MEMBER ARMIJO: No, they were in the range of AOOs. And I know one vendor in fact does actually analyze it.

MEMBER BLEY: They once actually had these happen.

MEMBER ARMIJO: No, they didn't. They didn't have them happen but that was a concern. In fact it was an early concern by the NRC that these transients would cause large numbers of fuel failures.

And so in the BWRs, people will find a liner, a zirconium liner cladding. And that gives you lots of margin. And that is how some people just address it. And so yes, they are in good shape.

In the PWRs, you know, they don't have a design fix in their cladding. And if they ever have one of these transients and it meets these characteristics, they could have a lot of fuel failures. And so what I am looking for is an analysis that says hey, this is how -- we understand PCI is a failure

mechanism. This is what we calculate. It is a strain that is possible during our worse transient of significant duration and it is trivial. It is far less than 0.1 percent, or it will never last more than 30 seconds because our automatic systems will terminate the event, or whatever other reasons you have. But you have got to write it down. What is your basis for coming to that conclusion.

MR. SPRENGEL: Right. And again, I don't have a problem with the evaluation if we found a way to scope it and define the criteria. But I do have a problem with proceeding with this additional analysis without that in place and also being ahead of the Staff and the industry.

So I don't want to make that move in this manner.

MEMBER ARMIJO: Well that is up to you guys.

MR. HAMZEHEE: Hossein Hamzehee again from NRC. I have one question and one suggestion.

My question is: To your knowledge has of the PWRs have done any evaluation that is even close to what you have in mind?

MEMBER ARMIJO: Not to my knowledge, no.

MR. HAMZEHEE: Okay. And my suggestion is

if you want to get something close, one way to address it, as John mentioned, is be a little more specific such as for instance how long do you believe or do you expect your transients to last and get some kind of timeline for those and then maybe that would then lead to the question that if none of them last longer than 30 seconds or a minute, then it is a moot point.

MEMBER ARMIJO: That is a good approach, Hossein. For example, we wrote a little memo to the -- I guess it was addressed to the Staff.

CHAIR STETKAR: Ruth had it.

MEMBER ARMIJO: Yes, it says the ACRS was expecting -- this was maybe the point -- a set of charts that showed what transients produced the greatest PCI challenge. And by that, I meant what is the maximum nodal power in kilowatts per foot that you achieved. What is the maximum nodal power delta, delta kilowatts per foot during the transient and the duration at which you are at maximum power? That is just data, no criteria.

And if you go through your list of all your transients and say there is nothing here, guys, there is no transient that last more than 30 seconds, I don't care.

MR. HAMZEHEE: That you don't worry about.

MEMBER ARMIJO: Yes, it is all over. There is no energy. You could start there.

But if you wind up that you say hey look, I have got this transient that took me from a peak nodal power level of six kilowatts a foot up to 14 kilowatts a foot, and the duration was several minutes --

MR. HAMZEHEE: Half an hour or so.

MEMBER ARMIJO: No, Hossein, we are talking three, four minutes, and it goes right through the cladding. Okay, then you have got a potential problem.

MR. HAMZEHEE: Then make it an issue for all the reactors.

MEMBER ARMIJO: Like I said, it is generic. Unless this was a unique machine. I don't think it is.

CHAIR STETKAR: Well, when I say unique machine, this is a machine. They have set points on trips. They have a set of -- they have an energy input called a core. They have a set of inputs on trips. They have a list of AOOs. And they have a fuel design. And all of those things are in some sense generic but the actual set points and the actual behavior of this particular machine is a little bit different than

somebody else's.

MEMBER ARMIJO: Yes, could be.

CHAIR STETKAR: Could be, yes. Now whether it is different enough to raise a concern, we don't know. I honestly don't expect that it would be much different but we don't know.

MR. SPRENGEL: All right.

CHAIR STETKAR: And to bring it back to you know an MHI design-specific type question, I think that is the area where we have to focus.

MEMBER ARMIJO: To get at Ryan's concern and I do appreciate his concern, I don't want to calculate something that could get me in trouble when I don't know what trouble is but you certainly can put a table together of all your AOOs and what the power increases are, what the duration is and see if you can just cut it off at that point and say our system terminates all these things before anything can happen.

MR. SPRENGEL: Okay.

DR. NAGAI: My name is Masatoshi Nagai with MNES licensing. I guess I understand the concern but however you rephrase the question, we would need established threshold against which we can compare any parameter against to determine that our US-APWR PW core

is vulnerable to PCI. Without a threshold, I don't think we can determine, we can come to any conclusion. That is my guess.

So I was wondering if you could provide me any insight on how to determine the data.

MEMBER ARMIJO: Well I think the first request would be more like a scoping kind of thing that says, we have 15 transients that we analyzed or 20, whatever the number is. And of those, all but these two or three are over in seconds, terminated for whatever reason, natural phenomena or automatic systems terminate it in a few seconds.

DR. NAGAI: Okay.

MEMBER ARMIJO: But these two require operator action and may not be terminated for five minutes, ten minutes. At that point, I would say that is an area where you want to really look at analysis and look at what the strains or what the powers are.

DR. NAGAI: Okay.

MEMBER ARMIJO: And then yes, you could have a real problem.

DR. NAGAI: Okay.

MEMBER ARMIJO: This is not a hypothetical thing. And the data on the criterion would be in the

order of a strain lasting for several minutes.

DR. NAGAI: I am not an expert in fuel integrity type of things but I guess it depends on the local conditions you are looking at. So it may be possible that even though you get only three seconds at high power, you may be vulnerable to PCI, depending on the threshold you are looking at. I'm not sure.

MEMBER ARMIJO: You are right.

DR. NAGAI: That is why --

MEMBER ARMIJO: But you know your peak powers aren't going to go to 50 kilowatts a foot. They are going to be down in the 14, 15, something like that. I have looked at your documents.

DR. NAGAI: Okay.

MEMBER ARMIJO: So that is not too far from the range before there is test data from Studsvik.

DR. NAGAI: Okay. That is why what Ryan was saying was that we need fresh, clear guidance to establish threshold so that we can analyze our AOOs.

And I guess at least my personal opinion is that we would like to address, if we have to, we would like to address this issue through appropriate regulatory process. That is my personal opinion, if anybody else wants to add something.

MEMBER ARMIJO: Well we have written a white paper and the ACRS issued a white paper a few years ago on this general topic focused on BWRs. We could provide that to -- the Staff, of course has access.

MEMBER SHACK: Sam, would you be happy just to see a history of power for each of the AOOs --

MEMBER ARMIJO: Yes.

MEMBER SHACK: -- and then you could make the judgment as to whether you thought there was a problem and discuss it further from there?

MEMBER ARMIJO: Sure, --

MEMBER SHACK: But if the powers are low and the times were short.

MEMBER ARMIJO: Exactly. I think it may be that this system has got built-in margin through the fact that the transients don't last very long and they aren't very big. I just don't know enough about it. So I was just looking for an analysis with either historical data or design data.

MEMBER SHACK: Because what always concerns me is you can do this for a sort of stylized set of accidents, you know, a transient that lasts for minutes with so much power, is there some way to dream

up a transient --

MEMBER ARMIJO: No, no, no. I don't want to make a hypothetical.

MEMBER SHACK: But if you only want to look at the stylized AOOs that they go through anyway, then that is a doable thing.

MEMBER ARMIJO: I am only looking for the ones that they actually go through right now. I am not trying to invent a new AOO.

CHAIR STETKAR: I think that is all that we, in practice, could ask.

MEMBER ARMIJO: Well, we can ask.

CHAIR STETKAR: We can ask for everything, sure. You have done it before.

MEMBER ARMIJO: But I am not asking for that.

MEMBER SHACK: I don't think we are going to do that now.

CHAIR STETKAR: That is what you are asking for then, is for the AAOs that they already analyzed, --

MEMBER ARMIJO: Exactly.

CHAIR STETKAR: -- what does the power history look like?

MEMBER ARMIJO: Yes, power, history including the time.

MEMBER SHACK: Well history sort of does include time.

MEMBER ARMIJO: Yes, you are right. History includes time. So you know, but that tells you whether you are not even close to this failure mechanism or whether yes, you are kind of in the ballpark and then it is up to you to decide whether you feel comfortable with that or not, whether there is a staff guidance. You know, you are the designers. You are responsible for the safety of the plant and the reliability of the fuel. Whether or not the staff has told you what the failure criterion to use.

MEMBER REMPE: So you are going to have, if they do this, are you going to rely on specific data for some other fuel or you want them to come up and show that they have done transient testing on their own fuel or are you just going to use a wag and say, it is thumbs up or thumbs down? Or is that going to be our decision?

MEMBER ARMIJO: They are the designers of this plant. They are responsible for the safety. They are responsible for fuel failures or lack of fuel failures. They are responsible for addressing all fuel

failure mechanisms. And that is independent of whether the staff tells them to do it or not. I did that as a fuel designer when I was designing fuel. Okay?

And so you know, it is -- to their point, even when there is no clear guidance, you still have the responsibility to address an unknown failure mechanism. And if you can prove that this failure mechanism doesn't apply to you because the characteristics of the mechanism, what are the characteristics of your plant, then it is over. You have done it. But you have got to write it down. You have got to address it.

MR. SPRENGEL: But there is still no criteria to evaluate against. So I guess I am hesitant to start when I don't know -- there is no end.

MEMBER ARMIJO: Well you know, if you wanted a duration of which you quit worrying, it is less than a minute.

MR. SPRENGEL: But I know that we have AOOs that last more than a minute.

MEMBER ARMIJO: Then you are in trouble.

MR. SPRENGEL: But we have no evidence of this as an issue.

MEMBER ARMIJO: But if you had those AOOs

in PWR fuel in your plants that lasted for several minutes and went to these kinds of powers, that is data. Then you can cite that and say look, despite what you say, these things have happened and we have never failed a fuel. That is perfectly satisfactory. In fact, probably the best data.

So but if you have never had the event and you are claiming --

CHAIR STETKAR: You know the problem of saying you have thousands of operating hours is an AOO is something that is expected to happen once in the life of a plant. You don't have thousands of operating years.

MR. SCHMIDT: This is Jeff Schmidt from the NRC. My understanding was that BWRs see this in normal operation. So by extension, they are probably more susceptible in AOOs. Right?

MEMBER ARMIJO: The BWRs are more susceptible because they operate with an external pressure of 1,000 PSI and the PWR has a 2,000 PSI external pressure. So the stress during any power transient is mitigated by that extra pressure.

But again, it depends on how high you go in power before you get into enough tensile stress on

the idea of the cladding for a period of time in which the fission products can initiate a crack when you wouldn't expect it.

If this happened -- if a severe AOO has happened in their plant lasting for much more than your one minute, two minute, three minutes, and nothing happened, that is very important information. That is what I -- I would just cite that and say here was the event. This is what happened and the fuel performed beautifully. You can't do better than that.

MR. SCHMIDT: I want to make sure I understand that BWRs have seen this in normal operation, though. Is that a correct statement?

MEMBER ARMIJO: They have seen -- the BWRs have had some AOOs but not to very high powers. But they know from normal operation that they are very susceptible to PCI. And so what they have instituted to just about everyone around the world to put in the liner cladding, which gives them a lot of margin in the material. PWRs haven't had them, except for Susquehanna, which they are on their own.

But the PWRs haven't had to do it because in normal operation, they have external pressure. They have always had fine motion drives. They have chemical

shim to change power. They have had a lot of advantages that the BWR didn't have.

So the BWR is clearly more susceptible but the PWR isn't immune and it should just be addressed. That is all I am saying.

MR. SCHMIDT: You know, I think again --

MEMBER ARMIJO: Even a narrative discussion, other than just saying hey we are not susceptible.

MR. SCHMIDT: No, I think the issue is the same almost for the Staff as it is for MHI is that I can postulate an AOO that can sit right below a trip set point and sit there indefinitely until somebody realizes they are at 108 percent power instead of 100 percent power and then an operator action would have to occur.

You know, if you are telling me that I only have a minute, that is an AOO I can construct fairly easily.

MEMBER ARMIJO: Well I don't know if you have seen our white paper that we have put out.

MR. SCHMIDT: No, I haven't.

MEMBER ARMIJO: You know, Girija, why don't you send that to the Staff? And if the MHI people want

to see that, it is in ADAMS. Because the data is two independent studies on BWR fuel tested with the very short transient test going to not particularly high powers either.

MR. SCHMIDT: Well I mean, give me some sense. In a PWR in this case you are probably going to go to the high flux set point of 109 percent power. So the core power has gone up 109 percent. Now, if you are worried about say if this is an issue for higher burnup fuel or mid-burnup fuel -- let's call it mid-burnup.

MEMBER ARMIJO: It is mid-burnup. After high burnup, things start tapering down.

MR. SCHMIDT: Right. Right, so let's go to a mid-power. So for a nine percent increase, your mid-power pins will probably go up to maybe 12 percent because they won't have the Doppler feedback to keep them up. So they will go up a higher percentage than the core average power will go up. So let's say if my estimates are correct, you take a mid-power pin that is sitting probably at a core average power of around one, so you are at 4.65 kilowatts per foot and you go up 12 percent --

MEMBER ARMIJO: What is a peak nodal power

at that point?

MR. SCHMIDT: Right, well that is what I am trying to estimate.

CHAIR STETKAR: That is where he is getting to.

MR. SCHMIDT: That is where I am going. You take the average kilowatts per foot times your FQ value, that is your nodal power. Right? So I am going up 12 percent in total core power or that pin really is going up 12 percent, and then times the same FQ I would normally take, which is 2.6 and calculate that.

Then I would compare it to this experimental data that you are referring to. But how long can I -- is there data that tells me how long I can sit there and be okay?

MEMBER ARMIJO: The only data I know is that test data from Studsvik.

MR. SCHMIDT: And that gives duration as well as distance?

MEMBER ARMIJO: Yes, they timed it. These are tests done for an international program run by Studsvik and they used fuel cladding from, I think it was AREVA but it might have been German cladding Kraftwerk Union. And they timed the time in-between.

They did very short transients just to address this issue of susceptibility to PCI during AOOs.

And they would terminate the test. Sometimes they could actually detect leakage. But the other times they would actually have to go into hot cells and they found that it was cracked three-quarters of the way through the cladding. And these were durations of very short time of 30 seconds to a few minutes.

In the BWR, then GE did a number of experiments and I was heavily involved in that. And we had got the same data with GE cladding, which is a different heat treatment and everything else. It was very consistent, a very short time.

And so if for example if the PWR peak powers never got above eight kilowatts a foot, even under the AOO transients and the pak nodes, they might be sitting pretty because those, you know, you need an absolute, you need to get to high power.

MR. SCHMIDT: Yes, I mean, it is going to probably be, you know if you take the 2.6 for FQ times your 4 point whatever it is, five, six times -- which is their average kilowatts per foot times.

MEMBER ARMIJO: I don't know what their peak factors are. It is all peak.

MR. SCHMIDT: Yes. I mean your FQ limit in this plant is 2.6. So that is the maximum value you would pick. That is what is allowed by tech specs.

MEMBER ARMIJO: Okay, so you go 2.6 times your core average power --

MR. SCHMIDT: Right, times your core average to get your node.

MEMBER ARMIJO: -- that would be your peak node and then you multiply that by 12 percent.

MR. SCHMIDT: Right and then you multiply that by 12 percent.

MEMBER ARMIJO: Yes.

MR. SCHMIDT: You are probably sitting around probably around 10 to 11 kilowatts per foot.

MEMBER ARMIJO: Well I have seen data in some of the Mitsubishi documents that shows data points for fitting around what I think is about 13 kilowatts a foot.

MR. SCHMIDT: That might be the hot -- the lower burnup assembly.

MEMBER ARMIJO: No, I am talking mid-burnup.

MR. SCHMIDT: Oh, mid-burnup. Okay. I mean that is probably not too far off. I was estimating

maybe around 11.

MEMBER ARMIJO: So if you are already at 12, you are in the PCI regime. Okay and you go up another ten percent, you are in the PCI regime.

Now you have the benefit of that external pressure. As long as you have got that, you might be okay. But again, it is -- that is where you are vulnerable.

MR. SCHMIDT: I think that 13 or 14 was under AOOs, wasn't it though? The data that you are looking at, aren't those AOO data already?

MEMBER ARMIJO: If they are, it may be. It may be. I don't remember.

MR. SCHMIDT: Because I had put together a table that was estimating the kilowatts per foot that you got up to in transients. And I was taking AOOs as -- but I will have to go back. I will have to actually go back and look at that. But that is where I would think you would end up under an AOO under this plant because you are starting with a really low kilowatts per foot. It is definitely below current PWRs.

MEMBER ARMIJO: Yes, I don't deny that. This is very conservative. You have got a lot of fuel. You have got a fuel rod length that you -- this problem

all is controlled by peak power.

MR. SCHMIDT: Right.

MEMBER ARMIJO: And you can have a really low average but if your peaking is really poor, peaking factor is high, you can get into it.

MR. SCHMIDT: There are a lot of plants out there like the 15 by 15 Westinghouse plants that run at a very high average kilowatts per foot that have a very, very similar FQ value. And I would hazard to guess also a very similar AOOs.

MEMBER ARMIJO: You know and then if the staff has information that they have gone through these kinds of transients and nothing has never happened, that puts it to bed. I haven't seen that.

And I have asked in the only way that I know how to ask is do this analysis approach.

MR. SCHMIDT: I mean the only thing I can say is prior to coming to this job, I was on the zero-by-2010 INPO team because of some issues at Palo Verde that I was at. And you know, we looked at all kinds of fuel failure mechanisms. You know the predominant one for PWR is this grid-to-rod fretting, as you are probably aware. You know, and then we have had some crud issues over the years as fuel failures.

We had some PCIM failures due to manufacturing defects.

But in this team work that I had done prior to coming to the NRC, we had never been able to identify a PCI fuel failure in actual plant operation. I think that is probably --

MEMBER ARMIJO: BWRs? That is --

MR. SCHMIDT: No, no. P, I was on the P group.

MEMBER ARMIJO: No, in PWRs have had PCI fuel failures. Not PCMI, PCI fuel failures. The most recent ones have been proven to be caused by chipped pellets being the cause.

MR. SCHMIDT: Right.

MEMBER ARMIJO: But before then there were fuel failures. Not as frequent as BWRs.

MR. SCHMIDT: What --

MEMBER ARMIJO: The whole thing here is it is an event that if it occurs, have you analyzed it and you have a good justification. Whether it is qualitated by virtue of experience or qualitated by virtue of claiming you have got it semi-quantitated by saying the power, the duration of the event will be over in a very short time, at least it has been addressed, not just a claim that hey, we are less than one percent strained.

That means we are okay. I just don't agree with that.

MR. SCHMIDT: Just to educate me, what time frame did you see the PCI failures in PWR fuel?

MEMBER ARMIJO: Most recent in the last eight years on not Mitsubishi fuel but two other PWR fuel vendors where the fuel was operated in the U.S. and there were a lot of assemblies affected.

MR. SCHMIDT: By PWR and PCI?

MEMBER ARMIJO: Yes, sir.

MR. SCHMIDT: Okay.

MR. SPRENGEL: At this time, I think Mitsubishi can take an action to look at the design aspects of it and confirm if there is anything different from other PWRs.

CHAIR STETKAR: I think that would be a good start.

MR. SPRENGEL: Beyond that, I guess we would ask for additional interaction with the Staff to define that --

CHAIR STETKAR: Yes, that sounds like a way to get us at least, hopefully a long ways towards -- in relation to this.

MR. SPRENGEL: And Girija, you will provide that paper or the reference?

MR. SHUKLA: Yes, the white paper.

MR. SPRENGEL: The white paper.

MEMBER ARMIJO: It is in ADAMS.

CHAIR STETKAR: We will find it.

MEMBER ARMIJO: And Zeyna can get it for you.

CHAIR STETKAR: We'll find it.

MR. HAMZEHEE: Girija, make sure we get a copy.

MEMBER ARMIJO: Yes.

MR. SPRENGEL: But to be clear, right as of now, we are not proceeding with additional analyses or evaluations outside of --

CHAIR STETKAR: Just the list of --

MR. HAMZEHEE: The RAI.

MR. SPRENGEL: No, I am talking about PCI specifically.

MEMBER ARMIJO: Are you not going to even list your AOOs and put a chart that says this AOO, this is the initial power, final power, duration?

MR. SPRENGEL: As Jeff mentioned, I am certain that we could create a situation with AOOs to get to an area you have mentioned but I don't know what to do with that.

So I don't --

MEMBER ARMIJO: Well let's hope you never experience it.

MR. SPRENGEL: I don't think I can create -- I don't see the need of creating a table when I already know what would be in it.

CHAIR STETKAR: Because you already know there will be at least one.

MR. SPRENGEL: Yes, you can create an AOO to lead you to a higher power for an extended time. You can create it.

MEMBER ARMIJO: Can the plant create it? That's all I care about. I don't care about me doing some hypothetical thing. But if it can happen in the plant, that is all I want to know. Is it reasonable to expect that to happen in the plant?

MEMBER BLEY: Once in a lifetime of the plant.

MEMBER ARMIJO: Once in a lifetime of the plant.

MEMBER BLEY: If it is a lot less likely than that, --

MEMBER ARMIJO: Then forget it.

MEMBER BLEY: -- then it doesn't really

belong as an AOO.

MEMBER ARMIJO: No, that's right.

MR. SPRENGEL: Then it gets into a risk assessment of sorts. And again, I get back to I don't know what the boundary of my evaluation is. And I don't know what actions we can take or not take. There is just so many unknowns that I --

MEMBER ARMIJO: That is why you are designers of nuclear power plants.

MR. SPRENGEL: But with our vast experience, --

MEMBER ARMIJO: I will submit you haven't got vast experience on AOOs and this phenomenon.

CHAIR STETKAR: I'm going to see if I can cut off the discussion because I think we all understand where we are.

MEMBER ARMIJO: We have beat this horse to death.

CHAIR STETKAR: One of -- and I hate to say these things but we are planning to have, I believe in April, a full committee meeting on US-APWR, one of these meetings where the full committee has a chance to weigh in on any interim items that we may have identified as sufficiently important enough to merit a full committee

letter. And the full committee weighs in an writes letters, not individuals.

So we have raised a concern here at at least the subcommittee level. Whether or not that gets raised to a higher level as far as part of the ACRS, kind of an interim letter on issues to be resolved during the licensing process remains to be seen. I certainly can't talk for the full committee, as none of us individually can.

And that is, I think, all we can do right at the moment as far as at the subcommittee level.

MEMBER ARMIJO: Sure.

CHAIR STETKAR: I suspect that, you know, we will need to be communicating over the next month or so to make sure that we understand what items, what chapters and topical reports that would be presented at the full committee at that April meeting and take it from there.

Any other members have any other questions or comments? If not, is there anything else from the Staff? MHI? Members of the public?

With that, I would like to again thank you all. I think it has been an interesting discussion, especially the last hour and a half or so. It is the

only way to get through a lot of these things. I know it is really, really frustrating to a lot of people but it is the only way to get them out on the table and work our way through it. We will get through it eventually.

And with that, thank you all and the meeting is adjourned.

(Whereupon, the foregoing meeting was adjourned at 2:53 p.m.)

Presentation to ACRS Subcommittee
MUAP-07009
Thermal Design Methodology
(Open Session)

January 15, 2013

Mitsubishi Heavy Industries, Ltd.

MHI Presenters

Lead Presenter:

Junichi Takeuchi

Senior Engineer (MHI)

Thermal-hydraulic Design

Technical Experts:

Takayuki Suemura

Engineering Manager (MHI)

Thermal-hydraulic Methodology and Software

Masaya Hoshi

Senior Technical Advisor (MNES)

Thermal-hydraulic Design

Overview of the Topical Report

- Comprehensive description of the thermal design methodology utilized by MHI
  - Based on approved code and methodology
    - ✓VIPRE-01 subchannel analysis code (EPRI-2522-CCM-A)
    - ✓WRB-1 and WRB-2 DNB correlations (WCAP-8762-P-A and WCAP10444-P-A)

      (Supplementary, W-3 utilized for low pressure events)
    - ✓RTDP: Revised Thermal Design Procedure (WCAP-11397-P-A)
  - Applicable to DNB analysis and transient fuel temperature analysis for MHI-designed PWR cores

VIPRE-01M

- MHI version of VIPRE-01
- Incorporated additional functions:
  - DNB correlations for design applications
    - ✓WRB-1/WRB-2
  - Fuel thermal properties for design applications
    - ✓Accommodate degradation effect of thermal conductivity of the fuel with burnup
  - Options added for hot spot PCT analysis after DNB
  - More user-friendly interfaces

Compliance with VIPRE-01 SER

- Code extension and application comply with NRC-issued EPRI VIPRE-01 SER
- SER conditions are discussed and addressed in the Topical Report:
  - Model options used for licensing analysis must be justified
    - ✓Justification for model options are described with sensitivity studies and/or benchmark with NRC approved codes
  - Newly introduced CHF correlations must be validated
    - ✓WRB-1/WRB-2 correlations are qualified by VIPRE-01M analysis of DNB test data
    - ✓Original DNBR correlation limit of 1.17 is conservative for VIPRE-01M analysis of Mitsubishi fuel

Qualification for Design Application

- DNBR results are similar or conservative in comparison with NRC approved codes
  - Steady state analysis results are compared against THINC code results for various plant conditions
  - Typical locked rotor analysis results (DNBR/PCT) are compared against FACTRAN and THINC code results

Conclusion

- MHI thermal design methodology consists of:
  - RTDP
  - VIPRE-01M
  - WRB-1 and WRB-2 correlation
- VIPRE-01M is an extension of VIPRE-01.
- The VIPRE-01M model options selected for the licensing analysis are well-accepted and conservative
- WRB-1 and WRB-2 correlations and their original DNBR correlation limit of 1.17 are conservative for Mitsubishi fuel in conjunction with VIPRE-01M
- In summary, the MHI methodology is applicable to the core T/H design analyses and all non-LOCA Safety Analysis relevant to DNB

Our Technologies, Your Tomorrow

Presentation to the ACRS Subcommittee

Topical Report MUAP-07009,
Thermal Design Methodology (VIPRE-01M)
Safety Evaluation

January 15, 2013

NRC Staff Review Team

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Technical Staff

- **Joshua Kaizer**
  NRR, Nuclear Performance and Code Review Branch
- **Anthony Attard** (retired)
  NRR, Nuclear Performance and Code Review Branch
- **Dan Hughes**
  Consultant, Information System Laboratories
- **Jeff Schmidt**
  NRO, Nuclear Performance and Code Review Branch

Project Manager

- **Ruth Reyes**
  NRO, Division of New Reactor Licensing

Overview of Staff Review Process

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- Staff used SRP 15.0.2 *Review of Transient and Accident Analysis Methods* to review MUAP-07009.
  - Staff relied on the previous SER for VIPRE-01 and other similar approvals of VIPRE-01 (Westinghouse, Duke, Dominion).
- Staff issued five rounds of RAIs and performed two Quality Assurance audits.
- Staff observed DNB testing at the KATHY loop in Germany.

Overview of MUAP-07009

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- Describes VIPER-01M and its applicability to PWRs
  - VIPRE-01M is EPRI's VIPRE-01 (previously approved) with minor changes.
  - VIPRE-01M is used to perform non-LOCA transient and accident analysis for the US-APWR.
- Topical Report provides details on the following:
  - Core Modeling
  - Transient Fuel Rod Modeling
  - Thermal-hydraulic models used
- VIPRE-01M is consistent with previously approved versions of VIPRE-01.

VIPRE-01M

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- Subchannel code used to predict transient behavior.
  - Usually used for predicting margin to DNB.
  - Can be used for PCT analysis (e.g. Locked Rotor).
- US-APWR is very similar to a standard PWR.
  - No challenges in the review of VIPRE-01M due to the reactor type (typical PWR).
- VIPRE-01 was approved generically, but each vendor must justify the specific models used.
  - MHI listed the models used and provided some justification.
  - Ultimately, the justification for the selection of thermal-hydraulic models is the accurate prediction of data, which was accomplished through the CHF testing.

VIPRE-01M Validation

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- DNB Test Data
  - Need to validate the DNB predictions with the same computer code and same models.
  - Need to validate that the DNB model can be used to predict the DNB performance of a specific fuel type.
  - Test data spanned the application range of WRB-1 and WRB-2 CHF models (and some outside the range).

- MHI used the KATHY facility in Germany to confirm the applicability of the WRB-1 and WRB-2 DNB models for US-APWR fuel.

- The tests did confirm that the WRB-1 and WRB-2 DNB models could be used to conservatively predict the CHF performance of US-APWR fuel.

QA Audit

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- MHI is a “new vendor” to the NRC, therefore we performed two QA audits
  - M-RELAP-5 and VIPRE-01M audit focused on the QA aspects used to modify the codes.
  - VIPRE-01M audit focused on the QA aspects used to exercise the codes.

- No significant issues were discovered.
  - One issue which lead to a condition and limitation in the SER was use of a non-frozen version of VIPRE-01M during some of the analysis.

Conclusions

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- MHI Thermal Design methodology is acceptable for licensing analyses.
- VIPRE-01M is for performing AOO and accident analysis.
- WRB-1 and WRB-2 are acceptable models for predicting the CHF behavior of the US-APWR fuel.