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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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ESBWR SUBCOMMITTEE

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OPEN SESSION

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TUESDAY

October 20, 2009

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ROCKVILLE, MARYLAND

The Subcommittee met in Room T2-B-3 at the Nuclear Regulatory Commission Headquarters, Two White Flint, North, 11545 Rockville Pike, at 8:30 a.m., Michael L. Corradini, Chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

MICHAEL L. CORRADINI, Chair

SANJOY BANERJEE

J. SAM ARMIJO

WILLIAM J. SHACK

SAID ABDEL-KHALIK

CONSULTANTS TO THE SUBCOMMITTEE PRESENT:

THOMAS S. KRESS

GRAHAM B. WALLIS

DESIGNATED FEDERAL OFFICIAL:

CHRISTOPHER BROWN

NRC STAFF PRESENT:

KATHERINE WEAVER, Senior Engineer

AMY CUBBAGE, NRO

ALSO PRESENT:

GARY ANTHONY

GERALD DEAVER

ZAHIRA CRUZ

TUAN LE

RENEE LI

ENRICO BETTI

PATRICK SEKERAK

STEVEN HAMBRIC

JULES LINDAU

WAYNE MARQUINO

RICK WACHOWIAK

DAVID JENG

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

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

(9:00 a.m.)

MS. CUBBAGE: -- open items. We would like to discuss the progress that has been made on that issue. And steam dryers. Those were topics, of course, that had just recently been submitted at the time that we briefed the ACRS on Chapter 3. So this is the first run through on those topics.

So tomorrow morning I will give you a status of the topics we are going to discuss tomorrow and again on Thursday. But that sums up what you are going to hear about today. I would like to turn to Gerry Deaver, who is going to represent GE Hitachi this morning.

MR. DEAVER: Good morning. I would like to give you the presentation on the IC and PCCS reactor hardware with regard to sloshing. Let's see.

Okay the agenda is first review the RAI status on this topic, followed by a review of the configuration of the IC and PCCS condenser configuration. Then we will have a discussion about the reactor building dynamic loads evaluation. Then we will review the PCCS condenser structural analysis methods and the design report results, followed by some sloshing pressure results from the building model analysis. We will talk about the IC condenser analysis and then conclusions.

Regarding RAIs, there was one RAI, 3.9-247 where the details of hydrodynamic loads and sloshing loads were requested and a response was provided. And at this time, the RAI is resolved.

CONSULTANT WALLIS: Does that mean we can't ask questions about it?

CHAIRMAN CORRADINI: No, he is just giving you the status. Now he is going to give you the details.

CONSULTANT WALLIS: Oh, okay.

MR. DEAVER: So what I would like to show you next is this is a 3D schematic of the two condensers. On the left we have the ICS condenser and on the right we have the a PCCS condenser.

CONSULTANT WALLIS: What I would need would be a cross-section of them so I can see the picture of the tubes and that kind of thing. Do you have that somewhere?

MR. DEAVER: The next page will have those coming up, the cross-sections.

CONSULTANT WALLIS: Now the other question.

MR. DEAVER: The other question?

CONSULTANT WALLIS: So I can see the picture of the tubes.

MS. CRUZ: Excuse me.

CONSULTANT WALLIS: See it cutting through the tubes.

CHAIRMAN CORRADINI: Well let's let him go a little bit longer and then we will see --

MS. WEAVER: I can't hear. So I think he is going to have to get closer to a mike.

CHAIRMAN CORRADINI: You mean for Gerry or for Graham?

MS. CRUZ: Graham.

CHAIRMAN CORRADINI: Graham, I don't think they can hear you exactly what you are saying.

CONSULTANT WALLIS: Why? There is a thing here.

MS. CRUZ: Your mike might be covered.

CONSULTANT WALLIS: It was for a while. Okay. Sorry.

CHAIRMAN CORRADINI: So keep on going. We will stop you.

MR. DEAVER: Okay. So we have the inlet steam pipe. This is the IC system. It is pressurized during operation. And these are two header pipes that tie in to the upper headers, followed by the tubes.

There is a bank of tubes. You can see that there are several tubes that span both sides and in towards the middle. So there are several banks of tubes that tie in here.

And then we have the lower header and then we have the return line.

CONSULTANT WALLIS: Well that is just sort of four layers of tubes and then there was another layer of three.

CHAIRMAN CORRADINI: Oh you are looking for, essentially the lattice structure. Is that what you want to see?

CONSULTANT WALLIS: The lattice structure.

CHAIRMAN CORRADINI: Is it triangular pitch?

MR. DEAVER: Triangular pitch.

CONSULTANT WALLIS: And how close are the tubes? That is the sort of question I wanted to get the answer to. Will you be going on to that later on sometime?

MR. DEAVER: Okay, I didn't bring the details but John Gallis is on the phone. He can give us that kind of detail.

CHAIRMAN CORRADINI: Why don't we take that under advisement and we will hear about it when we get to that.

MR. DEAVER: Okay. Similarly, the PCCS condenser has similar components but it has the inlet steamer pipe with the branch piping that ties into the headers. There are similar tubes, a lower header, and a return line at the base of the little header.

CONSULTANT WALLIS: It has more tubes. It looks as if it has more tubes. Has it?

MR. DEAVER: It has the same basic pattern but it happens to be longer.

CONSULTANT WALLIS: But the pattern looks different in the figures. Maybe it is an illusion.

MR. DEAVER: Well this figure is too hard to count tubes but I think they should be the same.

CONSULTANT WALLIS: Okay.

CHAIRMAN CORRADINI: So just to answer the question on a general basis. So if you moved it up higher you seem to just make it physically longer.

MR. DEAVER: Yes, that is true.

CHAIRMAN CORRADINI: Whereas the two bank structure, at least from a design standpoint, will have the same tube lattice structure and number of tubes in a row.

MR. DEAVER: Exactly.

CHAIRMAN CORRADINI: So in other words, if it is five here, five here, it will five here, five here, for either ICS or PCCS.

MR. DEAVER: That is true.

CONSULTANT WALLIS: But they are showing they aren't the same in the cross-sections. There are more tubes on the right than on the left.

MR. DEAVER: Okay.

CHAIRMAN CORRADINI: Correct.

MR. ANTHONY: The ICS is a thousand pound machine and the PCCS is only --

CONSULTANT WALLIS: But there is more in a cross direction, not just in the length. You will sort that out.

PARTICIPANT: Why would go to two pipes instead of four in PCCS?

MR. DEAVER: I don't know the total history on this. This is a lower pressure system, as opposed to PC. It operates at the full vessel design pressure.

PARTICIPANT: That is probably the reason, yes. Okay.

CHAIRMAN CORRADINI: Sam Armijo.

MEMBER ARMIJO: So remember we when we were going to be talking about the gas and condensables?

MR. DEAVER: Yes.

MEMBER ARMIJO: And similarly in the DCD, you mentioned that these systems were self-venting --

MR. DEAVER: Yes.

MEMBER ARMIJO: -- to get rid of non-condensables. Is there anywhere in these pictures you could show us where these vents are and how they adapt?

MR. DEAVER: This figure shows a vent line at the top of the header. It goes over here and joins --

MS. CRUZ: Gerry, you might want to go to your next slide.

MEMBER ARMIJO: Okay. I know this is a sloshing thing but I just --

MS. CRUZ: Oh, no. I mean, I think the figures on the next two slides might help you, maybe.

MR. DEAVER: Yes.

MEMBER ARMIJO: Okay.

MR. DEAVER: Okay, this is a cross-section of the PCCS. Actually here you can see there is actually eight tubes that tie in from this cross-section.

And this shows the gas accumulation function of this lower header here, where the gas accumulates in that part of the header. And then --

CONSULTANT WALLIS: Let's see that again. Let me see that. That is an interesting point. The gas accumulates down there?

MR. DEAVER: Yes. There is a, not shown on this figure is, another pipe. There is a --

CONSULTANT WALLIS: What kind of gas is there? This is connected to the RPV, isn't it?

MR. ANTHONY: No, this one is actually connected to containment.

MR. DEAVER: This is containment.

CONSULTANT WALLIS: Oh, I'm sorry. This is PCCS. It is the other one that is connected to the RPV.

MR. DEAVER: Right.

CONSULTANT WALLIS: Will you show where the gas is collected in the isolation condenser?

MR. DEAVER: That is the next figure.

CONSULTANT WALLIS: Show the detail.

CHAIRMAN CORRADINI: So just to clear up a couple of things. These things are meant to be their line drawings to be accurate? That is, at least in these cross drawings, you essentially have an eight tube -- eight tubes in a row --

MR. DEAVER: Yes.

CHAIRMAN CORRADINI: -- in both cases. And that is correct.

CONSULTANT WALLIS: -- and then seven. Is that the way it goes? The drawing says four.

CHAIRMAN CORRADINI: I know. That is why I am asking.

MR. DEAVER: If you look here, it is showing the full tubes. Other ones are just shown as lines.

CHAIRMAN CORRADINI: Yes. But all I guess I am saying is there appear to be all this rendering in the previous page and this was just more of, with dimensions. We should pay attention to this as an appropriate --

CONSULTANT WALLIS: Well look at the top, Mike. If you look at the top on the left where it joins the top header, it is sort of the second tube is recessed from the first tube. Right? They are showing two roes of tubes.

CHAIRMAN CORRADINI: Oh.

CONSULTANT WALLIS: So in fact it looks as though it was something like five and four. It has gotten anything like four and four or something. It is just really a bit strange.

CHAIRMAN CORRADINI: Okay.

CONSULTANT WALLIS: I don't think they did the geometry right.

MR. DEAVER: Excuse me. I may have misspoken earlier. These may be just rows. They are not pitched.

CONSULTANT WALLIS: No, I think it shows both a first row and a second row.

CHAIRMAN CORRADINI: Yes, I think they are pitched and you are seeing two rows.

MR. DEAVER: Right.

CHAIRMAN CORRADINI: And they are staggered.

MR. DEAVER: Yes.

CONSULTANT WALLIS: And he is going to clarify that later?

CHAIRMAN CORRADINI: Yes, I wrote that down. So why don't you go back to the profession that we took you way from, which is how is the gas vented from the lower header?

MR. ANTHONY: We will be able to give you that on the break.

CONSULTANT WALLIS: Okay, thank you.

MS. CRUZ: Yes, and I certainly want to the committee to get the questions answered but this really is a completely different topic.

So if we could proceed through the sloshing and the seismic issue and then we can take down any comments that you want addressed.

CHAIRMAN CORRADINI: That sounds fine.

MEMBER ARMIJO: The spacing they have to do.

MS. CRUZ: Oh, the spacing might but the venting.

CONSULTANT WALLIS: So while we look at that figure, can we talk about this thing or is that taboo?

CHAIRMAN CORRADINI: I would like to hold that off if we could. We are supposed to have all tomorrow for that.

Let's let him do what he came to do this morning.

MEMBER ARMIJO: Mike, if this is the best picture that shows how this venting is achieved, well, I just ask GEH to make sure it is in the package when we discuss the gases.

CHAIRMAN CORRADINI: Right. Okay.

MR. DEAVER: Okay, let me go back to the prior slide.

CHAIRMAN CORRADINI: That will teach you to show detail.

MR. DEAVER: Anyway, I just wanted to point out that the IC condenser is a Class D component so it is designed to NC versus the PCCS condenser which is part of containment, so it is an NC component. So it is designed to different standards.

The PCCS Condenser, the support structure is shown here. And the analysis report for this structure and for the PCS condenser has been completed. Basically, it is bolted to the floor. There are saddles underneath the headers and then there is supportive truss structure that also bolts to the floor. The connection point is at the top header, as you see at the top here, as where sloshing is really a phenomenon at the top part of the pool and the support structures provides adequate support to resist any sloshing loads.

CHAIRMAN CORRADINI: Just one question now about support. So is the support design for the PCCS and the ICS identical and you show one with and one without just for illustration purposes?

MR. DEAVER: We haven't finished or done the design analysis for the support structure for the IC system.

CHAIRMAN CORRADINI: I see.

MR. DEAVER: But we expect it to be very

similar.

CHAIRMAN CORRADINI: Okay.

MR. DEAVER: Okay, moving forward. The only point of this slide was to give you some relative dimensions. Here the PCCS is fully submerged and the primary component that would see sloshing loads is this upper header because it has the most surface area. And it is 1.58 meters below the water line. So everything is submerged in this system.

Okay, moving forward. The IC is a little different in that the water line, the upper piping is actually out of the water and the water level for the header is 1.38. So it is 0.2 meters shorter than the PCCS is.

CHAIRMAN CORRADINI: Is there a particular reason that they are different?

MR. DEAVER: I don't totally know the background.

CHAIRMAN CORRADINI: Okay.

MR. DEAVER: These were designed in the '90s and tested in the '90s.

CONSULTANT WALLIS: So this branch from the upper header to the wall is correct in the drawing before this one?

MR. DEAVER: Let me go back to that one.

CONSULTANT WALLIS: The distance from the wall is correct?

MR. DEAVER: This isn't meant to be an accurate representation.

CONSULTANT WALLIS: It is not meant to be an accurate representation?

MR. DEAVER: The pool width is five meters and the PCCS is about four meters, as I remember. So there is some clearance to the wall. Part of that clearance is actually shown in this figure.

CHAIRMAN CORRADINI: So just to repeat, it is about five meters tall and about five meters wide, the PCCS. And the pool itself is a bit wider. And I don't see any wider dimension here anyway.

MR. DEAVER: No but it is roughly five meters is the --

CONSULTANT WALLIS: The reason I ask is that when you shake something next to a wall, it is not same thing as shaking it in --

MR. DEAVER: At least a half a meter.

CONSULTANT WALLIS: Well that is what you say but until I see a drawing that is accurate, I don't really know.

MR. DEAVER: okay.

CONSULTANT WALLIS: Can we get that?

CHAIRMAN CORRADINI: We will get verification.

MR. DEAVER: Okay.

MEMBER ABDEL-KHALIK: Now the ICS supply pipe is outside the water. It runs hot. So the inside surface temperature of the pipe is 550 or about 500.

MR. DEAVER: Yes.

MEMBER ABDEL-KHALIK: And if this thing gets flooded, in other words, if there is uncertainty in the level, the outside surface temperature of the pipe would be pretty cold. What would be the thermal stress in the wall if there is enough variability in the level to cover the pipe for the ICS?

MR. DEAVER: Why don't you hold on to the IC picture? Okay, you know, this is the closest. There would be steam, a stagnant line but steam in it. But we have a guard pipe here. It is an outer pipe. This inner pipe comes in and joins near the top here. So the guard pipe does act as a thermal shield. And I believe one of the reasons the pipes are above water is because of the temperature.

MEMBER ABDEL-KHALIK: Both of the pipes are going to the header --

MR. DEAVER: Yes.

MEMBER ABDEL-KHALIK: -- are not guarded. Are they?

MR. DEAVER: No, they are not.

MEMBER ABDEL-KHALIK: So those are the pipes I am concerned about. The inside temperature is saturation of steam.

MR. DEAVER: Well, I think it will decay out. You won't see the full temperature of the vessel.

MEMBER ABDEL-KHALIK: But they can, potentially.

MR. DEAVER: Yes.

MEMBER ABDEL-KHALIK: And if the outside is flooded, the outside surface temperature would be a lot colder.

MR. DEAVER: Yes.

MEMBER ABDEL-KHALIK: So what is the maximum thermal stress that you would get if there is uncertainty in the level?

MR. DEAVER: We haven't -- we have done testing of this geometry so the sizing and materials have been established. I am not sure if we have the exact thermal stresses of those conditions.

CHAIRMAN CORRADINI: These are the experiments that were done in Italy. Am I remembering correctly?

MR. DEAVER: Yes, Sardinia did the testing, yes.

MEMBER ABDEL-KHALIK: This doesn't have anything to do with testing. It is just the structural integrity of this component.

MR. DEAVER: Yes. These are normal stick type pipes. You will get some temperature variation across the pipe but it will equalize itself out.

MEMBER ABDEL-KHALIK: I mean, if it is outside the water, then it is primarily pressure stress, --

MR. DEAVER: Yes.

MEMBER ABDEL-KHALIK: -- that you get from the inside.

MR. DEAVER: That is correct.

MEMBER ABDEL-KHALIK: But if it gets submerged, then you have to worry also about thermal stress.

MR. DEAVER: Well, yes. You will see a thermal gradient across the pipe because it will be hotter inside the pipe than outside.

MEMBER ABDEL-KHALIK: Right. My question is, how significant is that that we have to worry about uncertainty in the level?

MR. DEAVER: I don't believe it is all that significant because the temperature by the time it reaches this point will be quite a bit lower than the vessel.

MR. WACHOWIAK: This is Rick Wachowiak. I have a couple of clarifying questions. The condition you are talking about, are you talking about during normal operation of the plant or during some transient condition? Because the conditions that are going on are going to be different under those two situations.

Under normal operation of the plant, as the plant starts out, this system will, within a few hours of plant startup, become filled with water up to the surface, so it will be cold. And there is a steam bleed from the upper header back to that main steam line. So high point vent just like others.

So there would be one thermal gradient right at the top of the header and right where it comes to the surface of the water. So that is one.

Then, the transient conditions, that is when the drain and there is going to be hot steam on the inside of the heat exchanger and cold water on the outside. So that would be under a different set of conditions.

So your question goes to both of those

situations. What are the stresses during normal operation and then what are the stresses during the operation of the heat exchanger.

MEMBER ABDEL-KHALIK: I am just wondering if one should be concerned about uncertainties in the level that would cause the height to be covered, resulting in a thermal stress if the inside of the pipe is filled with steam at elevated temperature and pressure.

MR. WACHOWIAK: Right. And the uncertainty in the level is where I was little bit confused by the question because the system is designed to operate with the water, all the way up to the top of the cross pipes. And then with water slowly progressing down all the way to the mid point of the tubes. So under all those situations, it needs to perform.

CONSULTANT WALLIS: So what you are saying, Rick, is that this figure is incorrect.

CHAIRMAN CORRADINI: No, he is saying that water changes during the actuation.

MR. WACHOWIAK: During the actuation of the system, the water level in that tank goes on potentially to the mid point of the tube.

MEMBER ABDEL-KHALIK: But we were more

concerned about the case when the supply tubes are submerged, not when they are not covered.

MR. DEAVER: Well, this phase condition is actual operation of the condenser. That is why we have the actual steam coming in here and the water is cold. So, that part we have tested.

CHAIRMAN CORRADINI: But I guess maybe we should clarify the question and then we will leave it so you can go on and do some investigation.

If there is various operational modes, as you said, normal operation and various water levels during the accident progression, I guess, getting ready to answer Said's question is what is the worst case situation and what are the stresses there, I think. And then he asked the additional question about an older flooding and a higher water level.

If you could just keep that in mind and then we can come back to it. Does that make sense?

MR. WACHOWIAK: You are also concerned when we refill the pools, as we talked about in some of the previous subcommittee meetings, what happens when we fill past the top of those cross pipes.

MEMBER ABDEL-KHALIK: You know you are in a situation where not only do you have to worry about pressure stress inside the pipe but you also have to worry about thermal stress if you sort of burst a pipe in cold water when it is filled with steam at elevated temperature and pressure.

MR. WACHOWIAK: I understand your question now and the intent is for that pipe to be designed for that condition. Now the question is, have the stress calcs but done we are at the state we are at right now to give you the answer.

But the answer is yes, it does need to operate under that condition. That is a condition required operation for the system.

MEMBER ABDEL-KHALIK: So if you would just clarify that for us, that would be helpful.

CHAIRMAN CORRADINI: But he won't know the stresses until he knows the prior design.

MEMBER SHACK: The prior design.

CHAIRMAN CORRADINI: You know, he has to design that thing so that it accommodates those stresses.

MR. WACHOWIAK: That needs to operate under -- part of the tubes all the way to overflowing in the compartment.

CONSULTANT WALLIS: So this is an ITAAC, is it, that hasn't been designed yet?

CHAIRMAN CORRADINI: No, I'm sure this

hasn't been designed in detail.

MR. DEAVER: The structure itself has been designed. We have lines of this structure and we are duplicating the test results.

CHAIRMAN CORRADINI: Right. But I think just to make sure we close this, Rick's answer to Said was that, unless I misunderstood it, normal operation is the limiting mode. And then your question was, if that is the limiting mode, what happens in the worst case that I overfill. And your answer back is by requirement it has to be able to take those pressure stresses under various operational and overfill condition.

MR. WACHOWIAK: Right.

CHAIRMAN CORRADINI: But we are not expecting you have those stresses somewhere in a book that in 20 minutes we are going to get --

MR. WACHOWIAK: You are not going to get it in 20 minutes.

CHAIRMAN CORRADINI: That is what I thought.

MS. CRUZ: This would be covered by ASME. They would require ASME code reports to be available for inspection prior to authorization to operate. And there is an ITAAC for the stress report.

MEMBER ABDEL-KHALIK: Gerry, where you have a bolted or flanged cap at the top of the inlet pipe on the isolation condenser and you don't have that kind of arrangement on the lower pressure PCCS condenser.

CONSULTANT WALLIS: This is a schematic and this is one of these problems --

MEMBER ABDEL-KHALIK: The picture looks pretty detailed.

MR. DEAVER: This bolted connection?

MEMBER ABDEL-KHALIK: Yes.

MR. DEAVER: That is to provide inspection access to the top of the headers.

CHAIRMAN CORRADINI: Whereas you don't think you guys need that for the PCCS?

MR. DEAVER: This system when it sits there doesn't see any loads of pressures during operation because it is connected to the containment, whereas the IC system is pressurized during operation.

MEMBER ABDEL-KHALIK: Okay.

CHAIRMAN CORRADINI: And you are going to use that probably more frequently during normal startups and shut downs? I better ask the question. Is that going to be exercised much more, I assume, than the PCCS. I guess I am trying to --

MR. WACHOWIAK: ICCS is normally used for scrams.

CHAIRMAN CORRADINI: Oh.

MR. DEAVER: Yes, you would expect IC to operate some number of upstream right to the plant.

MEMBER ABDEL-KHALIK: Just getting at the issue if that thing leaked up there when you needed it, it would not be good news.

MR. ANTHONY: Well, we also had both the connections on the headers and so forth also for inspection and safety purposes. So we have a variety of bumper connections.

CONSULTANT WALLIS: Do you have a drawing of the ICS like the PCCS which is more detailed that we could look at?

This one here, the one in the previous slide you show more detail than you do in this. And I grant that schematics often depict the skeletons. So I would like to see the real scale of the ICS with details.

CHAIRMAN CORRADINI: We will get to that, though.

CONSULTANT WALLIS: Well I would like to see one of ISC if you have one.

MR. DEAVER: Okay, why don't we hold all

the questions and move on.

CONSULTANT WALLIS: There haven't been any questions yet.

CHAIRMAN CORRADINI: We want it in dribs and drabs. So we got our first drib. Keep on going.

MR. DEAVER: Okay. Next what I will talk about is the modeling of the pool under seismic conditions. It is traditional to model the sloshing as a convective spring mass in the system. And the impulsive rigid components are modeled as a solid connection because they are rigid. So this is typical in pool design.

CHAIRMAN CORRADINI: And then just to remind everybody because we kind of went over this with you guys in an exercise you did before. You actually went back to an original reference. This is a typical accepted practice to essentially break up the loads as one essentially, I will call it, spring mass and one a rigid connection --

MR. DEAVER: Yes.

CHAIRMAN CORRADINI: -- that has been done historically.

MR. DEAVER: Right.

CHAIRMAN CORRADINI: They are empirically based. It is not theoretically based. If I remember correctly, the paper you guys went back to and showed us was showed based on some experiments there was an empirical basis for this.

MR. DEAVER: Right. And there are equations that calculate these.

CHAIRMAN CORRADINI: Okay.

MR. DEAVER: Okay, the next figure just shows the overall model of the reactor building in the back with each of the pools are separately modeled. And it is a finite element model. And that is pretty much I had to say about the actual model itself.

In modeling the pool water in the building itself, typically the sloshing component is a very low frequency at 0.5 Hz. And none of our structural components have natural frequencies down in that range. So there is no amplification due to sloshing.

MEMBER ABDEL-KHALIK: On the previous figure, is this the actual modelization they use in the finite element analysis?

MR. DEAVER: I believe it is.

MEMBER ABDEL-KHALIK: And is that sufficiently detailed to capture what is actually going on?

MR. DEAVER: Well this is a building model but they do model water in it also. So this is primarily to analyze the building structure. So that is a civil question.

CHAIRMAN CORRADINI: Let me ask the question differently because I think I know where Said is going with this.

If you guys have a concern, do you then go in and do some more detailed modeling or is this the level of detail that you are looking at? That is like another area that I think that he is getting at. If something concerns you, what do you do relative to additional analysis?

MR. DEAVER: Well obviously if we have something that looks high stress, then we would refine the mesh and rerun the model.

CHAIRMAN CORRADINI: And so the same thing here relative to these pool structures, I guess is --

MR. DEAVER: Sure. I think the pool structures would be a similar situation.

CHAIRMAN CORRADINI: Okay.

MEMBER ABDEL-KHALIK: But that was not the case here.

MR. DEAVER: No, I don't believe they had to do any of that. That is a whole different topic.

We have, I am sure we have somebody on the line that could answer that, either Shaulai Lu or

Sirjan. Do you want to see if they are on the line?

CHAIRMAN CORRADINI: Can somebody allow them to speak, please, in the control room back there? Can somebody turn on the bridge line, please? Hang on a second.

MR. DEAVER: Okay.

CHAIRMAN CORRADINI: I think, I knew somebody was on your bridge line. Let me cut them on. Are you guys -- can you guys speak now?

TELEPHONE PARTICIPANT: Can you hear us?

CHAIRMAN CORRADINI: Yes.

TELEPHONE PARTICIPANT: We just went out of the room real quick to get food.

CHAIRMAN CORRADINI: Okay. So did you hear the question or do you want -- why don't we repeat the question?

MEMBER ABDEL-KHALIK: Well my concern is about the resolution of the mesh. I mean, this seems like a very course mesh. And the question is whether or not you actually checked whether the resolution of the mesh is adequate.

CHAIRMAN CORRADINI: Have you got the question?

TELEPHONE PARTICIPANT: Yes, we are waiting for Sirjan.

CHAIRMAN CORRADINI: Okay, that is fine.

MEMBER SHACK: Well I guess I have another one in the same sort of thing. I am looking at this table and it says summary of seismic analysis method and it says 3D mass stick coupled with soil springs. So I was expecting a stick lump mass model.

MR. DEAVER: It is all pressure.

MEMBER SHACK: Well you don't get dynamic loads from that and then you go back and do a stress analysis from those. So which model am I looking at here?

TELEPHONE PARTICIPANT: Okay, he is here. Go ahead.

CHAIRMAN CORRADINI: Why don't you start with Bill's question and then go to Said's about mesh refinement. Can you ask your question?

MEMBER SHACK: Yes. It is just you are showing a finite element model here of the building but when I look at the table, it says the seismic analysis is done with a lump mass stick, coupled with soil springs. So do you do the lump mass stick to get the dynamic load and then the finite element analysis is for the stress analysis? Am I looking at a second stage here?

TELEPHONE PARTICIPANT: No. What we need

is the mass of the water to the wall and onto the floor.

CHAIRMAN CORRADINI: I think now we are talking about your overall methodologies. So Bill is asking, what do you start with and then how do you refine it? Which leads to Said's question about at what level do you know the refinement is adequate.

TELEPHONE PARTICIPANT: I don't have that answer. I can get back to you and give you that answer.

CHAIRMAN CORRADINI: Well just let Bill ask the question again. Because I thought we had already gone over this before. But can you ask your question again?

MEMBER SHACK: It is just I am looking at it says it is done with a lump mass stick model and I am wondering what the relation to that lump mass stick model is to this finite element picture we are looking at.

CHAIRMAN CORRADINI: Do you have the picture we are looking at?

MS. CRUZ: We have someone from the staff here, a structural reviewer. If you want to step to the other side, there is a microphone.

CHAIRMAN CORRADINI: Identify yourself,

please.

MR. JENG: My name is Davie Jeng NRC staff, Mechanical Engineering. I think basically what we are doing is there are two sticks. For the seismic analysis, we used the mass model. And some time I will present it. I can produce it. The seismic stick with the masses and they are connected.

That is primarily for the analysis of seismic response. But then you realize that your structural elements is subject to the seismic walls. So that work has to be completed in a finite element model to get to that stress level of each element.

CHAIRMAN CORRADINI: So if I can just summarize, then. Your point is the stick model provides the boundary conditions for a more resolved detailed analysis --

MEMBER ABDEL-KHALIK: Well it provides the loads.

CHAIRMAN CORRADINI: -- provides the loads.

MR. JENG: Provides the loads, primarily. And that could input to other roads. And that gives input to each of these other loads. And that gives you a more defined dynamic finite element model that we are looking at.

CHAIRMAN CORRADINI: Okay.

MR. JENG: As to the question how do you know how refined should be adequate? I think the program is nearly built yet we check the convergence. Okay? If they want to try and see that they converge in a solution. If they don't converge, that means we have to move on so we cut the size to half inch and adjust until such a time your response is stable. That defines how refined this mortar should be. It is a basic technique available in that code technology.

MEMBER ABDEL-KHALIK: This is a quasi-static model. Right? He just does -- he will tie that in with the dynamic loads put on as though they were loads.

MR. JENG: Yes. They are completely static.

MEMBER ABDEL-KHALIK: Now what does it mean what the gentleman said before, that they added the mass for water for the floor and the walls?

MR. JENG: Okay, I will explain. The water has sink in the upper level. A huge mass of water which was in use massive natural wave and which is accounted for in the design of the subject. I think it has a tank.

So they took the mass, and then they use that equivalent mass of the water and tie it to the adjacent lumped mass in the same place that the increased mass could sink as an earthquake is applied to both of them.

So this is the equivalent here of a effect of certain water in the tank an to complete adequate conservative loads for the design of the structures.

MEMBER ABDEL-KHALIK: The gentleman from GE will get back to us on the adequacy of the mesh resolution?

TELEPHONE PARTICIPANT: Yes, could you please repeat the question again so that I can write it down?

MEMBER ABDEL-KHALIK: We were just wondering how do you decide whether or not the resolution of this mesh is adequate to resolve whatever you are trying to calculate.

TELEPHONE PARTICIPANT: Other than that? Well, all right. We will get back to you.

CHAIRMAN CORRADINI: Okay.

MS. CRUZ: I believe David spoke to that some in his discussion.

MEMBER ABDEL-KHALIK: I understand.

MS. CRUZ: Okay.

MR. DEAVER: Okay, I think we were on the second bullet.

The impulsive component responds in unison to the pool because it is treated as a rigid structure.

CONSULTANT WALLIS: And the component we are talking about here is the boundaries of the coolant. Right?

MR. DEAVER: Right.

CONSULTANT WALLIS: It is nothing to do with the structure that is in the pool like the PCCS itself.

MR. DEAVER: Right. In the building analysis --

CONSULTANT WALLIS: So don't you have the mass of the -- what do you do about the mass of the steel that is in there that is shaking, too? Does it move with the water in some way?

MR. DEAVER: In the structural analysis of the building, no components were modeled in the pool.

CONSULTANT WALLIS: They do have mass and they do move. Right?

MR. DEAVER: Well they do but they are anchored on the floor.

CONSULTANT WALLIS: So they move with the building.

MR. DEAVER: Yes.

CONSULTANT WALLIS: So they are mass added to the building?

MR. DEAVER: I know they accounted for the water weight.

CONSULTANT WALLIS: That is right but how do you account for the steel weight?

CHAIRMAN CORRADINI: Sinjee are you still there?

MS. CRUZ: No.

MR. DEAVER: Are they still connected?

CHAIRMAN CORRADINI: We may need to leave them on for a while?

CONSULTANT WALLIS: And the support, rigid or not, that the whole things moves in place with the building. Is that what --

CHAIRMAN CORRADINI: Well let me just try what I remember they said from last time, Graham. Based on this empirical thing, they take part of it being out of phase and part of it in phase. That is why we showed the original model as a --

CONSULTANT WALLIS: But you have a structure made of steel?

CHAIRMAN CORRADINI: The water, there is both an in phase and out of phase. The structure, there still ought to be --

MR. DEAVER: Actually without a structure in the pool, the loads on the water would be higher because you are taking up mass by having a structure in the pool.

CONSULTANT WALLIS: But that is a steel mass.

MR. DEAVER: But that doesn't apply load to the wall.

CONSULTANT WALLIS: It applies your load to the floor.

MR. DEAVER: Correct. Exactly.

CHAIRMAN CORRADINI: Yes, it actually acts as a resistance to the water and adds more load to the wall -- to the floor.

MR. DEAVER: To the pool itself.

CHAIRMAN CORRADINI: Do we have anybody on the bridge line?

TELEPHONE PARTICIPANTS: Yes, we are here.

CHAIRMAN CORRADINI: Okay. So did you hear the question about are the PCCS and the ICS structural steel added to the layer to the floor?

TELEPHONE PARTICIPANT: They are added to the floor, yes.

CHAIRMAN CORRADINI: Okay.

CONSULTANT WALLIS: They are within phase with the floor.

MR. DEAVER: No, not necessarily. The IC and PCCS components are individually analyzed with the floor response factor.

CONSULTANT WALLIS: So if they are not in phase with the floor, they must be doing something to the walls.

MR. DEAVER: Well, like I mentioned before, the worst case is to assume that there is no equipment in the pool because the water mass is --

CONSULTANT WALLIS: Well if you suppose they were very weakly attached to the floor, then all their motion would have to be somehow transmitted to the walls because there is no where else to transmit it to, presumably.

MR. DEAVER: Well, it is the floor that holds the structure.

CHAIRMAN CORRADINI: Well I think Graham is asking just a very simple question. He is saying the two extremes are they are not connected. So the would add to the mass of the water that is wiggling in the lateral direction.

The other extreme is they are totally rigidly connected, which means you have got to count they are really downward. And therefore, as you said, it minimizes the sideward.

So I think he is asking the question since they are connected but they are not exactly literally connected, do you properly account for the consistency from how it wiggles from side to side versus the connection at the bottom.

Do I have it?

CONSULTANT WALLIS: That is correct. That is about what I said.

MR. DEAVER: Well it really doesn't move structurally very much. Movement is very actually small.

CONSULTANT WALLIS: How can it move very much in this seismic model?

MR. DEAVER: We are comparing that to loads being generated on the side --

CONSULTANT WALLIS: If they can't give me a technical answer.

CHAIRMAN CORRADINI: Are the people on the bridge line understanding the question?

TELEPHONE PARTICIPANT: No. We did not understand the question. Could you please repeat that?

CHAIRMAN CORRADINI: Graham, do you want

to give it a shot again?

CONSULTANT WALLIS: The steel structure of the heat exchanger moves. If it is rigidly attached to the floor and really rigidly attached to the floor, then presumably its mass is added to the mass of the floor when you consider motion. If it is very flexibly attached to the floor, then its motion somehow is transmitted to the side walls.

And I want to know how you split the mass of the structure, the steel, and do you add it to the floor or the walls or some to one and some to the other?

MR. WACHOWIAK: This is Rick Wachowiak again. So what they are asking about is in Section 3(g)15415 of the DCD where we discuss the ANSYS model of the PCCS heat exchangers and how it is attached to the containment.

Now, what I believe they are asking you, is the PCCS heat exchanger analyzed along with the containment in the single finite element model that calculates the stresses on both the floor, the walls, and the individual components of the PCCS or is it combined in some sort of a piece meal way such that we would have to worry about how we partition out the different loads?

From reading the DCD, it appears to me that this all analyzed as an integral unit with the hand calculation that was performed to evaluate the effect of the sloshing on this beam and shell model.

TELEPHONE PARTICIPANT: No, this is what we did. We didn't evaluate values for the of the building for the operating under dynamic mode because of the response of the building. Between that, we added mass of the model. The mass of the model was added to the wall and also to the floor.

MR. WACHOWIAK: Okay but you don't take account of the mass of the heat exchanger when you are calculating the building response, then.

TELEPHONE PARTICIPANT: I will get back to that to you because I do not have it right in front of me. I do not know what that. We did account for equipment roll on the floor but I don't know specifically if we had accounted for the heat exchanger. But I will get back to that to you.

But this is how we did that. So once you get to response of the building then we did qualification, the high quality data out of the chamber. So we derived a response to the heat exchanger and we found out that this depends on the forces and the models. And that is how we qualified the heat exchanger.

CHAIRMAN CORRADINI: So if I might just ask the final point. So how do you consistently account for any heat exchanger weight in the lateral direction, in the horizontal direction adding to the sloshing effect?

TELEPHONE PARTICIPANT: Okay, this is what we did. We had mass of heat exchanger, which is steel that were inside of that heat exchanger, which is why we added the weight of the water. And then we account to the sloshing effect, we added a mass.

Then we analyzed the heat exchanger. Does that answer your question?

CHAIRMAN CORRADINI: I think I understood what you said. Does this answer your question, Graham?

CONSULTANT WALLIS: No but now he has raised another question. When you talked about sloshing --

TELEPHONE PARTICIPANT: All right.

CONSULTANT WALLIS: Now sloshing I understand is a low frequency so a motion of water but there is a impulsive component due to the water, too.

TELEPHONE PARTICIPANT: Right.

CONSULTANT WALLIS: And that is the one I was really talking about. Once the sloshing happens and the whole structure sways in the sloshing, I think that is a different analysis.

I was really looking at the impulsive component of this thing.

TELEPHONE PARTICIPANT: Right. The sloshing can go for very, very long.

CONSULTANT WALLIS: That is right.

TELEPHONE PARTICIPANT: And then when we did the calculations with that we found - I found it reached 417 Helmholtz.

CONSULTANT WALLIS: Now, I think the sloshing is not so much my concern. But when you do your stuff, you have to somehow couple this structure, the weight of the heat exchanger itself, into the various other things that are moving. In other words do something with it in you dynamic analysis.

Then you are going to do a full analysis of the PCCS, which you are getting to later, the actual motion of the heat exchanger itself. Somewhere in there, is the interaction between it and the floor, which must feed back to the other analysis in a consistent way.

Do you see what I mean? Maybe you say well, assume it is rigid and it moves with the floor.

And then you did the analysis of the thing itself later on and we see how good that assumption was.

TELEPHONE PARTICIPANT: Okay.

(Off-mic comment.)

CONSULTANT WALLIS: So there is no water in there at all and you move the floor.

TELEPHONE PARTICIPANT: Right.

CONSULTANT WALLIS: The heat exchanger doesn't necessarily follow the floor. The floor may move out of phase with the --

TELEPHONE PARTICIPANT: Yes, it could.

CONSULTANT WALLIS: So how you treat that mass is probably could be important.

TELEPHONE PARTICIPANT: Correct.

CONSULTANT WALLIS: All right. Well you don't know how you treated it until you look back at the paperwork.

Well, I don't want to keep going over this. This is something we need to follow up on, perhaps.

(Off-mic comment.)

CONSULTANT WALLIS: Oh it is a separate component in the seismic analysis?

PARTICIPANT: It is a system analysis of which is supported to a --

CONSULTANT WALLIS: In the stick analysis, it is one of the sticks?

PARTICIPANT: Yes, and then you apply the floor seismic motion to give that, this number.

CONSULTANT WALLIS: But is that what they actually do?

CHAIRMAN CORRADINI: We are still coming back. We are trying to get the floor response first. You are not looking at the heat exchanger. You have got the floor response first.

I am guessing that you treat the heat exchanger as an impulsive load. You just add that mass.

CONSULTANT WALLIS: I guessed that, too.

CHAIRMAN CORRADINI: I'm guessing that.

PARTICIPANT: Don't guess. I know how it is done.

CHAIRMAN CORRADINI: Okay.

PARTICIPANT: Based on the heat exchanger is the basically all the mass that is supporting frames like a base.

CONSULTANT WALLIS: In the stick analysis.

PARTICIPANT: In the stick analysis. Okay. So we use in a model.

CONSULTANT WALLIS: Well so you added

seismic mass to that?

PARTICIPANT: You take the motion at the floor, which comes with the other analysis. Okay.

CONSULTANT WALLIS: And you put the added mass to that then?

PARTICIPANT: Right. And when you apply that, it could affect the water and the equipment. And you just do the analysis of that single developing system with the forces. And forces should be transmitted through the floor to the tank. And that is another factor of structural analysis.

CHAIRMAN CORRADINI: Okay. So you estimated it with the forces. So the next question would be you then apply those forces both to the pool and to the structure, to the PCCS structure. Is that correct?

PARTICIPANT: Right. Correct.

CHAIRMAN CORRADINI: So at least I think I understand that part. At least I think I do.

So then the final thing that Graham is asking that I guess I am still not clear on is how do you consistently then put in the effect of the water, both its impulsive part and its in phase and its out of phase part, and how does the structural mass add into that? Because if it is going to be totally rigid, we are going to have nothing. If it was totally loose, it would have had everything. But it is somewhere in the middle. How do you consistently do that? That is what I am still not clear about.

PARTICIPANT: Okay. In a more bigger situation, it is literally there in that. It costs more to do that in doing a refined analysis. But in this case, what we did was use an equivalent analysis. We used a single mass to represent that equipment. And also used that amount of water displaced by this equipment and its equivalent water mass into the coupled equipment mass and did more rough analysis to get the effect of that sourcing equipment. And that would be a reaction to that floor and the effect is a seismic force by this seismic analysis performance.

So it is harder in a more rigid, simpler way. But it is --

CONSULTANT WALLIS: Okay. But until we see your equations, I don't think we know really what was done. But I think this discussion is helpful.

But until I see the equation, I don't really know how what you said was incorporated into the analysis. Do you have some kind of analysis which is written down that we can look at?

PARTICIPANT: Yes it is written down the

equations how it is done, the handling of the mass.

CONSULTANT WALLIS: Are they GEH's equations?

CHAIRMAN CORRADINI: I am sure they are GEH's.

CONSULTANT WALLIS: Okay. So are they available somewhere?

CHAIRMAN CORRADINI: So why don't we leave this as an item just for clarification? But I think this helped a bit in terms of discussion. But can we leave it with the folks on the bridge line that we are at least looking for clarification on the approach?

TELEPHONE PARTICIPANT: Yes.

CHAIRMAN CORRADINI: Okay.

MR. DEAVER: Well, I did bring with me an appendix of the building model stress analysis which addresses sloshing.

CHAIRMAN CORRADINI: What page is that? I am trying to find it myself.

MR. DEAVER: This is a GE document.

CHAIRMAN CORRADINI: Oh, this is not in the DCD?

MR. DEAVER: No, it is not.

CHAIRMAN CORRADINI: Okay.

MR. DEAVER: In here, there is empirical

equations that were developed based on testing calculating both the impulsive and the sloshing modes. And those are added to the building.

My understanding is that those are separately added to the other stresses to calculate the total stresses on the building structure, such as the walls.

CHAIRMAN CORRADINI: Okay. So, why don't we leave it this way. So you have something that has already been part of the RAI response or is this an internal GE?

MR. DEAVER: No, this is just an internal GE document.

CHAIRMAN CORRADINI: Okay. So to the extent that I will let staff work with you on that. If we are asking to at least get more clarification, you can decide if you want to use that as a way to clarify it. Okay?

MR. DEAVER: Okay.

CHAIRMAN CORRADINI: Why don't you move on?

MR. DEAVER: Okay. Back to the slide. The next bullet talks about the sum of the masses associated with each component is equal to the total water mass in the pool. So this is basically describing that all the water mass is accounted for either in the side walls or the floor of the model itself.

Okay and then for conservatism, the entire water mass of each pool is considered as impulsive mass rigidly attached to the structural nodes in the seismic stick model for predicting overall pressures of the building structure.

And all pools are included in the model, thus the effect of the pool interactions are accounted for. And pool to pool, since these are a series of pools.

The next slide talks about the seismic loads. Our goal to determine for shear movement an accelerations. Then there are local loads in the form of hydrodynamic pressure loads due to convective and impulsive modes of the pool. That is basically the water calculation that has been done for the pool walls.

So those are then combined with other loads and compared against the design to go to the acceptance criteria.

Okay. One other sensitivity that was done was to look at the sloshing effect to see if it had any effect on the building's natural frequency. So, what was done was to basically exclude the mass of the sloshing water from the total mass. And we are looking at just the elevation where the pools are, to the floor of the pools and there to the base of the pool.

And so in calculating just the mass reduction, there was a mass reduction of four percent in that local section of the building. And that equates to a frequency variation of two percent at the pool elevation itself.

Since the response factor has been broadened to plus or minus 15 percent, it was concluded that the two percent variation due to sloshing effects will not have any impact on the analysis itself.

So this was just a check to see if a sloshing affect was going to affect the building natural frequency.

MEMBER ABDEL-KHALIK: What is the building natural frequency?

MR. DEAVER: Seejay are there?

TELEPHONE PARTICIPANT: Yes, I am here. I don't recall that number.

CHAIRMAN CORRADINI: All engineers should own numbers. I figured this was your number. Don't you own this number?

TELEPHONE PARTICIPANT: Yes, I do own this number. Yes.

CHAIRMAN CORRADINI: Could you get back to us? Because you have to look it up.

TELEPHONE PARTICIPANT: But you are saying that when we did the analysis of the building, we -

(Off-mic comment.)

MEMBER ABDEL-KHALIK: We can read the slide. I am just asking about what the natural frequency is.

TELEPHONE PARTICIPANT: I can't tell you from the memory. Can I get back to you on that?

MEMBER ABDEL-KHALIK: That would be good. That would be good. Thank you.

TELEPHONE PARTICIPANT: Yes, sure. Yes.

MR. DEAVER: Okay, so in summary, on the building dynamic analysis, the building analysis included the pool water but not the internal structures. The actual building stressors were determined. And then the building seismic models included all pool water as impulsive mass.

CONSULTANT WALLIS: I still don't understand. What do you mean by sloshing?

MR. DEAVER: Sloshing is --

CONSULTANT WALLIS: What is the difference between the impulsive motion where things move and things move very, very quickly, and sloshing?

Sloshing to me means like a bath tub that goes --

MR. DEAVER: Exactly.

CONSULTANT WALLIS: -- up one side and that is driven by gravity.

MR. DEAVER: Exactly.

CONSULTANT WALLIS: That is what you mean by sloshing?

MR. DEAVER: Yes. Impulsive and rigid mean --

CONSULTANT WALLIS: But the sloshing, it goes off and then gravity brings it back again.

MR. DEAVER: Right.

CONSULTANT WALLIS: The restoring force is gravity.

In the quick motion, the restoring force is elasticity of things.

MR. DEAVER: Typically, --

CONSULTANT WALLIS: It is mechanical.

MR. DEAVER: -- at the bottom of the pool, there is no sloshing effect at the bottom because --

CONSULTANT WALLIS: Is that what you mean?

You mean gravity is the restoring force in sloshing?

MR. DEAVER: Yes.

CONSULTANT WALLIS: Are you serious? Okay, thank you.

MR. DEAVER: Okay.

CHAIRMAN CORRADINI: I thought he was trying to answer your question by saying that for the deep pools -- I just want to make sure he answered your question. I am not sure if this was your question but what he was answering was --

CONSULTANT WALLIS: -- has no effect on seismic. Right? Is that your argument?

MR. DEAVER: Yes.

CONSULTANT WALLIS: So let's forget it and let's talk about the very quick and impulsive response. That is what matters. You keep bringing this word sloshing into the conversation.

CHAIRMAN CORRADINI: That was their action item. Last time we did a little portion about sloshing. So they went away and analyzed sloshing.

MEMBER ABDEL-KHALIK: But the impulsive mode, they just included it in the model. All the mass.

MR. DEAVER: All the mass, yes.

CONSULTANT WALLIS: Except the mass of the steel when we get to the next slide.

You see there is no structures. This means that none of the steel structure was counted. Right?

MR. DEAVER: The one we did the stick model part it was but not in the actual building.

CONSULTANT WALLIS: This first bullet here, --

MR. DEAVER: Yes.

CONSULTANT WALLIS: -- says that no internal structures were included.

MR. DEAVER: In the finite element analysis of the building.

CONSULTANT WALLIS: The dynamic analysis, not the finite element. In the stick model. The stick model was what you --

MR. DEAVER: The stick model did include the masses. But the finite element analysis of the building structures --

CONSULTANT WALLIS: Well then you had better be clear about what you mean here. This you are talking about finite element part and it just says dynamic analysis. To me, it only means the stick model. How do things move, dynamics. And you mean the stress analysis.

MR. DEAVER: Yes, I am referring to stress analysis.

CONSULTANT WALLIS: Are you sure?

MR. DEAVER: That is what I believe.

CONSULTANT WALLIS: Did you prepare the slide or did somebody else?

TELEPHONE PARTICIPANT: I was discussing something else. Could you please repeat that? MR. WACHOWIAK: Well on the slide they say that in the building dynamic analysis included pool water but not the internal structures.

TELEPHONE PARTICIPANT: That was something we discussed before and I mentioned that I would get back to you whether the equipment load is added to the floor.

MR. WACHOWIAK: Okay but when you say building dynamic analysis, we mean the mass stick model. Right?

TELEPHONE PARTICIPANT: Stick model, right. Yes.

CONSULTANT WALLIS: You do. Right.

MR. WACHOWIAK: The thing is you make it --

TELEPHONE PARTICIPANT: I said this before. In the stick model, the mass includes the building and also the water weight. And he asked if there were another equipment weight added to that. And I will get back to that.

CONSULTANT WALLIS: But clearly with this slide, you did not.

CHAIRMAN CORRADINI: You know, it might be reasonable if overall the mass is a fairly small contribution.

MR. DEAVER: It is, in actuality.

In the next slide, I actually show the masses on the slide.

I am turning my attention to the actual structural analysis of the PCCS condenser. We performed a finite element analysis and in the finite element analysis, we included hydrodynamic mass to account for the displaced water.

CONSULTANT WALLIS: That is a question. You say you added the displaced water mass.

MR. DEAVER: Yes.

CONSULTANT WALLIS: Then what you were seeing it was moving sideways and the added mass coefficient was one.

MR. DEAVER: What we did was we adjusted the density of the structure itself. We added in the mass of internal water plus all of the displaced mass.

CONSULTANT WALLIS: No but hydrodynamically, there is an added mass coefficient when you move a body in water. And for assume it were moving sideways in a large massive flow, it is now a displaced mass.

When you said that there isn't an array, the added mass coefficient is different than one.

MR. DEAVER: In this analysis, we simply added mass to the structure.

CONSULTANT WALLIS: Yes but you have to know how much mass to add. And you add by taking an added mass coefficient times the -- you take the building or the structure, take a coefficient, multiply it by the density of water. In this case, you have the added mass.

If you have cylinders side by side and touching, moving like this, the other mass coefficient is infinite because the water can't get through.

So you know, it really changes the added mass. And I just want to know what you did about that. And when you add a wall, the wall restricts the motion of the water and the added mass coefficient goes up when it is moving towards the wall and away from it. When it gets close to the wall, it has no added mass. I just want to know what you did about those factors.

MR. DEAVER: As we discussed earlier, there is some distance between the structure and the wall. Okay?

CONSULTANT WALLIS: And you can calculate the effect. And if it is small, then you get that.

MR. DEAVER: Okay. What was simply done in this case was to take the three rates, the mass of the structure, the mass of the internal water, and then the whole displaced mass of the structure.

CONSULTANT WALLIS: Yes. So the added mass is 16,295 pounds.

MR. DEAVER: Right.

CONSULTANT WALLIS: And you add that to 27,575. Right?

MR. DEAVER: Right.

CONSULTANT WALLIS: And you get the total mass, which is shaking.

MR. DEAVER: We also have the internal --

CONSULTANT WALLIS: Yes, but that is the common state inside. It is the water inside the tubes.

MR. DEAVER: Yes.

CONSULTANT WALLIS: Right. I am not sure that moves with the tubes but anyway.

So if you have mass coefficient with two and not one, you would be adding 32,600 pounds, which would be more than the mass of the steel, wouldn't it? If you added twice the displaced water mass because the outer most coefficient was two and not one. You have something significant. I just want to know what the other mass coefficient is for this array, which is why I asked what the array looked like.

MR. DEAVER: It is a steady flow, not an accelerated flow.

CONSULTANT WALLIS: No, there is not a nice and steady flow. It is all a dynamic effect. We worked on this problem.

MR. DEAVER: Okay.

CONSULTANT WALLIS: I just want to know what you did. It seems to me someone said oh, we only have a mass for one so we will add one. They didn't consider the effect of the neighboring tubes on the other mass. It may not be important.

CHAIRMAN CORRADINI: He is talking about, that is why we started the whole question about -- he was leading us down a primrose path, with all due respect. That is why he was asking the spacing of the tubes in terms of the array. Because if you cut through it and you look at the array of tubes, if they are tightly packed, they behave as he said and you drive up essentially the equivalent amount of mass. But if they are relatively openly spaced like a very sparse forest, it essentially goes back to essentially what he was talking about as one.

CONSULTANT WALLIS: Think about it. If you are moving a tube, it takes mass with it. So you have to put the water around. And if you move that, when it blocks, it is all added mass.

So if you have some of them side by side, moving like this, and they touch, then they are behaving like a bear. Then there is enormous added mass. If they are in line then there is sort of the slip stream effect decreases the added mass.

So when you have an array, you have to consider all those effects. I don't know how big are your tubes and I think you ought to know. That's all.

MR. DEAVER: Well as far as sloshing is concerned --

CONSULTANT WALLIS: Well it is not sloshing I am concerned about. I am just wondering about the inertia. When you move these things, the question is how much water moves when the things shift quickly in very small displacements.

And it may not be important. I just say

you ought to consider it. And probably because of all the factors of safety, it doesn't matter. But I don't know that until you do the analysis.

MR. DEAVER: Okay. All I am reporting is the very simplistic approach that was used to consider the mass.

CONSULTANT WALLIS: That's right.

CHAIRMAN CORRADINI: So let's let you go on but let's just take at least as an action item. Do you understand now the point he was asking about the impulsive loads so you can at least do a check on that?

MR. DEAVER: Yes.

CHAIRMAN CORRADINI: Okay?

MR. DEAVER: Right.

CONSULTANT WALLIS: The added mass.

CHAIRMAN CORRADINI: The added mass to the impulsive load.

MR. DEAVER: Okay.

CONSULTANT WALLIS: I didn't know how much water was in the tank. When you use the mass of a steel that is small compared with the overall water, that was for the previous slide, do you have any idea how much water is in the tank completely?

MR. DEAVER: Inside the condenser?

CONSULTANT WALLIS: No, in the tank.

MR. DEAVER: In the tank.

CONSULTANT WALLIS: In the pool.

MR. DEAVER: In the pool.

CONSULTANT WALLIS: So maybe this mass of steel is very small compared to --

MR. DEAVER: It is, yes.

CONSULTANT WALLIS: How much water is in the pool?

MR. DEAVER: We could calculate it. It is basically a five meter by five meter by 4.8 meter high pool.

CONSULTANT WALLIS: So it is a hundred cubic meters?

CHAIRMAN CORRADINI: Six hundred and twenty five tons. Five times five times five. I'm sorry. One hundred and twenty five tons.

TELEPHONE PARTICIPANT: One hundred twenty cubic meter.

CHAIRMAN CORRADINI: One hundred five metric tons.

TELEPHONE PARTICIPANT: Right.

CONSULTANT WALLIS: And we have got how many tons of steel here?

MR. DEAVER: Six.

CONSULTANT WALLIS: Twelve. So it is ten times. Okay.

MR. DEAVER: Okay. So we took no credit for the dampening effects in water. And the pool response spectra at the floor was applied to the model, on the building model.

CHAIRMAN CORRADINI: Keep on going.

MR. DEAVER: Okay. The next slide shows the results of the structural design report of the PCCS condenser. As mentioned earlier, the first mode natural frequency was 14.7. For the limiting design condition, which would be the seismic event, I summarized the stresses and allowable stresses and their margins for the different components. At this point, the connecting pipes would the be the limiting component. This would be the connection of the pipe into the top header pipe right at that junction.

So our conclusion from this is that we have large structural margins in this structure because of the low pressures and so forth.

The next slide shows the results of an analysis that was done for the actual sloshing force at different elevations in the pool starting with at the very surface going to the bottom of the pool.

CONSULTANT WALLIS: And this is a

sloshing? This is really due to the -- it is not sloshing. Now we are talking about you have a 14.7 Hz response. It is not sloshing at all.

MR. DEAVER: This is going back to the building dynamic.

CONSULTANT WALLIS: No I think you are using sloshing for two different meanings. When you get this high frequency, the thing shakes very rapidly. Gravity is irrelevant. There is no sloshing going on at all. It is all the impulsive modes that matter and sloshing shouldn't appear in these slides at all because you are not talking about sloshing. You are talking about the motion of the water in response to the impulsive loads. That is what we are talking about.

CHAIRMAN CORRADINI: He was getting back to the building now.

CONSULTANT WALLIS: Oh you are back now to the sloshing?

MR. DEAVER: Yes.

CONSULTANT WALLIS: Or were you talking about the previous slide? You just analyzed the motion. What you ought to do is take the motion you just analyzed for that PCCS structure and go back and figure out what effect that has on the figure and see how much it changes the impulsive mode. I thought that was what you were going to do. Now all of a sudden you are talk about sloshing, which is a low frequency thing. Is that what you are talking about?

MR. DEAVER: Well that was the topic that I thought we were addressing today.

CHAIRMAN CORRADINI: Just for clarification, Graham, I think they have now gone back to the building.

CONSULTANT WALLIS: Gone back to sloshing?

CHAIRMAN CORRADINI: So this slide is not connected to the previous slide.

CONSULTANT WALLIS: It is. It is because what the impulsive loads are on this structure effects the building and the coupling between them. That is what I am looking for in the next slide and now you are going -- okay, you have gone back to something else.

MR. DEAVER: Yes.

CONSULTANT WALLIS: Which is gravity driven sloshing?

MR. DEAVER: Yes. What I am trying to do is given appreciation for what type of loads sloshing creates on the walls in the structure itself.

CONSULTANT WALLIS: Well what type of

loads does this previous 14.7 Hz shaking of the structure impose on the walls? That is more interesting to me. That is the one that matters.

CHAIRMAN CORRADINI: But let's just take a step back, just real quick. So let him at least go through this. And so what you are asking for is once we know this effect, you want to compare it on a relative basis to the dynamics --

CONSULTANT WALLIS: Well he could reshapes a structure in a water pool, it effects the rest of it. Sloshing has nothing to do with -- I mean gravity has nothing to do with that.

If you lit a bomb off in a swimming pool, you might knock the walls off. Right? It's like an extreme case. If you get something shaking in the pool.

So I don't understand the sloshing -- well okay. Go ahead.

MR. DEAVER: At any rate, this gives you an appreciation for the sloshing loads that were calculated on the pool wall itself.

CONSULTANT WALLIS: By sloshing you mean -- no, I am serious.

MR. DEAVER: That effect, yes. Not the impulsive rigid --

CONSULTANT WALLIS: For the it going up by 4.2? Gravity force goes up by 1.39 psi?

MS. CRUZ: I think the --

MEMBER SHACK: These are stresses.

MR. DEAVER: These are pressure forces.

CONSULTANT WALLIS: But they are driven by gravity and pressure must lift the water that is sloshing.

MR. DEAVER: That is the side load onto the wall.

CONSULTANT WALLIS: But that is tied into it all because of hydrostatics. I mean just -- it is a sloshing mode but psi is going to lift the wall because --

MR. DEAVER: That is the component but this is the effect of the horizontal sloshing.

CONSULTANT WALLIS: It is tied together because gravity is driving what is happening. You can't have one without the other.

I wonder if you really are analyzing sloshing as driven by gravity.

CHAIRMAN CORRADINI: But you can't slosh without inertia.

CONSULTANT WALLIS: Yes but the inertia because of that because they are tied together. When it stops, it is not moving. So it really goes up a foot or two, this sloshing stuff?

MR. DEAVER: This is only accounting for the zero location, which is the --

CHAIRMAN CORRADINI: Gerri, let me just, I think I know where he is going so let me just say it back to you to make sure we are on the same page and then we have to go on.

I think Graham's point is near the surface you are predicting a pressure of about 1.4 psi.

MR. DEAVER: Yes.

CHAIRMAN CORRADINI: A tenth of a ball, which means the water rose a meter.

CONSULTANT WALLIS: That is right because he says the distance below the water level is zero on the left side here.

CHAIRMAN CORRADINI: But does it Graham? In some sense, I mean, I look at the gradient of this and it is actually a very steep gradient. So you are down to less than maybe ten or 15 centimeters of movement down deep into the pool.

CONSULTANT WALLIS: That is what happens with water waves.

CHAIRMAN CORRADINI: So I think he is just observing the fact that --

CONSULTANT WALLIS: But I have difficulty believing that the level goes up three feet or something on the top. Does it?

MEMBER SHACK: Didn't we actually see that and solve a seismic event?

CONSULTANT WALLIS: So there is evidence. Okay. Thank you. So it did go up.

MR. DEAVER: Yes.

CONSULTANT WALLIS: Okay, thank you. So we are talking about sloshing.

MR. DEAVER: Yes. I said that we calculated that the elevations with the centerline of the headers were at the elevation of 1.38 and 1.58 to see what thee pressure of sloshing force would be at that elevation. And the value is quite small compared to other loads that are going to be applied to the structure.

And particularly in dynamic analysis where we use some SRSS methods to take different components, when you look at the magnitude of the other components, such as the best impulsive load and the structural loads, then the sloshing effects, in essence, are very, very small and a minor effect on the actual structure itself.

CONSULTANT WALLIS: But let me go back to the previous question here. When you have an array of tubes near the wall and they are oscillating, they move water with them. So there is water at the wall as they move to and fro. So there is a load on the wall due to the moving of a structure near the wall. That is what I was looking for.

So now you have done this analysis of the added mass and all that and there is no numbers on these slides but when you are talking about structural design, headers, calculated stress, allowed stress, whatever that is, number four here, now I see you having done that, what is the effect on the wall?

CHAIRMAN CORRADINI: Gerry, just to make sure I am clear, Graham's point, I think is, that he feels comfortable there is no sloshing but now he is back with the impulsive load and he wants to do some sort of comparison quantitatively between what that layer is and what the --

CONSULTANT WALLIS: I think you will find the load is bigger than the sloshing load if you --

CHAIRMAN CORRADINI: Right.

MR. DEAVER: Yes. Well, what we were trying to address today was sloshing.

CONSULTANT WALLIS: ACRS used the word sloshing?

CHAIRMAN CORRADINI: It is our fault. We asked for it.

MS. CRUZ: Well it has been a long time since we had the subcommittee meeting. So I think too many memories are fading away. But at that time, I believe the committee was satisfied with the response of the water impacting on the structure. And the remaining concern was the effect of the water on the components themselves and what is that factored in.

And so that was the point of this presentation. I do know that there are some lingering concerns perhaps with the material that was presented before. GE was not prepared to discuss that in detail today. So we need to get some guidance from the committee on if you want more information we can ask.

CHAIRMAN CORRADINI: Before we give you an action item that may or may not be necessary, I guess the only observation is I see a few open items that you guys want to clarify but I will wait until you are finished and just to review them so we are on the same page.

MR. DEAVER: Okay, the next slide. As I mentioned earlier, we have not analyze the IC condenser structure, performed that structural analysis. So our plan is to complete the analysis as part of the detailed design of the plant.

The sizing of the condenser already considers the normal operating condition loads and use Alloy 600 materials to provide a stronger material response to the higher stresses.

Dynamics can be readily taken care of by the support structure by fixturing and support similar to the PCCS support structure. And then added loads can be taken care of by the structure itself.

We expect the sloshing loads to be very close to the PCCS condenser loads. It is closer to the water surface but it is also shorter. So the actual surface area times the pressure comes out with a similar load. And the PCCS condenser will be analyzed using the same analysis methods as the PCCS condenser. And we are not anticipating any problem with the actual analysis when it is performed.

And as far as conclusions, we considered the effects of sloshing on the PCCS and ICS condensers but we haven't separately analyzed them due to the conservative hydrodynamic analysis methods that were used.

The effects of sloshing are expected to be very small compared to the other dynamic loads.

And based on the large structural margins, we don't see any problems with the IC calculation that will be performed.

So that is our prepared material.

CHAIRMAN CORRADINI: Okay, let me at least review. Thank you very much. Let me just ask for questions from the committee. Let me just at least review what I had written down because you guys wanted to check a few items of information.

One was the question about the lattice arrangement. And I think that couples back to Graham's question about the impulsive loading. The guess is that the lattice arrangement is such that the added mass approach you are taking may be appropriate, it is just a matter of getting clarity.

Also, Professor Abdel-Khalik was asking the question about relative to the header arrangement, the isolation condenser, since it is out of the water and what are the thermal stresses. We left that to mean that the pressure and thermal stresses are essentially going to have to be calculated when the detailed design is done. So at this point, it remains an ITAAC that has got to meet ASME code levels.

And then the last one that I have down here is that there was a question about what the natural frequency was and one of your colleague was going to check on that and get back to us. More information on all of these cases.

MR. DEAVER: Right.

TELEPHONE PARTICIPANT: And that is our duty.

CHAIRMAN CORRADINI: Excuse me?

TELEPHONE PARTICIPANT: And that is our other duty.

CHAIRMAN CORRADINI: Correct, yes.

MR. DEAVER: So as a follow-up, I have the drawing the lattice.

CHAIRMAN CORRADINI: Okay.

MR. DEAVER: It is here. Pass this around but we have someone coming up, driving up today, and he is going to bring the drawings but if you want to talk a look at it on the two-inch screen, I have got a version of it here.

CHAIRMAN CORRADINI: Now you know the virtual mass coefficient for that lattice.

CONSULTANT WALLIS: Mr. Chairman?

CHAIRMAN CORRADINI: Yes, sir.

CONSULTANT WALLIS: When we are talking about the stresses in the structure, you have got stresses of 100 megapascal. A big stress. And then the sloshing of course they are talking about kilopascal. For something that is 10,000 times bigger on the pipes, now I don't know what it is on the walls, but if I can set up 100 megapascals in the pipes, even if it is attenuated by a factor of 100 to one, it is still a megapascal in the walls, which is 100 times bigger than what you are worried about in the sloshing. So, I think I have reason to be interested in the coupling between the motion of the structure and the wall.

The numbers are so much bigger. I mean, so much bigger. And then when you do this, and you take, naturally, if you put in some kind of a forcing function like seismology and you worry about, do you worry about some sort of resonance at the structure?

MR. DEAVER: The structure with respect to the --

CONSULTANT WALLIS: You put in the frequency from the seismic. There is no resonance frequency in the seismic itself. It is just the whole spectrum of stuff. But the response is particularly at the resonance frequency. Is that why we are getting this high stress because there is a component of 14.7 Hz in the seismic driving force?

MR. DEAVER: Which slide are you talking about?

CHAIRMAN CORRADINI: I think he is on the slide, can you go back three slides?

CONSULTANT WALLIS: Right here where you say you have a margin of 38 percent. Now if you multiply the other mass by a factor of two, this might be significant in changing that stress.

MR. DEAVER: Well that would only add another 48 percent.

CONSULTANT WALLIS: Well I don't know how much it adds but if it adds 48 percent, that is more than your margin of 38. So it seems to me you ought to do this again.

CHAIRMAN CORRADINI: So why don't we just summarize. So this is the peak stresses near the natural frequency based on the seismic input. And Graham's question is just to be clear with the impulsive load making sure the added mass is appropriate. Otherwise if it is missing it, you might be closer to the margin you first suspect.

CONSULTANT WALLIS: And what effect does it have on the wall? If it can produce these very large stresses in the pipes, does it have some effect on the wall?

MR. DEAVER: The location where the higher stress is, it is also supported well.

CONSULTANT WALLIS: Is it at the bottom or the top?

MR. DEAVER: This is at the top. The connecting pipe is at the top connection to the top header pipe.

CONSULTANT WALLIS: Oh these things are coming across the top.

MR. DEAVER: Yes.

CONSULTANT WALLIS: Okay because the other pipes are trying to move --

MR. DEAVER: Right.

CONSULTANT WALLIS: -- and that is restrained in the middle that connecting pipe.

MR. DEAVER: Right.

CONSULTANT WALLIS: Okay. Maybe you ought to not restrain it in the middle and you would be okay.

CHAIRMAN CORRADINI: We are not going to design it for him.

CONSULTANT WALLIS: Okay.

CHAIRMAN CORRADINI: We just observe.

CONSULTANT WALLIS: Okay, thank you.

CHAIRMAN CORRADINI: Okay. Other questions.

MEMBER SHACK: Yes, I had a question on

the choice of materials for the isolation condenser. Now you said you are going to use Alloy 600 because it is stronger.

MR. DEAVER: Yes.

MEMBER SHACK: Is that driven by this concern about sloshing or just other factors?

MR. DEAVER: The combined situation.

MEMBER SHACK: Because it is a higher pressure system?

MR. DEAVER: Right.

MR. ANTHONY: Actually, it is a heat driven thing. That is one thing -- I mean, a heat transfer, you want the walls thin. And so you want to use a higher strength material to deal with it, get the heat transfer.

MEMBER SHACK: Okay. And the big headers and all of that is in canal?

MR. ANTHONY: All canal, yes.

MEMBER SHACK: Okay, that is a very pricey thing.

MEMBER SHACK: Okay, the other thing is just my recollection of when we started this was concern that the sloshing would put loads that hadn't been taken into account onto the walls. Well my concern was that sloshing that put loads on the component, the condensers themselves, where they are supported at the base and basically damage the component in a seismic event so they wouldn't be available to do their job if you had an accident.

So somehow I think we got, at least I got confused that we got that answer. Are these components going to be, have a lot of margin at their structural supports, the component itself, the tubes, attachments to the header? Is that analysis yet to be done?

MR. DEAVER: On the IC system, yes.

MEMBER SHACK: And but the PCCS you feel you demonstrated that you got margin?

MR. DEAVER: We have done the analysis and have the results.

MEMBER SHACK: Okay. I think you need a little bit more.

CHAIRMAN CORRADINI: Well can I just rephrase what you just said? At least I heard differently when you first said it to Sam. My understanding is that they have done the structural support for the PCCS. They have analyzed it. They see a lot of margin relative to our original question about sloshing. And they have yet to do it with the isolation condenser. But going forward, they will use the same design approach so they expect the same result.

MR. DEAVER: Yes.

MEMBER SHACK: And my question was the Alloy 600 selection had nothing to do with sloshing.

MR. DEAVER: No. It was driven by the heat transfer.

CHAIRMAN CORRADINI: Okay. Other questions? Thank you very much.

Staff is going to join us up here.

CONSULTANT WALLIS: One thing occurs to me. When you did these in Switzerland or something on the PCC condenser, did anybody shake it and see what its frequency was?

MR. DEAVER: No, this was a performance test. It wasn't a --

CONSULTANT WALLIS: No one has shaken the condenser yet?

MR. DEAVER: No.

CONSULTANT WALLIS: Thank you.

MR. LE: Hello. My name Tuan Le. I am the lead technical review for the SRP section 3.9.3. This section for my technical review consider is condenser, concentrate on component, component support and core support structures.

I am really taking the responsibility for 3.9.3 for technical review and awareness of review 2.4.7, regarding the structural effects of the seismic analysis.

I would like to review here a little bit the background and the RAIs and the result of the review, the RAI. Back then, the previous issue, the seismically induced dynamic loads could affect the structure, effecting basic changes, submersing the loads in the water pool.

Then this committee reviewed and asked additional question needed to demonstrate the dynamic loads forced and the seismic event could affect loads in the analysis of the heat exchanger such as the reactor, ICS condenser and ICS and the containment coding system in the PCCS heat exchanger. This equipment is submerged into a large water pool.

In response to that response, generally an RAI, the staff asked GEH to demonstrate how dynamic forces from seismic events treat it in the nozzle of the heat exchanger submerged in the elevated water pool.

They responded with a letter and as part of their response, it was disclosed in the product 2008.

This response was reviewed. The GEH responded to RAI and we had discussion in the telecoms and prior to their responding to the RAI in the 22,000 words.

In addition to that meeting, telecom, and the meeting on October 14 of this year, the staff noticed that two items. One is the PCCS submerged changes support and the seismic is complete but the ICS submerged changes support is not completed.

Therefore, in the supplement of this RAI, the staff preferred that the applicant provide DCD changes. The staff asked the applicant to provide these changes to describe the methodology of the sum of the masses with the sloshing effect asked in previous presentation from the application regarding to these methods.

And secondly, the staff would like to have the method to compare the ICS and the PCCS heat exchangers' support design to follow up and make a comparison. This has been completed.

That is all I have for today.

CONSULTANT WALLIS: So you don't have any of the kind of questions that I was asking?

MR. LE: No.

CHAIRMAN CORRADINI: Did you hear his

question?

MR. LE: I'm sorry?

CONSULTANT WALLIS: Did you hear the questions I was asking GEH when they were up there? I just wondered if you asked any of the same kind of questions.

MR. LE: Well the discussion on the 10/14 meeting last week, we asked about the pressure regarding the mass methodology. What happened was my question was asking them what method that they applied through the PCCS system and the stress location is where is it located on the pipe wall or on the wall of the pipe, pipe connection to heat exchanger on the support system. But it lead to the ICS system has not been completely designed for the support here.

What I will see is that the stress would be in the system wall or the piping itself because it is a pressure retaining component.

CONSULTANT WALLIS: But you didn't ask the questions about the affect of the array or the walls on the added mass of the structure.

MR. LE: No.

CONSULTANT WALLIS: You didn't ask any of those. Okay. So I have to be very explicit in my report.

MEMBER SHACK: Did your review address the loads on the PCCS structure where it is bolted or attached to the floor? Did you address? Because it would seem to me if there are sloshing loads, you have a big moment at the very top of the equipment, which is transmitted down to where it is connected to the floor. And that, you put stresses there and then you have got your vertical component as the water changes. Buoyancy tends to let things up.

So did you go to that level of detail in your review?

MR. LE: As far as that level of detail has not been provided to the staff until now because the detail of that would be in the design report. The staff hasn't looked at that because it is not available at the time that I took responsibility for review.

MEMBER SHACK: So that is not taken into account in this analysis?

MR. LE: The analysis was based on the previous discussion and also when we discussed with them, as described to the applicant earlier, taking the effect of the stick model where they had the spectrum and the load. And you got load in the header model to generate the stresses there.

And you have got a sloshing effect at the top a little more challenging for the stick model to simulate the force loading condition combination with the mass of the equipment, the mass of the water.

MEMBER SHACK: Yes. Well just my concern is more that this equipment could basically, unless it is anchored properly and analyzed very carefully, that that is where the weak link is, is the loads that are transmitted to that support structure while it is anchored.

And apparently, I don't know if GEH has done that analysis to size the bolting or whatever arrangement they have to make sure that that doesn't happen.

CHAIRMAN CORRADINI: So let me take a -- I guess -- well, I didn't want to interrupt the staff. You go ahead and finish answering his question. I'm sorry. Go ahead.

MR. LE: It doesn't --

MEMBER SHACK: Yes, it is very simple. If there was no water in those pools, this would just be a plain dynamic seismic analysis. Okay, you get your modes and stresses and you could do it.

But since you have got water and it is moving, it is a backed up effect, it is putting big loads at the top of those structures. Those structures are very stiff. Those load stresses are transmitted down to where it is rigidly attached to the floor. And the question is, has that been analyzed enough so that you know it is going to stay there and not break physically.

MR. LE: In that detail, I haven't had that stress indication. Also the how the method used result in that stress that transmitted materially in the structure.

MEMBER SHACK: Okay.

MR. LE: No, I didn't work on that.

MEMBER SHACK: Well maybe GEH has done that. Maybe I am totally off base but is that a really significant concern to GEH?

MR. LE: Does anybody want to answer that question? Did it stress the support of the piping as it changes?

CHAIRMAN CORRADINI: GEH, did you hear the question?

MR. WACHOWIAK: Yes, this is Rick Wachowiak. The question was, have we analyzed the forces on the component itself being translated down into the anchorage on the floor. And that is a to be done analysis.

We have the forces on the component and it looks reasonable that we will be able to design the support structure to support that and not break that support. But that specific calculation has not been done yet.

MEMBER SHACK: Okay. I hope somebody does it.

CHAIR CORRADINI: So let me just roll back. Do you understand the question that Dr. Wallis was asking about the impulsive load not the sloshing load? We kind of did a bait and switch with GEH. So we are going to do the same thing with you.

Have you looked at the analysis they have done relative to the PCCS, since that is the structural support? They looked at the PCCS structure and then the associated pool and you are satisfied with what they have done?

MR. LE: I think that the methodology, we are satisfied with the response to the RAI. Although we see other methods that used the code generally the seismic effect and all the impulse.

CHAIRMAN CORRADINI: Great.

MR. LE: But this method the staff RAI respond seriously but then the authority is to send it back and respond for the staff review. For me, I discussed with them recently and I have no objection to their method.

CHAIRMAN CORRADINI: Okay. So, but just let me be clear and then we will leave it at that.

In some sense, at least personally, I don't disagree with what you are saying. I think they answered the RAI. I understand their response. I understand your position. And I am not worried about what we originally brought up.

But in the conversation we had today the concern was raised, or at least the check was questions -- the question was raised that the impulsive loads depend upon an assumption relative to essentially the added mass. And is that added mass appropriately computed? So I think that is just kind of a check that we want to be clear about. At least that is --

So I just wanted to make sure you understand what our question was.

MR. LE: Yes, Mr. Chairman, I understand that question.

CHAIRMAN CORRADINI: Okay.

MEMBER BANERJEE: What is the volume --

CHAIRMAN CORRADINI: Good morning Dr. Banerjee.

MEMBER BANERJEE: Good morning. What is the volume of water within the bundle or the mass of water? Because added mass obviously relates to that. Right?

MR. LE: I understand --

MEMBER BANERJEE: My assumption would be --

CHAIRMAN CORRADINI: Well if you had been here, it is in the slide number 11. I'm sorry. I had to do that to you. I'm sorry. That is inappropriate.

MEMBER SHACK: It will all be covered, 2,779 kilograms.

MEMBER BANERJEE: Okay. And the mass of the -- so all of this mass is taken into added mass.

CHAIRMAN CORRADINI: Right. We will catch you up on this. But basically the question was they assumed an added mass factor that depends upon the details of the header design -- not the header design -- the tube design and we still want to be clear about what that tube design was so that what they assumed and what the tube design are consistent.

CONSULTANT WALLIS: They just assumed an added mass coefficient of one.

CHAIRMAN CORRADINI: Yes.

CONSULTANT WALLIS: Irrespective of the

tube design or the proximity of the wall, all these other things.

MEMBER BANERJEE: Well, the coefficient is one but the amount was --

CONSULTANT WALLIS: No, the coefficient is not one.

MEMBER BANERJEE: No but the amount of material in that --

CHAIRMAN CORRADINI: That we know.

MEMBER BANERJEE: All the interstitial liquid. Right?

CONSULTANT WALLIS: No, they don't do that. They take the water displaced by a tube.

CONSULTANT WALLIS: Well, we can talk about it since we have been through this.

CHAIRMAN CORRADINI: Okay. So we will catch you up. We will catch you up.

MEMBER BANERJEE: All right.

CHAIRMAN CORRADINI: Other questions for Mr. Le?

MEMBER ARMIJO: I have a quick questions, as long as we have all of the sloshing experts here.

In the analysis, how high were the seismic events that you were treat? How high up the wall does this sloshing occur? And are you sure that you can retain all of the water, that it always stays in the pool or can it slosh out of the pool?

Do you have an answer to that?

MR. ANTHONY: There is a cover on the compartment.

MEMBER ARMIJO: So it never gets -- it just puts loads on the top and sloshes right back.

MS. CRUZ: Is the concern a flooding concern?

MEMBER ARMIJO: No, I just thought -- I didn't know.

CHAIRMAN CORRADINI: He was worried about losing inventory.

MEMBER ARMIJO: Losing water, yes, that it stays put.

CONSULTANT WALLIS: What is the force on the cover?

MS. CRUZ: I guess we are talking posturally in a seismic event and them needing the equipment for a LOCA.

MEMBER ARMIJO: Yes.

MS. CRUZ: Okay.

CHAIRMAN CORRADINI: Okay, other questions for Mr. Le?

Thank you very much.

MS. CRUZ: Should we take a break now?

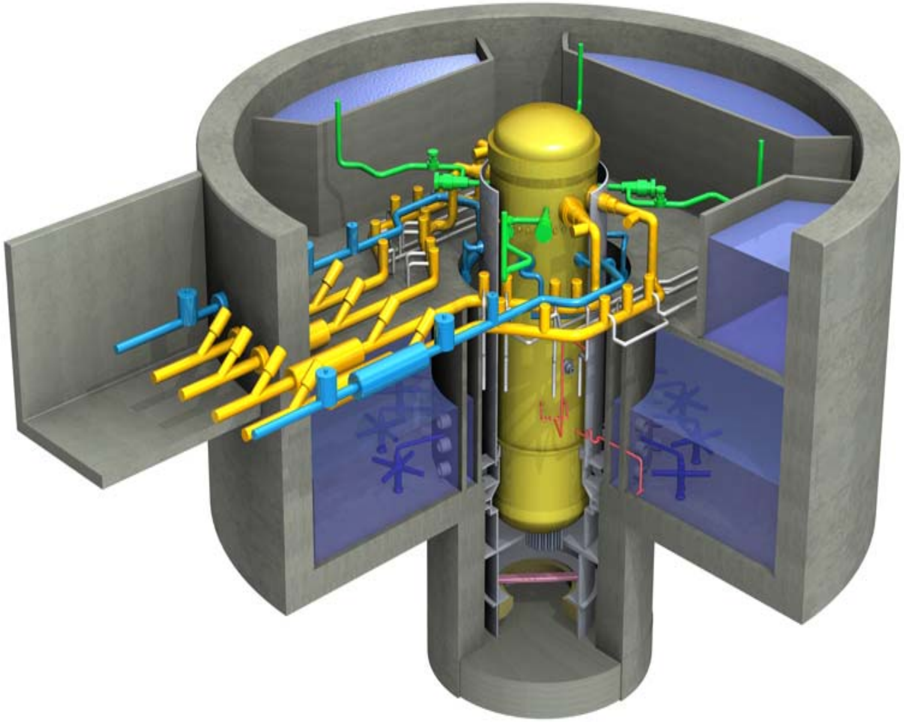
CHAIRMAN CORRADINI: Well, I think this would be the most logical thing to do at this point. Why don't we take a break until about 20 of and we will go into closed session. We will shut down the bridge line and we are going to come back together.

(Whereupon, the foregoing matter went off the record at 10:23 a.m., ending the open session, and resumed at 10:42 a.m. to the closed session.)

ESBWR DCD

Seismic Design of PCCS & ICS Reactor Hardware (impact of sloshin water)

Advisory Committee on Reactor Safeguard



October 20, 2009

GE Hitachi Nuclear Energy

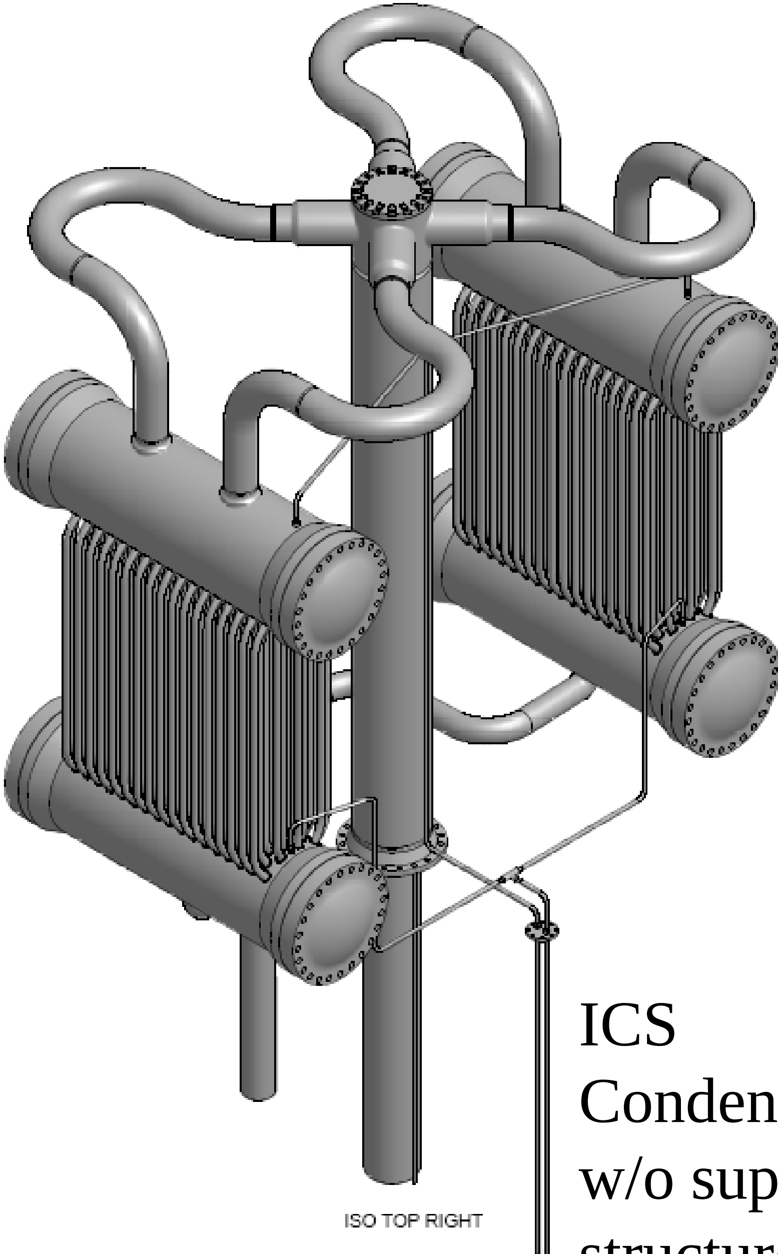
Agenda

- RAI Status
- Review of IC & PCCS Condenser Configuration
- Review of Reactor Building dynamic load evaluation
- Review of the PCCS Condenser structural analysis methods
- Results from PCCS Condenser Design Report
- Sloshing Pressure Results
- IC Condenser Analysis
- Conclusions

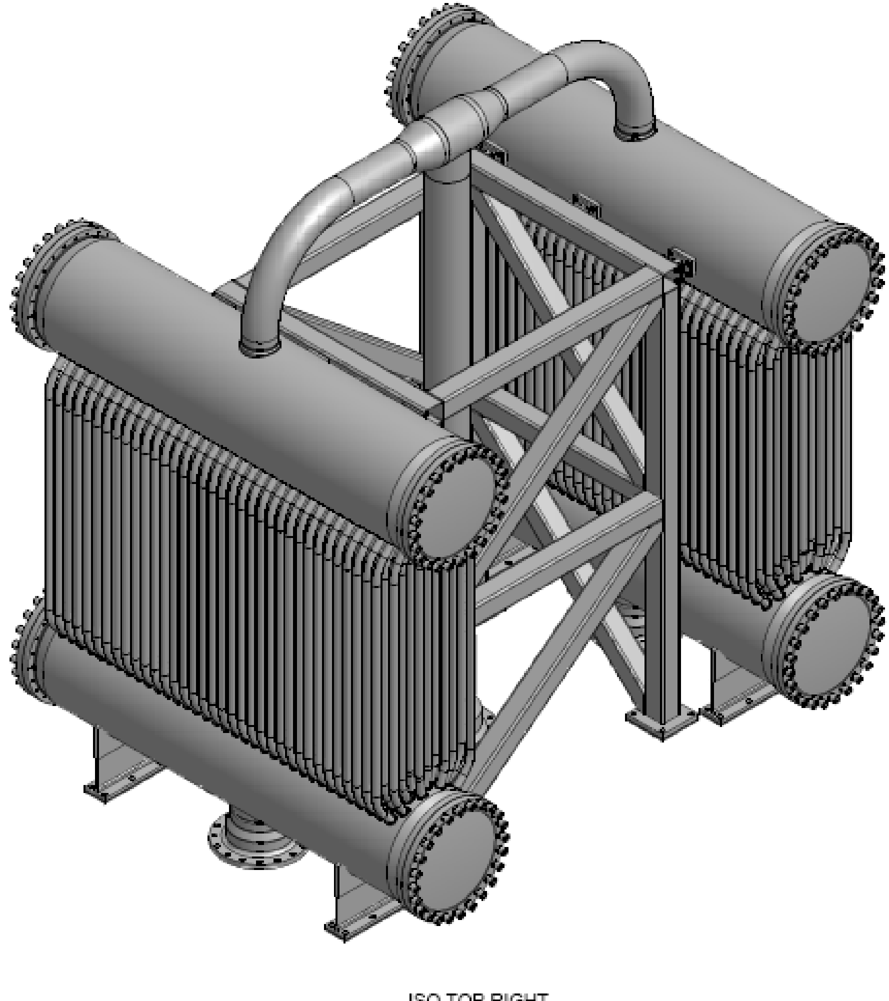
RAI Status

- RAI 3.9-247

  Requested details on how hydrodynamic including sloshing loads on the IC and PCC Condensers are addressed
- This RAI has been Resolved

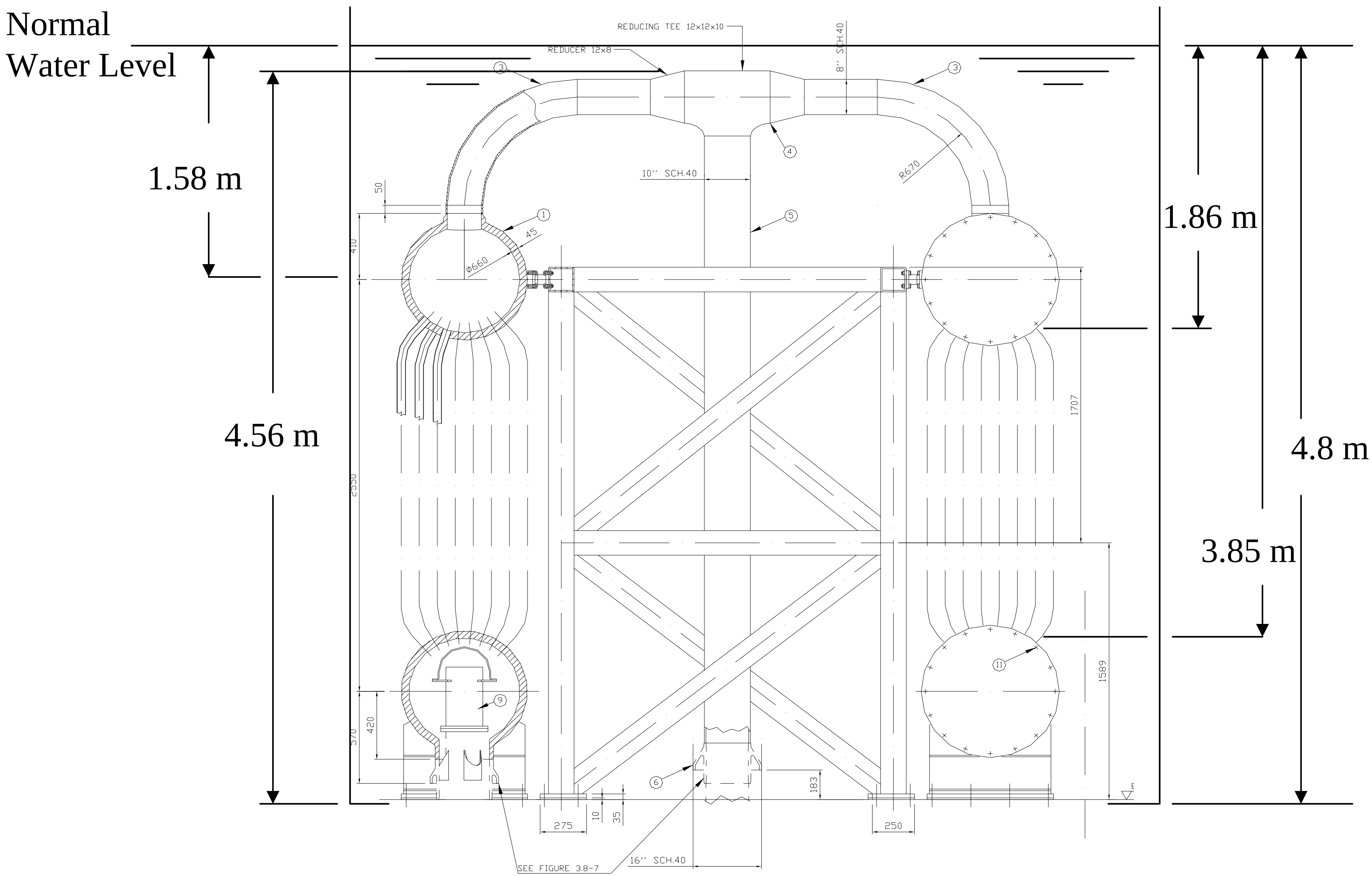


ICS Condenser w/o support structure

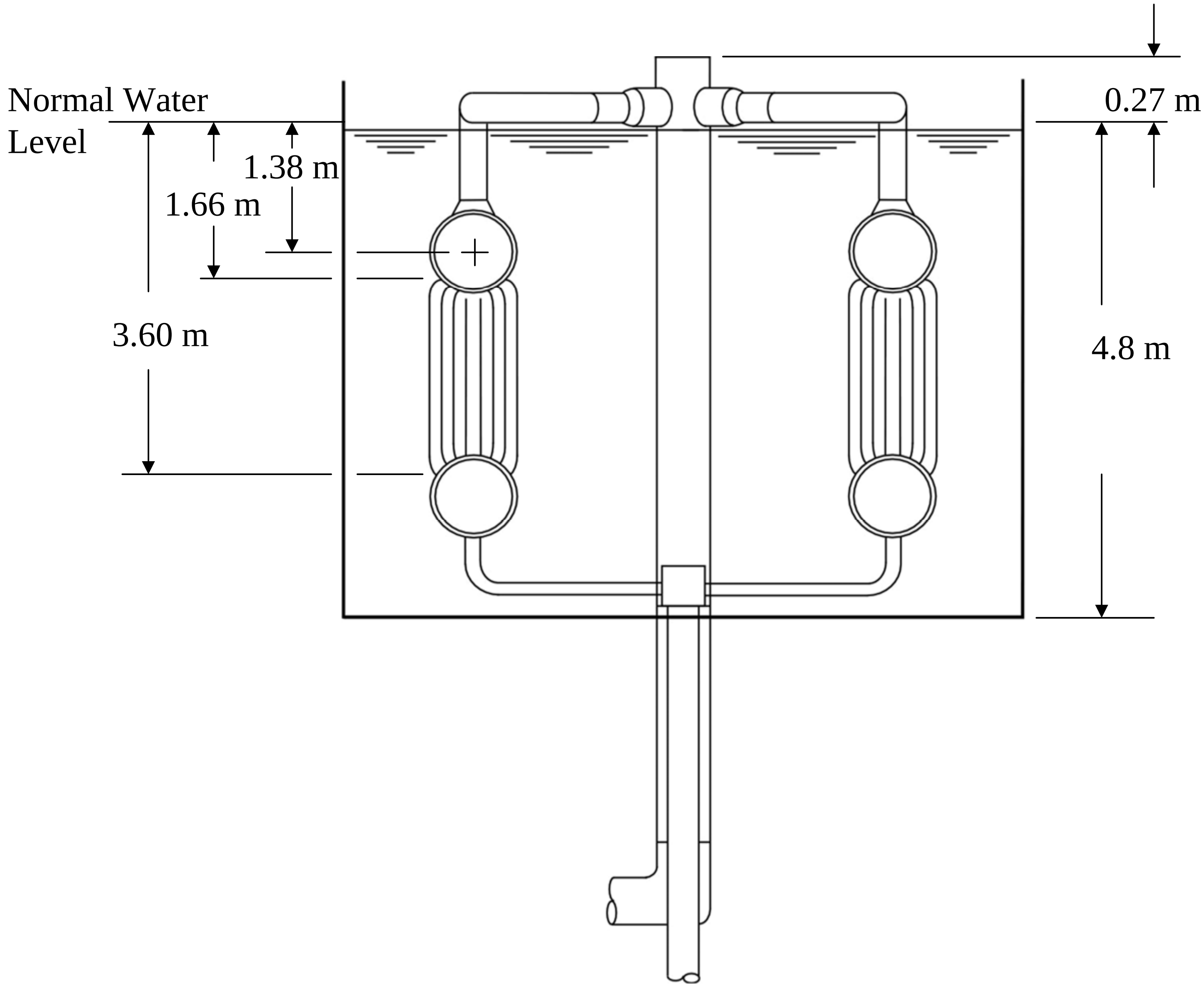


PCCS Condenser with support structure

PCCS Condenser

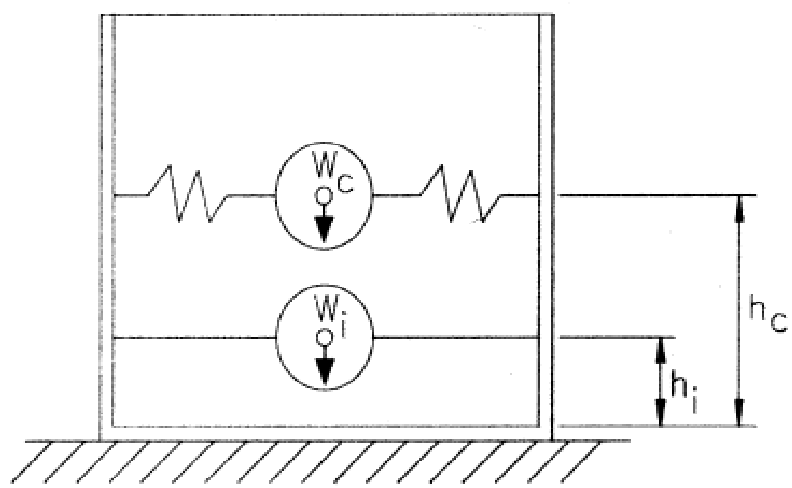


Isolation Condenser Schematic



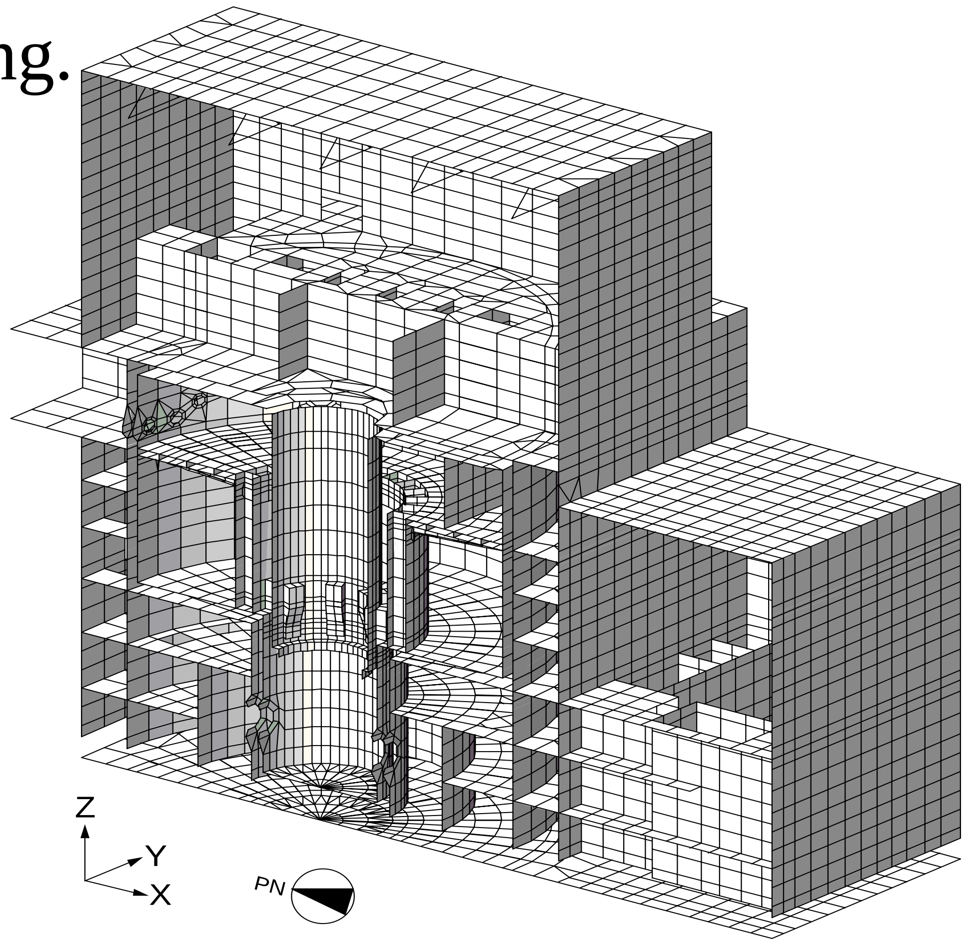
Modeling of Pool Water under Seismic Conditions

- Fluids contained in pools are commonly modeled as mass-spring system made of convective (sloshing) and impulsive (rigid) components.



Stress Analysis of Pool Structures

- Each pool structure is explicitly modeled and included in the overall finite element model of the building.



Modeling of Pool Water in Reactor Building Seismic Analysis

- Sloshing component responds in very low frequencies (typically<0.5 Hz) where no structural modes of vibration exist
- Impulsive component responds in unison with the pool structure and its effect is treated as added mass
- The sum of masses associated with each component is equal to the the total water mass in the pool
- For conservatism, the entire water mass of each pool is considered as impulsive mass rigidly attached to structural nodes in the seismic stick model for predicting overall response of the building structure
- All pools are included in the model, thus the effect of pool interaction is accounted for

Stress Analysis of Pool Structures

- Input seismic loads consist of
  - Global loads in the form of maximum shear, moment and accelerations calculated from the seismic response analysis.
  - Local loads in the form of hydrodynamic pressures due to convective and impulsive modes on the pool boundaries.
- Resulting stresses are combined with others per required load combinations to meet design code acceptance criteria.

Sloshing Sensitivity Evaluation

- An assessment was completed to determine whether sloshing could cause a local variation in the Reactor Building structure frequency
- Conservatively excluding the sloshing mass resulted in a total mass reduction of 4% for the RB, and a frequency variation of < 2% at the pool elevation
- This is well within the +/- 15% broadening range for design floor response spectra

Summary of Reactor Building Dynamic Analysis

- For the PCCS/ICS pools, the building dynamic analysis included the pool water but no internal structures
- The reactor building seismic model included all pool water mass as impulsive (rigid)
- A separate sloshing sensitivity evaluation concluded that any local building frequency shift would be insignificant
- A separate analysis has been performed, using standard equations, to calculate sloshing pressure loads on the pool wall structures

PCCS Condenser Structural Analysis Methods

- A Finite Element Model (FEM) was prepared for the condenser and support structure

  - FEM included hydrodynamic mass to account for the displaced water mass of the Condenser

  - The analytical process of adding displaced water mass to the structure conservatively accounts for all the hydraulic effects including sloshing [7,390 kg (16,295 lbs) of external water mass was added to the FEM = 48% mass increase]

  - The Condenser steel mass is 12,510 kg (27,585 lbs) and the internal water mass is 2,779 kg (6,128 lbs)

- No credit was taken for the damping effects of the water in the model
- The pool floor response spectra from the reactor building dynamic analysis were used to input the dynamic effects into the base of the condenser and support structure FEM

Results of PCCS Condenser Structural Design Report

- First mode natural frequency was 14.7 Hz
- Limiting Service Level C/D Stress Results (MPa)

	Calculated Stress	Allowable Stress	Margin %
- Headers	47.8	137.9	65
- Tubes	66.4	180.7	63
- Connecting Pipes	112.9	180.7	38
- Head Cover	92.0	180.7	49
- Head Bolts	70.3	220.2	68

Large Structural Margins Exist

Reactor Building IC/PCCS Pool Wall Sloshing Pressure Results

	Distance below water	Sloshing Force	Sloshing Force
	meters	kN/m^2	psi
	0	9.56	1.39
	0.96	5.40	0.78
CL of IC Upper Header	1.38	4.25	0.62
CL of PCCS Upper Header	1.58	3.81	0.55
	1.92	3.19	0.46
	2.88	2.14	0.31
	3.84	1.87	0.27

•Actual Sloshing Loads applied to the condensers will be less (water mass is decreased due to displaced mass from condenser, condenser dampens sloshing)

•Since dynamic loads are combined by SRSS (not phase coherent), any stress increase from sloshing becomes negligible

The effect of a sloshing load is very small compared to Impulsive Water and Seismic Structural loads

IC Condenser Structural Analysis

- Analysis will be completed during the detail design of the plant
- The sizing of the condenser already considers the loads cased by normal operating conditions, and the design uses higher strength materials (Alloy 600) for the Condenser
- Dynamic loads can be readily taken care of by the support structure that is expected to be similar to the PCCS support structure
- Sloshing loads on the IC Condenser that are very close to the PCCS Condenser loads are considered negligible
- The ICS Condenser will be analyzed using the same conservative analytical methods as the PCCS Condenser
- No problems are anticipated with the ICS Condenser based on the large structural margins of the PCCS Condenser

Conclusions

- The effect of water sloshing in the PCCS and ICS Condensers have been considered, but are not separately analyzed due to the conservative hydrodynamic analytical methods that are used
- The effects of sloshing are expected to be very small compared to other dynamic loads and the support structure placement is ideally located to react such loads
- Based on the large structural margins calculated for the PCCS Condenser, there will be no problems in completing the IC Condenser design analysis

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review

Topic of Interest:

Seismic Design of PCCS and ICS RH (impact of sloshing water)

October 20, 2009

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Topic of Interest
Seismic Design of PCCS and ICS RH (impact of sloshing water)

Review Team

- Lead PM
  - Amy Cubbage
- Lead Technical Reviewers
  - Tuan Le (SRP 3.9.3)
  - David Jeng (SRP 3.7.2)

RAI Issued

RAI 3.9-247: Staff requested GEH to demonstrate how dynamic forces from seismic events are treated in the analysis of heat exchangers immersed in elevated water pools.

RAI Status

- RAI response in GEH letter MFN 08-743 (ML0821406820)
- RAI was closed in October 2008

RAI Response Review Results

- GEH'S RESPONSE OF THE RAI IS SATISFATORY.
- PCCS SUBMERGED HEAT EXCHANGER SUPPORT DESIGN AND SESIMIC ANALYSIS IS COMPLETED.
- ICS SUBMERGED HEAT EXCHANGER DESIGN IS NOT COMPLETED.
- DCD CHANGE TO DESCRIBE THE METHEDOLOGY OF SEISMIC ANALYSIS WITH SLOSHING EFFECT ON ICS AND PCCS HEAT EXCHANGER. ADD ITAAC TO CONFIRM THE ICS AND PCCS HEAT EXCHANGER SUPPORT DESIGN.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
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Discussion/Committee Questions