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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

January 16, 2008

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARD

(ACRS)

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ESBWR SUBCOMMITTEE

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WEDNESDAY

January 16, 2008

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ROCKVILLE, MARYLAND

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The subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Michael Corradini, Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL CORRADINI, Chairman

SAID ABBEL-KHALIK, Member

J. SAM ARMIJO, Member

SANJOY BANERJEE, Member

DENNIS C. BLEY, Member

COMMITTEE MEMBERS (continued):

JOHN D. SIEBER, Member

ROBERT E. UHRIG, Member

THOMAS S. KRESS, Consultant

GRAHAM B. WALLIS, Consultant

GARY HAMMER, Designated Federal Official

C-O-N-T-E-N-T-S

P R O C E E D I N G S

(8:31 a.m.)

OPENING REMARKS

CHAIRMAN CORRADINI: Okay, let's get started. The meeting will come to order.

This is a meeting of the ESBWR subcommittee. My name is Mike Corradini. I'm chair of the subcommittee.

Other ACRS members in attendance are Said Abdel-Khalik, Sam Armijo, Sanjoy Banerjee, on his way, Dennis Bley, Otto Maynard, Bill Shack and Jack Sieber.

Graham Wallis and Tom Kress will also be attending as consultant to the subcommittee. We have one of our consultants here.

Gary Hammer of the ACRS staff is the designated federal official for this meeting.

The purpose of the meeting is to review and discuss the safety evaluation report with open items for several chapters of the ESBWR design certification.

We will hear presentations from the NRC's Office of New Reactors, and GE-Hitachi Nuclear Energy America, LLC.

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

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register. Portions of this meeting may be closed for the discussion of unclassified safeguards and proprietary information.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting. A transcript of the meeting is being kept, and will be made available as stated in the Federal Register notice.

Therefore, we request that participants in this meeting use the microphones located throughout the meeting room when addressing the subcommittee.

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

We will proceed with the meeting, and I'll call upon Jim Kinsey of GEH to kick us off.

Ken.

MR. KINSEY: Thank you, Jim. My name is Jim Kinsey from GE-Hitachi. I work in the regulatory affairs organization.

We appreciate the opportunity to make

these presentations with you this morning. We've brought a relatively large integrated team from GE-Hitachi that includes a number of members from both our technical and our licensing organization.

I understand the agenda for the morning is to go over a presentation of our DCD Chapter 4, which includes the basically the reactor and internals, and then that will be supplemented or discussed by the NRC staff, and then we would plan to move into a discussion of stability after the Chapter 4 discussion.

And with that I guess I'd like to turn it over to John Sorenson to introduce the team.

MR. SORENSON: My name is John Sorenson. I work in regulatory affairs at GEH.

On my right is Russ Fawcett, who will be discussing the price of DCD Chapter 4. And further on my right is Jerry Deaver, who will also be discussing the remaining part the DCD Chapter 4.

We have -- Jeff has -- Mr. Kinsey brought a team that covers a fairly wide range of disciplines, so we have a fairly large contingent of engineers to support us.

Content of Chapter 4 includes a summary discussion, and then in the details of the fuel system design. Mr. Fawcett will be discussing the fuel system design and nuclear design and the thermal and hydraulic design.

Mr. Deaver will discuss the acting materials, and reactivity control system functional design, and will give a brief summary.

Section 451 only provides a overview. There is no detailed technical information. It only provides an overview and a roadmap to the content of the remainder of Chapter 4.

Now let me turn things over to Mr. Fawcett, who will discuss Sections 4.2, 4.3 and 44.

MR. FAWCETT: Good morning, my name is Russ, Russ Fawcett. And I'm the manager of core and fuel advanced design for Global Nuclear Fuels.

And I'll provide a brief description of BCD Section 4.2, .3 and .4, which describe the fuel, assembly, design, evaluations and bases as well as the control rod, the nuclear design of the core, as well as the thermal hydraulic design.

Again this will be a brief description. I think we conclude that brief is adequate, as the ESBWR core is really just another BWR core comprised of proven technologies with characteristics very similar to the existing fleets.

The beginning of 4.2, the fuel system design, similar in 4.3 and 4.4, we describe design bases for the fuel assembly and the control rods; the description of the design, as well as the evaluations performed to demonstrate compliance.

In terms of the fuel rod design in the evaluations, we performed thermal mechanical evaluations based on either worst case or statistically bounding limits including uncertainties.

And these analyses are performed to assure that we comply with licensing requirements during both steady state and anticipated operational occurrences.

Likewise the control design is evaluated to coordinate stress, strain and fatigue limits; that it's capable of being inserted during all modes of plan operation in that it has mechanical compatibility with the remainder of the reactor internals.

And again, by and large, the ESBWR fuel system and control rods are similar to those used in the operating fleet.

Next slide, please.

In terms of the fuel assembly, it is identified as GE14E, which is really just a modest variant of GE14 that we have been delivering for many years and is operating throughout the fleet.

GE14E is comprised of the same components, identical components and materials that were installed in the GE14 that we got experience in taking fuel to assembly, average exposures as high as 68,0000 megawattage per ton.

That corresponds to approximately 80,000 peak pellet exposure, which is 15 percent higher than our licensing limits.

So we have in-core radiation experience far and above where we will be taking reload batches of fuel.

MR. ARMIJO: Let me just interrupt.

When you say identical, do you truly mean identical including cladding thickness, pellet density, plenum to fuel volume ratio? I mean this thing is really a scaled version of the standard GE14?

MR. FAWCETT: I would say at the component level with the exception of the fuel rod the answer is yes. The spaces are identical; the pellets are identical; the tubing is identical; the area of thickness is identical; pellet to clad gap is identical.

One key difference that you noted was the fuel plenum to fuel volume ratio is actually bigger for the ESBWR fuel rod, so we have introduced some additional margins. So we anticipate and will project some fairly significant reductions in fuel rod internal pressure relative to our current experience.

MR. ABDEL-KHALIK: Hydraulically they are not really similar. Because you have different length of part-length rods, ratio between part-length rod and full-length rod, location spacers, et cetera.

MR. FAWCETT: Well, I would say on a nodal basis they are the same. The integral hydraulic resistance --

MR. ABDEL-KHALIK: Yes.

MR. FAWCETT: -- is different because it's shorter.

Now recognize that our analytical methods are nodal-based, and our hydraulic models for losses are nodal-based or component-based.

And I'll touch on this a little bit later. Now we have performed GE14-specific testing to confirm the adequacy of our hydraulic models.

CHAIRMAN CORRADINI: So if you do cover it later I guess I'll add to Steve's question, which is that because you are shorter you are trying to preserve some sort of limit by reducing it so that you can get the appropriate flow; I assume it's minimum CPR.

But when the time is right I'd appreciate to be clear as to what's the limit you were bumping up against to require the fuel to be shorter.

MR. FAWCETT: Well I think this is a good time to discuss that. I don't know if you would say that there was a hard limit per se, as much as what was considered a good balance. And in developing natural circulation reactors, and we've been doing that for a very long time, it involves a composite evaluation, looking at the pressure vessel height, the core height, the power density, all the things that influenced our recirculation flow, and the objective is to construct or sample a good balance or balanced performance.

And that's how we arrived at the preferred assembly length that we have for GE14E, that gives us adequate core flow and sufficient peak design flexibility to manage assembly powers.

Is MCTR the most important design consideration? Yes, it probably is. The remainder of the things that the nuclear designer considers in fuel application are very straightforward to address, and critical power is straightforward to address, because we do have adequate flow with very mild transient response, the core with good operating limits.

MR. WALLIS: Your enrichment profile and your burnable poisons and everything are all the same as you already have?

MR. FAWCETT: I would say for a BWR fuel application every cycle is different. The specific nuclear design is tailored to meet a utility's objective.

We used the same techniques in distributing Gadilinium, the enrichment and the assembly, that we do today.

So depending on cycle length and discharge exposure, we may put Gadilinium preferred at the bottom of the core to flatten axial power shapes.

I'll say, one of the things that are inherent, that I will touch on a little bit later, is that the N-lattice, which is the ESBWR is comprised of, which is the same as the ABWR lattice, exhibits significantly more hot-to-cold reactivity swing than, say, BWR-2 through 6.

So we don't have to solve problems with cold shutdown margin as significant -- in fact it's almost a nondesign issue today in the ESBWRs.

So to answer your question, yes, standard techniques.

MR. ARMIJO: You're not using any

unusually high Gadilinium concentrations or loadings or anything else? What is your maximum Gadilinia?

MR. FAWCETT: Eight percent for a two-year cycle. It's really a function of the cycle length, and the cycle exposure, given the power density, ESBWR cycle exposures are similar to what we have today.

CHAIRMAN CORRADINI: Just to remind us, so if you are going to start talking about things that we need to talk about in a proprietary or closed session, let us know, because we are not going to know.

MR. FAWCETT: Sure.

MR. ABDEL-KHALIK: Will you be talking about the applicability of the GEXL14 correlation to this short bundle?

MR. FAWCETT: Yes.

MR. ABDEL-KHALIK: Okay, in an open session or closed session?

MR. FAWCETT: Open, to the extent we can.

MR. ARMIJO: Just one back issue that I want to get and make sure before we leave this prescription.

You are going to use a barrier fuel design. And I looked up the composition in one of your reports, topical reports.

And it showed it was just the pure

version. I thought GEH was using an iron alloyed barrier. I didn't find it in the SER or the DCE what the actual line of composition is?

CHAIRMAN CORRADINI: That is probably a good topic for a closed session.

MR. ARMIJO: Okay, we'll get to that.

MR. SIEBER: The overall dimensions of the fuel are in the core such that you get more neutron economy that you otherwise would get with a longer fuel.

MR. FAWCETT: I will say that fuel requirements for ESBWR fuel efficiency is comparable to the top quartile in the fleet, perhaps slightly higher leakage axially, but it is large radially, and on balance it is similar.

Next slide.

In terms of the control rod design, it is a derivative of the Marathon control rod design. The key noteworthy item here is for ESBWR we have introduced some additional margins, mechanical margins, and have modified the design to accommodate B4C 12 over and above what's available in the existing product line.

Next slide, please.

Okay, 4.3: the nuclear design, again, we described the design bases. That related to reactivity management and assuring we do not have positive reactivity coefficients, or such that would allow a reactivity excursion as well as the overpower bases that ultimately result in limits on the power distribution.

Our analytical methods for steady state, core simulations; how we calculate reactivity coefficients as well as stability methods; and results of our evaluations in terms of assuring negative reactivity feedback; control requirements; subcriticality during refueling; power distributions; and stability.

Next slide, please.

A few words about the ESBWR core from, again, from a core management --

MR. WALLIS: I'm sorry, you haven't yet tested it for flow-induce vibration, I understand?

MR. FAWCETT: That is correct.

MR. WALLIS: Are you going to do that?

MR. FAWCETT: Yes.

MR. WALLIS: Is it going to be different? Haven't you already tested the 14 fuel?

MR. FAWCETT: Yes, we have. And overall from an FIV point of view, the ES GE14E will see less duty or less susceptibility to vibrations, because flow rates are lower, that's why. But we will pass it anyway.

Again, from a fuel designer's point of view, the ESBWR is just another large BWR core that does operate at somewhat lower flow rates. The rate of power is 4,500 Megawatts thermal, and the core is 1,132 bundles.

Within the BWR fleet there is a wide range of core sizes from as small as 240 bundles, to as high as 872 bundles, with the ABWR.

Core size is not particularly noteworthy from a core management perspective, except that small cores tend to have higher flux radiance and higher peaking than do large cores.

The design has FMCRD spine motion control rod drives, which have a smaller notch size, and the locking piston CRD.

The attributes of the FMCRD, it has a fast scram which is another asset that provides your transient response with redundant insertion and reduced fuel duty.

The power density of ESBWR is moderate at about 54 kilowatts per liter. Within the fleet we see and have experienced a range of power densities from about 30 kilowatts per liter for the BWR2s to as high as 60 kilowatts per liter or higher for BWR6s at power uprated conditions.

So the power density of the ESBWR core is moderate.

The --

MR. WALLIS: This is an average value presumably?

MR. FAWCETT: Yes, it is.

MR. WALLIS: Are the peak values comparable with existing -- they probably are, they are probably within the same range?

MR. FAWCETT: Peaking, similar yes, to a moderate to high power density plant.

Also peaking is really an output. We design whatever peaking conforms to thermal limits.

MR. ARMIJO: That is a pretty picture there. What are you trying to show us with that?

MR. FAWCETT: Oh, just the size of the core.

MR. ARMIJO: Is there anything significant about the colors?

MR. FAWCETT: Uh-uh.

MR. ARMIJO: Okay, the colors don't mean anything?

(Laughter)

MR. FAWCETT: I think that -- it's hard for me to see -- I think that maybe peak assembly power where blue is higher than red, versus yellow, which is the periphery which does give a sense for the radial power distribution.

MR. SIEBER: Ones on the end are oval cores, right? The flow rate is about 30 percent less?

MR. FAWCETT: Yes.

MR. SIEBER: And the number of assemblies compared to BWR6 is like 850 to 1,100 roughly?

MR. FAWCETT: The ratio is proportional to your reduction in core --

MR. SIEBER: Well, the core is about two feet shorter I guess.

MR. FAWCETT: Yes.

MR. SIEBER: The way I seem to figure it out.

CHAIRMAN CORRADINI: Will there be a discussion about reducing the core height and increasing the core radial size on the stability later. And the effect, when we discuss stability, I'm curious of its effect on stability.

MR. FAWCETT: There is a discussion of stability planned.

CHAIRMAN CORRADINI: Okay, then let's just go ahead.

MR. FAWCETT: The N-lattice, again, the assembly, it's after the fact that it's shorter, has the same dimensions as the assembly for the existing fleet.

The N-lattice, the primary aspect or parameter of the N-lattice is a slightly larger bundle pitch, so there is a little more space in between assembly.

And in the hot operating condition, that reduces the void coefficient slightly, which is good, and in terms of reactivity characteristics, it improves cold shutdown margins.

This is the same lattice again that the AVBWR is comprised of. So the cold shutdown margin benefit has been demonstrated with AVBWR.

Next slide, please.

This has a little more substantive information in terms of power distribution. This is beginning of cycle power distribution for the equilibrium design.

For design certification we prepared an equilibrium design as it is more representative of the plant lifecycle.

We have also provided the staff with an initial core design as well.

This illustrates the actual power shapes that we observe are very consistent with that that we observe with other BWR --

MR. WALLIS: No, in this picture, presumably, red is hot?

MR. FAWCETT: Yes.

MR. WALLIS: Whereas in the previous picture it was cold?

MR. FAWCETT: That is correct.

(Laughter)

MR. FAWCETT: So looking at those distributions as is typical of assemblies that are close to our design target, which is what the designer is trying to achieve, is really a small population of fuel.

And so those red assemblies would be associated with assemblies having somewhere between 10 and 15 percent of thermal margin relative to the operating limits. Likewise for LHGR.

Control rod patterns are the same kinds of control rod patterns that we design for the operating fleet.

MR. SIEBER: These power distributions

will change, significantly is not the right word but, somewhat as burnup progresses because of the change in reactivity and also because of the rod patterns?

MR. FAWCETT: Yes.

MR. SIEBER: This is beginning of life, I take it?

MR. FAWCETT: Just an example of beginning of life.

MR. SIEBER: If you were to look at it through 10 slices in time, you would see variations all of which are enveloped by your thermal hydraulic calculations?

MR. FAWCETT: Yes, in fact you would see the axial power shape move from the bottom as the core is depleted, and in the power and the voids tend to collapse, you would see the axial power shape start to move up the core.

MR. SIEBER: That's because of the gadilinium depletion power.

MR. FAWCETT: And the physical inventory depletion at the bottom.

MR. SIEBER: But you never get to a top-loaded core?

MR. FAWCETT: We concede, looking at the top of the core with the peak, you know, and this nodalization as high as node 20. It's certainly -- it's an acceptable power shape.

So why do we need thermal limits? And in terms of establishing thermal limits, we certainly analyzed all the safe ones in the cycle that exhibit all these different power shapes.

MR. SIEBER: And you are using this as an example of an initial core but not a guarantee that an initial core is going to react like that, other than including the envelope that you designed, correct?

MR. FAWCETT: So this is the beginning of cycle for an equilibrium cycle, yes. An initial cycle would have somewhat different characteristics. You know, again, really any power shape is acceptable, as long as it meets thermal limits.

MR. SIEBER: Right.

MR. FAWCETT: Next slide, please.

Moving on to the thermal and hydraulic design in Section 4.4, we describe the natural circulation flow configuration, the power operating map, and introducing feedwater temperature control.

We talk about the thermal and the hydraulic design basis, ensuring that we have adequate heat transfer, and that we comply with our specified acceptable fuel design limits during normal operation in AOOs.

And in terms of the methods and evaluations focusing on compliance with critical power limits, and core thermal hydraulics.

Again the ESBWR is very similar to the existing plate.

MR. ABDEL-KHALIK: Is this where you are going to talk about the applicability of the GEXL14 correlation?

MR. FAWCETT: Uh-huh, in two more slides.

MR. WALLIS: You are still using Finley Dix (phonetic) after, whatever it is, 40 years or something?

MR. FAWCETT: For the void correlation, the Dix void correlation, yes.

MR. WALLIS: No attempt to upgrade it in anyway? It just seems to keep working?

MR. FAWCETT: Uh-huh.

MR. WALLIS: Rather amazing.

MR. FAWCETT: It was well done.

MR. WALLIS: It has enough coefficients in it, I think.

MR. FAWCETT: Next slide, please.

A boiling water reactor has good natural circulation flow depending on the design, or let me say that there is different capability depending on the design.

The AVBWR has internal pumps, and a fair amount of hydraulic resistance in the down-comer. The BWR6 and other jet-pump plants have reduced hydraulic resistance in the down-comer in higher natural circulation flow.

The ESBWR has very little hydraulic resistance in the down-comer. We had a reduced core height, and an extended chimney that increases the level height and driving head in the down-comer.

So the ESBWR has very good natural circulation flow characteristics.

MR. WALLIS: So you have one curve on this map. WE are used to seeing this map with all kinds of things, regions and things, and here you have just --

MR. FAWCETT: Yes, it's natural circulation flow is really -- the flow is a function of the power system.

MR. WALLIS: This other map which is referred to about a core power feedwater operating map, are you going to show us that?

MR. SORENSON: We have a separate presentation.

MR. WALLIS: You are going to get to that at sometime?

MR. SORENSON: Yes.

MR. ABDEL-KHALIK: But compared to a rated full power flow, this is natural circulation flow?

MR. FAWCETT: Uh-huh.

MR. ABDEL-KHALIK: So for the ESBWR mass flux at full power is roughly half of the mass flux at full power at BWR6 for example?

MR. FAWCETT: I would say that -- now recognizing that the fleet with extended operating domains has quite a range of core flows at rated power. So if we compare say ESBWR at 100 percent power to BWR6 at 100 percent power, we have a single flow for ESBWR for either flow.

For BWR6 at 100 percent flow, ESBWR mass flux is about 70 percent of the BWR6 at 100-100, 100 percent power, 100 percent flow.

MR. ABDEL-KHALIK: Point nine five times ten to the sixth pounds per hour --

MR. FAWCETT: Yes.

MR. ABDEL-KHALIK: -- per square foot.

MR. FAWCETT: Right.

MR. ABDEL-KHALIK: Versus 1.8 times 10^6.

MR. FAWCETT: No, actually in -- if -- I should clarify, when we think of mass flux, or when we talk about mass flux, we tend to look at the active in-channel mass flux, or four-circ plans like BWR6, at 100 percent flow.

The in-channel mass flux is approximately one million pounds per hour per square foot. ESBWR is approximately .6 and .7 depending on the assembly power.

MR. SIEBER: The pressure drop is about half, right?

MR. FAWCETT: Yes.

Next slide, please.

So here is where we talk about GEXL. We've applied again GEXL14 is a boiling length critical quality correlation that's been developed in GEXL14, the GE14 specific correlation was developed on an extensive database from several different facilities to describe the onset of boiling transition for GE14.

And we applied that GE14E with a shorter overall length.

As part of the DC review we developed a conservative set of correlation statistics for GEXL14 and applying it to GE14E. That conservatism manifests itself in the operating limit MCPR. It's somewhat higher by virtue of these conservative correlation statistics.

In being responsive to the staff, we conducted a fullscale critical power test of GE14E. What I'll say is a complete critical power and pressure drop test to confirm the adequacy of GEXL14.

We completed that in November.

MR. ABDEL-KHALIK: Where was that done?

MR. FAWCETT: Stern Labs. And our --

MR. ABDEL-KHALIK: Will we have access to that data?

MR. FAWCETT: You will. We'll be providing a report on that. We are in the process of completing our work on that analysis and the final report that we will provide to the staff.

MR. ABDEL-KHALIK: When you talk about conservative -- go ahead.

MR. SIEBER: I understand that's sending two by diverse means, so that I get one.

MR. ABDEL-KHALIK: When you talk about conservative statistics, I assume this is the way you were applying of the correlation by assuming no heating beyond the length of the GE14E.

And yet even with doing that, it seems like the calculated CPR is higher than the measured CPR as indicated in your topical report.

So how can that be conservative?

MR. FAWCETT: And it's a confusing thing to understand why it's conservative. You are absolutely right in that we declared GEXL14 nonconservative by an amount that we have established throughout the DCD review. And so we say, GEXL14 is a few percentage points nonconservative.

Now our process for establishing operating limits is always to address any GEXL nonconservative by increasing the operating limit. So that is how the conservatism is propagated through the design.

So we have artificially declared GEXL nonconservative.

MR. ABDEL-KHALIK: I don't know, maybe you are not prepared to discuss the results of this fullscale test for the GE14E, but how does that compare to the level of nonsconservatism, the CPR prediction of GEXL14 for the GE14E as explained in the topical report?

MR. FAWCETT: And certainly we will provide the detailed results to the staff. But qualitatively, the test data shows that GEXL14 is a very good prediction of critical power for GE14E, just like it is for standard GE14, and with no significant trends bias.

So that testing confirmed that GEXL14 really is just as good a best estimate critical power predictor for GE14E as it is for GE14.

MR. ABDEL-KHALIK: To be seen?

MR. FAWCETT: To be seen.

MR. ABDEL-KHALIK: It implied that they sort of declared GEXL14 to be nonconservative by X percent because of the conservative way in which it was applied.

MR. FAWCETT: Right.

MR. ABDEL-KHALIK: Can you sort of say with confidence that GEXL14 is conservative?

MR. FAWCETT: GEXL and our overall critical power methodology is -- or let me say our licensing basis is conservative. GEXL is a best estimate prediction of critical power.

The uncertainty in the prediction of critical power is addressed in the formation of the operating limit, or in the existing fleet, the safety limit. So that is how uncertainties in the prediction of critical power are addressed.

So GEXL is a best estimate prediction of critical power. Uncertainties are addressed in the operating limit.

Effectively we've increased the

conservatisms here in the operating limit by assigning this penalty to the GEXL.

MR. ABDEL-KHALIK: But just looking at the average one really can't tell whether there is a consistent bias?

MR. FAWCETT: Right, but in looking at the data GEXL is not showing any trends bias, or GE14E, and that will be illustrated in the report.

MR. ABDEL-KHALIK: I guess we will just have to wait and see. Thank you.

MR. SORENSON: That is the last slide we have in Section 4.4.

MR. ARMIJO: Just one slide there, the one showing the -- yeah, that curve of the ESBWR average power per bundle versus average flow per bundle curving back on itself, you know, does that imply you could have for the same flow two different powers, operating power per bundle?

MR. FAWCETT: Uh-huh.

MR. ARMIJO: Is that a problem? I don't understand it, I guess that's what I'm telling you.

MR. FAWCETT: So I think I will ask Mr. Wayne Marquino to perhaps --

MR. WALLIS: Isn't there something there about the control rod position? It's not just one curve?

MR. MARQUINO: That's right.

MR. WALLIS: It's along the curve.

MR. MARQUINO: This is Wayne Marquino, GEH, and at different control rod positions we can have different power levels with the same flow. That curve is showing how power increases as we pull control rods out.

MR. MAYNARD: The key is that the power is setting the flow, not the other way around. So for any given power you can only have one flow. You are not setting a flow and see what the power comes out to be; you are setting a power and then you are going to --

MR. WALLIS: In the normal map for BWR you would have rod lines. But you don't --

MR. MARQUINO: That's right.

MR. DERWER: Okay, thank you.

My name Jerry Derwer with with GEH. The lead in the nuclear island systems and components group.

I'll be covering 4.5 and 4.6. 4.5 deals with reactor materials, basically there are two sections within -- or parts to Section 4.5. One deals with control rod drive materials; the second deals with the reactor internals materials.

With respect to the control rod driver materials, basically the fine motion control rod drive is essentially the same as the ABWR design that has been previously certified.

MR. ABDEL-KHALIK: Excuse me if you will, but when are you going to talk about stability?

MS. CUBBAGE: They are going to have a separate panel. Excuse me, this is Amy Cubbage. They are going to do it right after Mr. Derwer.

MR. ABDEL-KHALIK: Thank you.

MR. DERWER: Two major differences in the design are the change from induction motors -- or to induction motors from stepper motors.

Basically the ABWR has been in operation in Japan with the stepper motors for over 10 years with successful operation. The induction motors have been incorporated in their newer designs, and there is one plant with operational experience over two years at this point with the induction loaders.

And they have also incorporated a seal-less design to minimize leakage and maintenance with -- for the drives themselves. Basically the drives also are two-foot shorter because of the fuel geometry. S o those are the main differences. As far as materials are concerned, the drive is predominantly stainless steel material. In a couple of areas we used XM19 where we needed higher strength or -- and corrosion resistance.

But fundamentally the drive materials are pretty much the same as we've been using in the past.

The next drive shows the configuration of the drive itself. I'll just point out a couple of features.

Basically we have the traditional CRD housing. We have a middle flange and a lower flange.

These are all the pressure boundary materials, and we provide those in accordance with the ASME code.

Starting from the bottom we have the motor which is different from traditional hydraulic designs. The motor is what drives the ball screw which will advance the drive into the core, or withdraw it as needed.

Then we have insert line. This is for the scram function. So for normal operation we'd have the motor-driven drive, but in a scram condition we have the hydraulic design which -- the hydraulic control unit drives a piston within the drive to insert the blade rapidly.

We only have insert lines as opposed to prior designs which had the withdrawal lines also. And we don't have the discharge line anymore.

MR. WALLIS: So when the hydraulic system scrams, what happens to the motor drive? Does it just rotate or clutch out or what happens to it?

MR. DERWER: Yeah, it clutches out allowing the drive to be inserted.

And we have the traditional ball check valve here. If we had a break in the line the insert line, then this would be blocked by the check valve.

Let's see, we have the traditional bayonet lock at the top. This is the same interface that we had between the blade and the drive.

And we have as with other drives we have a position indicator probe which gives us an accurate idea of where the blade is. And then we have a separation probe which tells us whether we separated between the drive and the cover.

MR. WALLIS: The whole thing hangs on the valve, does it? The whole thing is supported by that valve, or is there some other support?

MR. DERWER: Well, the housing -- the load path for the fuel assembly and so forth is down through the control rod guide tube.

MR. WALLIS: Which is also fixed?

MR. DERWER: Yes, and this is the main welded structure within the assembly. It transfers the load into the vessel bottom head.

We have a locking feature in the drive such that we don't need the pull out protection in the drive, which is a difference from the hydraulic type designs.

MR. BLEY: What keeps this drive in position?

MR. DERWER: Well, basically, we have a brake assembly that once it's moved it holds its position.

MR. BLEY: What kind of assembly is that? The motor has nothing to do with that, right?

MR. DERWER: The motor is powered to turn it. And if the power is stopped, then there is a break assembly in here that you know it's prevention from dropping of the blade and moving of the blade after the motor has moved it.

MR. BLEY: That is something that releases when the motor is driving and grips otherwise?

MR. DERWER: Yes, there is magnetic indicators in here that operate it.

CHAIRMAN CORRADINI: is there any

difference between this drive and the ABWR line motion control rods?

MR. DERWER: Fundamentally all these components are the same basically. It's just a difference in a motor down here that is really different.

CHAIRMAN CORRADINI: Which you are changing into some ABWRs is what I remember you saying?

MR. DERWER: Yes, they have already changed to the induction motor.

Basically it's just a cost factor that they went to the induction motors, and easier to control.

MR. ARMIJO: So mechanically, materials, everything is the same --

MR. DERWER: Yes.

MR. ARMIJO: -- except for the induction motors?

MR. DERWER: That's exactly right.

MR. ARMIJO: Okay.

MR. DERWER: I think that is all I wanted to talk about.

MR. BLEY: I'm sorry to go back to this.

MR. DERWER: Okay.

MR. BLEY: When you change from a stepper motor, was the stepper motor involved in holding the rod in position? Or was that still the same brake arrangement?

MR. DERWER: Oh, the same brake arrangement. All that is the same.

Moving forward, including on to the reactor materials, reactor internals are predominantly stainless steel materials which we control the carbon content.

So as I explained in previous sessions we control the materials to be resistant to intragranular stress corrosion cracking, and then we control the impurities and surface things that can occur with materials.

And then we -- additionally we control cowork and -- to avoid those kind of issues with the stainless materials.

In some cases we use a modified Alloy 600 material. We use code case and 580-1, which allows the niobium content to increase, and it stabilizes the feed canal to be resistant to intragranular stress corrosion cracking. A

MR. SHACK: What is the carbon limit on that material?

MR. DERWER: Well, it's that ratio between niobium and carbon that is important, you have to establish a certain ratio there. So it can vary, but there are ranges that it has to be within.

MR. ARMIJO: is that defined in the code case? The range?

MR. DERWER: Yes, it is.

MR. SHACK: But if you just depend on that ratio, don't you end up with a knife line attack problem you had with the 347?

MR. DERWER: Brian, can you? We have Brian Frew here who is our materials expert. He'd be in a better position to answer that.

MR. FREW: Brian Frew from GEH. No, the -- we haven't had issues with knife line attack in this material. I mean you have to control that ratio. There is sufficient chrome to avoid that problem.

MR. SHACK: What is the -- do you have a range on the carbon? What is the upper limit on the carbon?

MR. FREW: The upper limit is -- I'd have to look at the code case to tell you the exact number. But with that ratio the carbon content tends to be lower.

MR. SHACK: You are following the Japanese experience?

MR. FREW: Yes.

MR. SHACK: Their choice of these materials?

MR. FREW: Yes.

MR. SHACK: And this has been used in all the ABWRs?

MR. FREW: Yes. Yeah, it's been --

MR. SHACK: And there is a statement that says your stresses everywhere are below the threshold for intragranular IASCC. Does that mean you don't have any welds, or all the welds are stress-relieved?

MR. DERWER: I wouldn't say that as a positive statement.

MR. SHACK: I wouldn't think you would, no. MR. DERWER: We are working on things like that, recognizing you know the shroud is a large structure, and when we fabricate a structure we would to solution heat treat it, but we are not there yet. We are exploring those issues at the moment.

MR. SHACK: But this is a bolted shroud as I understand, so it could be replaced if it had to be?

MR. DERWER: Yes. That's correct.

Looking at the components that use the Alloy 600 materials, the shroud supports, which in this case are brackets for the lower vessel. I'll show you on the next slide.

Then we basically, the CRD penetration is the typical penetration which provides us this transition between the low alloy steel and the stainless housing.

The chimney head bolts in prior BWRs, the shroud head bolts, have the same basic design where we use the Inconel material for thermal expansion differential to apply the load actually in the bolt when it heats up.

Then we have in-core guide tube restraints. This is a lattice of materials that stabilize the cores in the lower plenum area, and again, we use this because of the thermal expansion characteristics.

Then we use it in the guide rods. Guide rods are just for guiding in components like the dryer and the separator when we do refueling, so they don't -- aren't in actual operation when the plant is operating. They just -- they are sitting in there.

We do use castings. Basically the casting applications are the same as we've always used for the orifice fuel supports, the feedwater end brackets, and the veins in the separator itself where it swirls the steam flow.

We use XM-19 for all bolting in the reactor. In the past we've used stainless steel without any real problems, but we feel that the XM-19 provides more corrosion resistance and higher strength, so it's an improved material, and that's what's been used on the BWR6, or the ABWRs, and we haven't had any issues with that.

The X-750 is limited strictly to a retainer screen in the shroud -- in the chimney head assembly. It's -- we have a retainer that holds the nut in place, and it only gets exercised when we are trying to unbolt or bolt the chimney head. So that is a very limited application, and it's not really stressed in operation.

Going to the next slide --

MR. ARMIJO: Before you leave that, Jerry, in the SER, in the DCD, the staff from GEH had some exchanges related to the use of 304 and 316 stainless steels, in which I believe GE made a commitment, or it was your intent to limit the carbon content in those alloys to effectively -- the same levels as the L-grades. 304 would have an O2-carbon maximum of seven three sixteen, the same as your L-grades. And that is nice, but the implication was that you were using, or you stated you were using these steels because they were higher strength than the L-grades. And that confused me.

Why -- what would you add to 304 or 316 to get higher strength than a 304L or a 316L?

MR. DERWER: Well, yes, material suppliers use a nitrogen addition to help.

MR. SHACK: So you'd use a nitrogen strengthener?

MR. DERWER: Right.

MR. SHACK: Okay, so you'd get that, and you'd increase the yield strength?

MR. DERWER: Exactly, and so we want them -- the improved mechanical characteristics, properties --

MR. SHACK: Without the sensitization risk?

MR. DERWER: Right, and with still the low carbon issues.

MR. ARMIJO: Have you tested these nitrogen strengthened 300 series steels for IGSEC resistance in high temperature oxygenated water tests or anything?

MR. DERWER: Yes, they were tested. We are performing on these.

MR. ARMIJO: Okay, so they have been tested and found to be acceptable?

MR. DERWER: Yes.

MR. SHACK: You said you were going to give us detailed specifications once you had them. I assume you are just pushing the nitrogen up to the 304 limit, you are not actually making this an LN series steel?

MR. DERWER: Right.

MR. SHACK: So you just go up to that limit. But the Japanese actually use the LN grades, right? They take the nitrogen up to .12 or .14?

MR. DERWER: That could be; I'm not familiar with what they have been doing.

MR. SHACK: But you are just going to push it up so it stays at 304, but you are just taking the --

(Telephonic interference)

MR. SHACK: -- as you do with the 316 nuclear -- the nuclear grade?

MR. DERWER: That's correct.

Going to the next slide, I was just going to -- this is a small picture of the reactor, but I will point out where we have been using these materials. It's here at the attachment to the shroud, these are brackets in the lower bottom head area.

In the stuff tubes as I've explained before, the major change is the addition of the chimney and partitions within the reactor. And these are stainless steel materials.

And the other change is, the routing of the standby liquid control line is different. We bring it in from the upper part of the vessel now, and bring it in, and we penetrate through the shroud so that the injection of the sodium pentaborate solution can be injected directly into the core region itself.

MR. SHACK: This is still the same -- so you are going to have like the nickel weld pads, where you make the attachment welds for things and the internals and stuff as you do in the conventional BWR?

MR. DERWER: Yes, you are talking about brackets?

MR. SHACK: Yes.

MR. DERWER: Well, typically, in the upper part of the vessel we have stainless steel cladding, and the brackets, you know, are welded onto structural material as a base for those brackets.

When we get into the bottom head where we have mainly Inconel components there, or welded on, we've changed the cladding material to Inconel for the bottom head region only.

MR. SHACK: So the whole bottom head is clad with an Inconel weld?

MR. DERWER: Yes, it is. So for components like the scrub tubes and in-core housings, and the shroud support, all those Inconel welds are made to an Inconel clad structural material base. Okay?

MR. ABDEL-KHALIK: What determines the size of the cell in the chimney?

MR. DERWER: Well, that is -- basically has 16 bundles within the cell itself. So it encompasses four units that we typically had in -- associated with the control rod blades.

So we have four blades, and they are associated with four fuel assemblies with -- in each of those.

Wayne Marquino would be best to address that issue.

MR. MARQUINO: We also considered the range of data where we had the high diameter of our chimney characterized. Initially we had I think it was Wilson and EBWR reactor measurements, set the size of the chimney partition.

And eventually we had the Ontario

hydrotest specifically for the ESBWR.

MR. WALLIS: Why do you have partitions at all?

MR. DERWER: Well, that is important to make sure we straighten the steam flow up up to the separator area?

MR. WALLIS: You don't want to have some sort of swirling going on in there?

MR. DERWER: Exactly, we get some vortexing otherwise that --

MR. WALLIS: It seems to me that you have designed them to be as big as you have tested essentially.

MR. SHACK: Again, your original design was change three, wasn't it?

MR. MARQUINO: I think the very first ESBWR design did not have them, but before -- I think before we submitted anything we put partitions in.

CHAIRMAN CORRADINI: So you were going to finish the statement when you said you had compromised what with the vortexing, with the swirling?

MR. DERWER: Oh, yeah, if we didn't have the partitions, you'd get the vortexing and steam, you know, vortexing within the core. And so you'd get a very unequal steam flow into the separators.

MR. SIEBER: I think you would get chugging.

CHAIRMAN CORRADINI: I was going to say, you get a washing machine. You've got -- you could have enormous wiggles in the system by having an enormous washing machine.

But what I am curious about is, the four by four sites, if this is the wrong place to discuss it, that's fine, but eventually I'd like to discuss this question, because I'm kind of curious, was it picked or by the experiments, was four by four look alike some sort of optimum because of some sort of characteristics?

MR. MARQUINO: This is Wayne Marquino. It was picked based on Dodoward (phonetic) and the total experience at the time we had to set that design. And there was the ESBWR reactor did not have a chimney. It had a pretty big hydraulic diameter.

When we saw some -- it didn't have adverse performance, but we saw some recirculation in there, and basically we don't want to use a CF - you know, a very complex CFD code to analyze the flow there, so to keep it within the applicability range, or a TRACG code, we set the chimney size, the partition side.

MR. WALLIS: So you wanted it to be one

dimensional?

MR. MARQUINO: No. No.

CHAIRMAN CORRADINI: I know what you said, but what you are telling me, I changed the design so I could analyze it.

MR. MARQUINO: That's right. That helped.

MR. WALLIS: You want it to be one dimensional, essentially, is that it?

MR. MARQUINO: Yes.

MR. ARMIJO: Just a quick question. Now there is going to be a lot of welds in that chimney. Is that correct, that these are going to be all welded construction, all the lengths up and down those --

MR. DERWER: Are you talking about the partitions specifically?

MR. ARMIJO: Yes.

MR. DERWER: There will be a considerable number of welds.

MR. ARMIJO: Are these like full length?

MR. DERWER: Yes, they are. Our idea is to use a cruciform for the intersections where the cells are, and then we would have plates that are welded full length, full penetration, and with a cruciform design it allows us to take the weld away from the discontinuity of the intersections. So --

MR. SIEBER: So that's sort of like an extruded or --

MR. DERWER: An extruded -- it's like in the blades where we have the tie rods.

MR. ARMIJO: Okay, and that material will be the same as the shroud, it's not an L-grade?

MR. DERWER: Oh, it'll be stainless.

MR. ARMIJO: Stainless steel, very low carbon.

MR. DERWER: Low carbon, and we have a program where we are going to develop a mock up and use the actual welding parameters, and then our GRC is going to evaluate it for stress corrosion.

MR. WALLIS: Is there a follow up with flow induced vibration in the chimney?

MR. DERWER: No, we actually had Hitachi do a flow test for us.

MR. WALLIS: With a full sized chimney matrix or just one cell?

MR. DERWER: Well, we did one cell. We started out with a 1/12th scale. We went to a 1/16th, one sixth, and then they openly did a full scale with a single cell, and when we did that we saw that the vibration characteristics improved for the full one. And that is why we ultimately did that.

CHAIRMAN CORRADINI: WE may want to move on, because we are going to hit them with the stability.

MR. ABDEL-KHALIK: Just one question which is related to this, which is again the size of the cells, the projection of what you call super cell is four by four, 16 bundles, is that correct?

MR. DERWER: Yes.

MR. ABDEL-KHALIK: So in either a fresh or an equilibrium core, what is the largest radial power gradient between a bundle and a bundle that is four rows away?

MR. DERWER: I don't think I can quote a number off the top of my head.

MR. ABDEL-KHALIK: I mean looking at the power distribution maps, even though they are sort of qualitative in nature, it is possible to have one of these super cells where you have a very large power gradient between the bundle that is on one edge of this cell, and another bundle that is four rows away.

So the issue of one dimensionality of the flow within the chimney can be sort of questionable in situations of this sort.

MR. FAWCETT: I'd like to turn to Mr. Marquino.

MR. MARQUINO: In terms of numbers we will have to get back to you, but let me clarify something.

We have maybe a 2-1/2 dimensional analysis of the chimney in our TRAK code. We model different power bundles within a chimney partition. We have the ability to do that, and we have the ability to monitor different power partitions.

The biggest gradients are at the edge of the core. You can kind of get that from the colors on his map.

MR. ABDEL-KHALIK: But we would like to find out if you don't mind, if you have that information.

MR. MARQUINO: Okay, we can get you some information on that.

CHAIRMAN CORRADINI: Please proceed.

MR. DERWER: Okay, I believe I have pretty well covered most of what I wanted to on the figures.

Okay, the next is the 4.6 which is the basically the system for reactivity control of -- this is the control rod drive system.

This system is essentially the same as the provision control rod drive system that you have seen in the past, except that we've added one new feature, and that is the high pressure make-up flow. This is ju9st a belt and suspenders thing that adds a feature, you know, if it's needed in an accident condition.

The three major components are the prime motion control rod drives. There are 269. The hydraulic control units, which are 135. So there are two HCUs that support two drives.

And then we have the hydraulic subsystem which is the system that provides flow to the system.

MR. WALLIS: How much water do you bring in through these control rods? What does it correspond to in terms of megawatts and boil off? Can it supply the boil off after two hours of decay heat or something?

MR. DERWER: Are you talking about the amount of fluid that is injected?

MR. WALLIS: Well, you are introducing here a sort of a pumped versus cooling system.

MR. MARQUINO: But you need a small quantity of water, compared to the core volume.

MR. DERWER: It's a very small volume.

MR. WALLIS: Is it really?

MR. MARQUINO: It does have the capability right after scram to go into high flow mode, and that makes up for boil off decay heat.

MR. WALLIS: It could cool the core?

MR. MARQUINO: Yes, so it's diverse from the IC function.

MR. WALLIS: So if quality is turned off --

(Laughter)

MR. DERWER: So going to the next slide, so the FMCRDs is a -- has been mentioned before, has the electric motors to drive it during normal operation, the hydraulic function during normal conditions.

The HCUs as always have been the source of hydraulic power for scram, and those fundamentally are the same. As a matter of fact the HCUs for ABWR where we used directly for ESBWR, and the hydraulic system basically provides demin water, and regulates and distributes it to the HCUs and the perch (phonetic) flow within the drives. The perch flow helps keep the drives clean, and does keep them cooler with the perch flow.

MR. ABDEL-KHALIK: What is the total worth of all the control rods in a cold clean core?

MR. FAWCETT: The cold rod worth?

MR. ABDEL-KHALIK: Yes, total.

MR. FAWCETT: In other words cold all rods out to cold, all rods in?

MR. ABDEL-KHALIK: Correct.

MR. FAWCETT: I believe it's around 15 percent, but we would need to confirm that.

MR. ABDEL-KHALIK: Okay, thank you.

MR. DERWER: And moving forward, this is a schematic of the CRD system. As I mentioned it is provisional with prior systems. These are the FMCRDs on this side. This box pertains to the hydraulic control units. The new feature is the -- coming off the pumps is, we have these valves that are normally closed. This is the flow path --

(Telephonic interference)

MR. DERWER: -- flow into the reactor water cleanup, and ultimately into the feedwater system which would go back into the reactor vessel itself.

In this system we draw out water from the condensate storage tanks which is typical, and so there's nothing really new about the system.

Okay, if you want to cover that, John?

MR. SORENSON: Well, I think the bottom line is, we continue to work with NRC staff to resolve and adjust open items.

MR. ARMIJO: There are a lot of open items. There's 31 in chapter four that I know of. Maybe I got to ask that staff at some point.

MR. SHACK: Let's do that after break.

CHAIRMAN CORRADINI: Well, they'll have an answer.

MS. CUBBAGE: And GE needs to switch teams to continue with Chapter 4.

MR. ARMIJO: We still have one more presentation for Chapter 4, so I want to move on to it.

Any other questions for this group?

Okay, thank you very much. You are going to have another member join you?

MR. SORENSON: We are ready to begin.

Let me introduce Dr. Jun Yang, who will provide a discussion of the ESBWR stability evaluations.

MR. YANG: Good morning, everyone. My name is Jun Yang, and I am here to share with you the evaluation results for ESBWR stability, including recent events since our last meeting.

I'm going to start out today by specifying the licensing requirements that ESBWR needs to satisfy.

So the conditions that need to be examined for stability through normal operation and also AOOs and the JDC-12 requires that power oscillation is either not possible or can be detected and suppressed.

Next slide, please.

And based on the stability results we have seen so far, we can safely conclude that ESBWR are stable during normal operations, and AOOs, and the growth of large power oscillations is not a credible event.

In addition GEH will implement a detect and suppress solution to further protect --

MR. WALLIS: This isn't just based on analysis, this is also based on comparison with experiment, isn't it, this conclusion, first conclusion?

MR. YANG: It is mainly based on the TRACG analysis in terms of decay ratio.

MR. WALLIS: There had to be experiments too. Maybe it's a different forum where we investigate these.

MR. MARQUINO: There has been experiments. We saw the Advisory Commitee's view about two years ago when we submitted our TRACG method for analyzing ESBWR stability.

MR. WALLIS: I remember that. I'm just thinking about what would they call it, the experiments in Holland, the Genesis experiments. Have you come to terms with those yet in TRACG? Because they had difficulty modeling -- they had a Freon loop that modeled the whole system and supposedly scaled properly. They had some trouble modeling it analytically.

Have you come to terms with that yet? Maybe we should investigate this in a subcommittee or some other subcommittee.

MR. MARQUINO: We didn't have any open items.

MR. WALLIS: Well, I wondered about that. Because they had real trouble -- this was presented in Pittsburgh in the fall, and maybe you should look at the Genesis experiments, because we are going to ask about them again.

MR. MARQUINO: I think this is not exactly the forum, but I think we have to talk about them.

MR. ABDEL-KHALIK: The DCD says that, in Section 4(d)(1)(5), that therefore the stability during AOOs is assured by the scram protection. And in there you talk about a level -- low level trip, and the high powered trip.

MR. MARQUINO: There is a scram protection on Level 3.

MR. ABDEL-KHALIK: Right. Now how does that protect against regional instabilities during AOOs?

MR. YANG: So basically all the density being reduced the stability will be protected by limiting the power level. So scram protection will limit the power level.

MR. ABDEL-KHALIK: How does the high flux trip protect against regional instability?

MR. YANG: Once you do the high level height, similar to the high-power scram established, and the power, the low ratio will decrease. So based on the TRACG results the decay ratio will improve, give you a lot of margin, so that the regional decay ratio, regional performance, is protected.

And I will get to that in later slides.

MR. MARQUINO: I think your concern is that if you are in a regional oscillation, the sides of the core are oscillating, the APRM won't have a good indication of that, right?

MR. ABDEL-KHALIK: Correct.

MR. MARQUINO: But what we're crediting is the average power of the core which does increase in the loss of feedwater heating event.

We are not saying that that is going to detect the oscillations, but it's going to detect the power increasing as the feedwater temperature drops.

MR. ABDEL-KHALIK: I guess you will talk about that in more detail.

MR. WALLIS: So these oscillations never occur?

MR. MARQUINO: Right.

MR. WALLIS: They never occur unless they are really -- I guess with the MELLLA+ we go into some discussion about, couldn't use the DIVOM curves because of single channel oscillations. You ever get into that? How do you know, because TRAC says so?

MR. MARQUINO: We will see numbers in a minute.

MR. ABDEL-KHALIK: Back to the point you are making, the high flux drift, I guess you're saying it protects against overall increase in power level?

MR. MARQUINO: Right.

MR. ABDEL-KHALIK: During a loss of feedwater heating event?

MR. MARQUINO: Right.

MR. ABDEL-KHALIK: Now are you sure that you will actually hit that point sooner than the point where these regional oscillations coupled on top of the overall power increase would put you at a point where you will exceed your CPR limits?

MR. MARQUINO: Yes, because we analyze with the -- in order to get the regional oscillations, the power has to be above that trip. So that is what Dr. Yang is demonstrating with his calculations, that from a loss of feedwater temperature, or a loss of feedwater, or just normal operation, where enveloped by a certain power level, and at that power level the core is stable.

MR. YANG: There is less stress in AOO stabilities.

Next slide, please.

These are all the major possible conditions that can lead to instability at least here. And all this scenarios have been analyzed by using TRACG code, and the methodologies using stability LTR, and has been approved by NRC.

So basically for density being induced instability which is also called Type II instability, there are three modes to consider.

The single channel mode is when the flow of a single channel oscillate with small power oscillation. And the core alignment mode is when the power in the flow of all core channel, oscillating in phase; while the regional model is when half the core oscillates out of phase with the other half.

And also several other kind of instability -- mode of instability are considered during the plant start-up including the condensation in the region instability, and also the flashing the void induced LOOP instability also considered during plant startup.

Also the xenon transient effect on the power distribution is also considered using TRACG methodology for simulating the plant startup.

MR. ABDEL-KHALIK: Do you analyze situations where some of these instability modes are coupled, where you have single channel instabilities on top of regional instabilities?

MR. YANG: I think, in a sense, there are a couple actually. Because the regional instability, there is a limiting bundle we analyze. So it is the single channel we are considering in the original model.

We see like the limiting bundle based on the power peaking and also the harmonic peaking.

MR. ABDEL-KHALIK: So you don't ever foresee a situation where the core is going like this, and within that region a channel is going like this at the same time?

MR. YANG: Right, we are monitoring the limiting channel during the regional model also. So inside there are a couple, we evaluate the performance based on a single channel performance.

MR. WALLIS: I think when you do that the limiting bundle has the same frequency as the regional mode; it's not doing its own thing on top of that.

MR. YANG: That is covered by the hydraulic single channel mode.

So basically for the single channel mode it's purely concentrated on the hydraulic performance of single channel. And I will get to that, showing you the decay ratio value, you can see the margin.

Next slide, please.

This slide shows the decay ratio result for the normal operating conditions, both the equilibrium for any initial core. Since the last ACR meeting, GEH has performed a series of additional analysis for its colder level sensitivity, and it determined that the peak hot access cycle point is the limiting state.

MR. WALLIS: So you did use a Courant number of one? You put enough nodes in that chimney? Because this was a question we had before?

MR. YANG: Right, we addressed that by using fine nodalization model.

MR. WALLIS: So you didn't artificially damp the void perturbation?

MR. YANG: Right, and also in TRACG --

MR. WALLIS: I think in some other forum we probably should look at the details of that, too, again, visit that again.

MR. MARQUINO: Okay, I want to clarify what Jake is discussing is the channel nodalization. And we answered a lot of your questions and did additional investigations of the chimney numerical tracking, and we dispositioned that in the TRACG review.

So what we did in --

MR. WALLIS: Well, we said we wanted to revisit it again in our letter, I think, because you hadn't actually reported your current number of one results throughout the whole chimney at that time.

I understand you have done some better simulations done.

MR. YANG: The calculations showed that the chimney region has a minimum effect on stability performance, especially with decay ratio value.

So you can see that all three mode decay ratio meet the acceptance criteria with very good margin, and all the region can be made here is, among this remote, if the channel, single channel mode, has the largest margin, which means hydraulically, yes, we believe our channels are very stable.

And the regional mode is limiting mode, and -- but adequate modeling is --

Next slide, please.

So here we start talking about AOO stability. So beyond normal operation, in the AOO space, there are two limiting events that have been identified. One is the lost feedwater heating event where the power will increase as the feedwater temperature reduces. Another one is loss feedwater flow event, where the water level drops.

And the trajectories of these two events are given on this power core fuel map, and you can see that three lines of defense are established, to handle the power level for the lost feedwater heating event.

So on detection of a temperature drop in feedwater, the SCRRI will be initiated through control of power, overall power level.

And if power keeps rising, simulate thermal power scram, and the trip from this detect/suppress solution will further limit the power level.

And as far as the loss of feedwater flow event, the scram on a level three will protect stability.

Next slide, please.

MR. ABDEL-KHALIK: If I may just go back to the previous table where you talk about the channel decay ratio. You talk in the DCP about the statistical analysis, or the channel decay ratio that you have done 59 trials or something like that. And you select the parameters from the distribution. And you say that a TRACG calculation is made for the perturbed set of parameters to obtain a steady state.

Were you able to obtain a steady state result for each of the 59 trials?

MR. YANG: Yes.

MR. ABDEL-KHALIK: For each case?

MR. YANG: Yes, because to evaluate stability performance, we need to have a variable steady state first, using TRACG.

MR. MARQUINO: To evaluate the decay ratio number, yes.

MR. ABDEL-KHALIK: Okay, thank you.

MR. YANG: Okay, back to AOOs. From the results for the normal operating condition, we know that regional mode is limiting mode. So here only the regional decay ratios are given.

And you can see that for this two AOO events, limiting events, the decay ratio value shows adequate margin against acceptance criteria.

MR. WALLIS: Doesn't this vary with the time in the cycle? Because the power distribution is so very different in the beginning and end of cycle, it must affect stability?

MR. YANG: Actually it --

MR. WALLIS: It's a worst condition there or something?

MR. YANG: We determine the limiting cycle point is at peak access, so we perform this --

CHAIRMAN CORRADINI: Sorry, the limiting cycle point is what?

MR. YANG: Is at the peak of access, reactivity cycle point. Is where the max reactivity is the maximum during the cycle. And that would give you the worst axial power shape.

CHAIRMAN CORRADINI: So it's near the beginning of cycle.

MR. YANG: It's right in middle of -- middle of cycle and end of cycle.

MR. WALLIS: The bottom is worse for

instability?

MR. YANG: Yes. So actually this decay ratio obtained, and that peak of access point.

CHAIRMAN CORRADINI: So just so I understand what you just said, so I were to plot the overall core K effective, what you are saying is, with gadilinium burn out, instead of going down you are doing this, and you are picking that peak point?

MR. YANG: Yes, there is the peak during the cycle.

CHAIRMAN CORRADINI: Okay.

MR. YANG: This decay ratio number recall is the worst case.

MR. ARMIJO: In an initial care would you expect it to be less? Would it meet the acceptance criteria in an initial core? Would it be closer to -- the decay ratios be closer to your acceptance criteria?

MR. YANG: Yes, we provided in the initial core stability evaluation, the initial core LTR, and the results were similar results to the palladium core, and between these two cores, the equilibrium core is a limiting condition for stability.

MR. ARMIJO: Equilibrium core is limiting?

MR. YANG: Yes.

MR. ARMIJO: Okay.

MR. YANG: Next slide, please.

So following -- we are going to the startup stability -- following the established startup procedure, the voiding begins out of the core. So there is no void reactivity oscillations during this phase, so the core flow remains single phase sub cooled. So largely CPR moderator is maintained during the plant startup.

And there is no oscillation can challenge the fuel design limit during the startup. So stability is not of concern for plant startup.

MR. ABDEL-KHALIK: Do we have a complete description of the startup procedure from cold shutdown all the way to hot flow power step by step?

MR. YANG: In DCD 4B there is a startup analysis up to 300 megawatts. And there is an in-process effort to using Tri-G (phonetic) to get to the full power rated commission.

MR. ABDEL-KHALIK: You know I looked everywhere looking for -- from an operational standpoint, a step-by-step procedure for how to go from a cold shutdown to a hot full power. And I couldn't find it.

MR. SIEBER: Well, you wouldn't find that in this kind of a document. Procedures are a tier lower than that, more detailed. The FSAR DCD sets the envelope and the limits. The procedures themselves are the product of the utility operator. So they don't appear.

MR. MAYNARD: Typically they would be inspected during startup and they wouldn't be submitted as part of the FSAR.

MR. YANG: And for existing plant --

MR. ABDEL-KHALIK: But without knowing the detail step by step procedure for this machine, I would find it hard to say that, oh, we have no stability problems there at startup.

MR. MAYNARD: I'm just saying where the review normally takes place is at that point. But the NRC still, they do review those. I'm not sure when the ACRS would get something like that.

MR. SIEBER: You wouldn't. You wouldn't.

MR. MAYNARD: Without asking for it.

MR. SIEBER: The commission wouldn't get it either. It's just part of a startup.

MR. MAYNARD: It would be -- there would be some estimate of it in the COL phase I would assume.

MR. SIEBER: Yeah, and the startup test

procedures would determine whether the procedures were adequate to meet the limits that were set in the DCD and the FSAR, and you would design and run tests to show that.

MR. MARQUINO: And we have documented the initial startup testing in Section 14.2 of the DCU.

MS. CUBBAGE: Yes, I was just going to indicate that the staff has an open RAI at this time requesting that the maximum heat up rate be specified, and that limit would be implemented by the utility in their startup procedure.

MR. KINSEY: And again this is Jim Kinsey from GE-Hitachi, again getting back to the discussion we just had.

It is not our intention to put a detailed startup summary in the DCD, although we won't know that one -- we recognize that one is needed as part of the overall process, but it would be further down the road in the process.

MR. ARMIJO: But to understand this plant, how can you analyze it unless you think it through what's going to happen at each step?

CHAIRMAN CORRADINI: I guess in 4(d)(6) on a nondimensional map you kind of hand wave yourself through the startup.

But I think what Sam is looking for is some sort of progression. But you showed one slide but the next figure in you DCD is the one that I'm assuming you are eventually going to talk to relative to how you proceed through -- you proceed through a Type I instability in the chimney, but by doing that avoid the Type II instability.

MR. YANG: There is I believe there is a trajectory including 4(d) on the sub-cooling number map, but that's a schematic figure, and there is an effort to perform evaluating Type II instability over the plant start to the full power. We will establish several steps and achieve the steady state -- good steady state at the different power level, and the performance stability, and provide the decay ratio values.

CHAIRMAN CORRADINI: I see. Okay. Can I say that back to you one more time? So you are going to use TRACG and have stop pourings to see how the decay ratio evolves as you proceed down through low whatever it is, low power but increasing temperatures, and then come back up through your path, and look at the various stability decay ratios all the way through that?

MR. YANG: And those we can't see from the power flow map, my prediction is, the stability performance will improve the power decrease, because the power flow ratio decreases, because the power changes more quickly than the flow changes.

MR. MARQUINO: Let me try and address what you said and give you a brief like one minute description of the startup.

We heat the vessel up with external heating to get up to 80 Centigrade based on RT and DT limit before we pull rods. And at that point we pull rods, and that is the beginning of our TRAC analysis. We start TRAC with the rods full in; pull the critical; and then we are limited by a heat uprate that is the same tech spec heat uprate as the operating plants, 100 degrees Fahrenheit, and we've shown that the reactor is stable, and it doesn't get into a Type I or condensation slash flashing instability during the heat up and pressurization that we are limited by that thermal stress power level versus the Type I instability power level.

So that was in Section 4D of the DCD. When one unique feature of the ESBWR is because of the Type I instability we minimize the steam load and the VOP during startup. So we -- in the initial core evaluation, analyze with some steam flowing from the reactor based on condensation in the drains. But we try and minimize the steam flow until we get to high pressure, and we are out of any Type I instability concern.

Now you were talking about what we are going to do?

CHAIRMAN CORRADINI: Well, I'm just repeating what I thought he said, which was, you will take us through the startup path and at some selected points in there look at a TRACG analysis to see that your decay ratios and how they are evolving as you are coming up in power and flow; that's what I thought I heard.

MR. MARQUINO: No, we documented our stability evaluation in 4D, and we were looking for -- we started out looking for flow instability in the fuel channels. And three years ago the staff asked us to do a kinetics evaluation, so we responded by including a 3-D kinetic simulation, and that is in 4D now.

We don't have to characterize the decay ratio, because we show the power is stable during the startup, and we have very large margins to CPR.

CHAIRMAN CORRADINI: Thank you.

MR. YANG: The next slide, please.

In summary, based on the approved methodology, the results show that ESBWR is stable during normal operations and AOOs, and based on the results, we can see -- we can say the ESBWRs meets the GDC-10 and 12 requirements.

I will take -- I will use the next two slides to go through the affirmatory items for this stability LPR summation, and for the first three items, GE's -- GEH's resolution is that there is no change in the field design, the phase parameters.

And also we show that stability is not sensitive to CPR correlations.

And also we have evaluated stability performance during ATWS. And it show that stability performance is not of concern during ATWS events.

Next slide, please.

And there is an ongoing effort to develop the detect-suppress solution which will, based on existing methodology, but it will consider the ESBWR characteristics.

And for the startup stability, I think Mr. Marquino summarized, and we will further evaluate with different methodologies and also looking at xenon trending effect.

MR. WALLIS: The ESBWR is stable during

startup as long as you startup slowly enough, but you go into it for other reasons. It isn't inherently stable. You've got to do things right. Isn't that true?

MR. MARQUINO: That's true.

There was a lot of focus on this in some universities and lab testing, and they did prove that if you do something you can get the flashing condensation instabilities.

But in the bundles, we are -- we're not limited in that we -- as long as we comply with the heat uprate, which we already had as a limit, we can generate that regime.

MR. ABDEL-KHALIK: On item #5, will we have the opportunity to review that design detail?

MR. YANG: Right, there is an open item on this and GEH will address this.

MR. ABDEL-KHALIK: Right.

MR. YANG: So on the last item, we have shown that for the gap conductance obtained from different model, they are similar. One is from the prime pallette model, another one is just for gap-conducting model. And the results show there gave similar results on the stability performance.

That will be all for stability.

CHAIRMAN CORRADINI: Other questions?

MR. MAYNARD: On stability, what is your current status on simulator? Do you have a simulator?

MR. MARQUINO: Yes.

MR. MAYNARD: Have you run a startup on the simulator?

MR. MARQUINO: I have the simulator right here on my laptop. I can show you during a break maybe.

We --

MR. MAYNARD: I wonder if that might be a way to go through a startup in similar -- you asked for a detailed procedure. Well, a detailed startup procedure is going to be involving a lot of system line and some other things that are going on.

I think you are really interested in the key aspects from the reactivity -- and there may be a way to step through that without having a detailed procedure --

MR. SIEBER: Well, Chapter 14 doesn't give you the details. It tells you all the criteria you have to meet.

MR. MAYNARD: I think what you are interested in is what is going to occur, what limits on rates and what parameters are really being looked at from step to step there. If you have something like that, I think it would help with the process.

MR. ARMIJO: You know, related to that, one of the things that BWR used to be very good at, the old BWR had flow controlling power, and so you wanted to raise power very smooth, very slowly; for example, preconditioning fuel that was -- had PCI risk, that was a nice feature of the -- with the conventional BWR.

With the ESBWR I personally don't know exactly if you could do the same thing.

MR. MARQUINO: Dr. Perditza (phonetic) has a presentation that will go through that shows how we will do that.

MR. ARMIJO: Okay, I'll just hold on.

CHAIRMAN CORRADINI: Any other questions from the members? Or else we will go into a break.

Thank you very much, and we will have the staff talking to us about their SER and open items after a break at 10:30.

(Whereupon at 10:14 a.m. the proceeding in the above-entitled matter went off the record to return on the record at 10:30 a.m.)

CHAIRMAN CORRADINI: All right, so let's get started. The staff is here, so we will let them begin.

SER WITH OPEN ITEMS FOR CHAPTER 4

MR. DONOGHUE: Before we get started, I'm Joe Donoghue. I'm the branch chief in reactor systems NRO. I just want to give you a couple of words on the staff's perspective of getting ready for this meeting.

You see members, you will see some more members, including people in front of you, from NRO and from NRR. Remember that we formed NRO a little over a year ago, so there are people that -- this is a long review for ESBWR, and the people who had started out, reviewing NRR, and there are some people that are still in NRR. So don't be confused when you see that on slides.

Just wanted to say that in preparing for this, we have a -- the staff members here, we contractor support, and we are also going to have members of the staff of research, the Office of Research here.

We prepare presentations to cover a lot of ground. We do have to cover a lot of material, but there is more for us to do, we realize that.

So we basically have given you a status of the review. There are many open items. I think that was mentioned earlier.

There is also relatively new information that has come in. In the earlier presentation you heard about, I know you were interested in, the staff is reviewing -- it's still reviewing. There are more areas for us to inquire about, and we realize that.

And if you get into some areas of detailed questioning, we are prepared for some of that, but it's up to the committee how you want to spend the time today and tomorrow.

We are prepared to do some of that detail today. We can come back in future meetings and give you some more detailed presentations.

And definitely by the time we are at the final SER stage, when we think we have resolved the open items, then we'll be ready to talk in a lot more detail, okay?

CHAIRMAN CORRADINI: That sounds good. Thank you very much. I would say just to answer one of the points you raise is, we want to try to get through at an appropriate level the four chapters over the next four days.

If there are major things we have to note and come back and schedule an additional meeting on this, I think staff will then have to decide, and we'll try to find a mutually agreeable time to do that, to get into more detail.

MR. DONOGHUE: Thank you.

MR. BAVOL: Well, good morning. My name is Bruce Bavol. I'm the lead project manager for Chapter 4, ESBWR.

This morning's presentation, the outline, we are going to be briefing the subcommittee on the staff's ongoing review, like Joe mentioned, of the DCD application.

First up will be 4.2, fuel system design. And we will be doing 4.6, functional design of fine-motion control rod drive; 4.3, nuclear design; 4.4, thermal hydraulic design; and finally 4 delta and 21.6 stability.

I left off 4.5, reactor materials. That's not going to be part of the presentation, but we have the technical reviewers in the audience today if there are any questions.

Besides myself, Amy Cubbage is discussing items this morning. She is the team lead for this project. The lead technical reviewers are going to be Paul Clipper (phonetic), George Thomas, Dr. Peter

Yarskey (phonetic), James Gilmer, Dr. Weidong Wang, Dr. Jose March-Leuba, excuse me, you know who he is. Robert Davis, and Nihar Ray.

This slide indicates a summary of regulations and review guidance. Just wanted to post that briefly.

REI status. The original number of REIs started out 184, and we've resolved 150, and the number of open items is currently 34, but as this is an ongoing review, these numbers --

MR. WALLIS: Only 34? When you read these documents, it seems like more than 34. Is that because they are ongoing, or they are being tracked for something? Is that why it seems so many?

MS. CUBBAGE: It should match with what you have there.

MR. ARMIJO: I had 31, but close enough.

(Simultaneous voices)

(Laughter)

CHAIRMAN CORRADINI: We are also trying to get them one at a time.

(Laughter)

MR. BAVOL: Each chapter will lay out the specifics for that. But like you were saying there is ongoing information still being reviewed. So these numbers will definitely change.

The first section up for discussion is Chapter 4.2, and I'd like to introduce Paul Clifford from NRR.

MR. CLIFFORD: Good morning. I will begin my presentation by describing the fuel design criteria that is specified in the DCD, and then I'll move on to discuss the topical reports which detail the hardware, the fuel design and the control blade design, which will be used by the ESBWR, and that meet the fuel design criteria specified in the DCD.

The fuel design criteria that are specified within ESBWR DCD, for example, shall not fail fuel during an AOO, maintain a coolable geometry, is consistent with the currently operating fleet, and likewise, the control blade design requirements, such as the ability to insert control blades during seismic events and design basis events are consistent with the current operating fleet.

MR. BANERJEE: This includes earthquakes, right?

MR. CLIFFORD: Right.

Even though the criteria was identical to the current fleet, the staff did identify a couple of open items with the criteria themselves.

The first issue we identified which is an allowance for limited fuel centerline melting during AOOs. That remains and open item.

And secondly, the staff had concerns with the mechanical database according to 1 percent plastic straining criteria at end-of-life conditions.

MR. ARMIJO: I have a question on that. There seems to be an open item related to the use of uniform strain or ultimate strain, the difference between GEH and the staff.

Could you give us a little summary of exactly what the issue is there?

MR. CLIFFORD: Sure. The cladding -- I'm sorry, the staff prefers the use of uniform strain based upon more typical stress characteristics such as you would find in a balloon test, as opposed to the ultimate tensile strength you would see -- I'm sorry, the ultimate stress that you would get during like a tensile test.

The type of loading that you see, and also, there were sensitivities in the results with gauge length, et cetera. And what we've seen from GE to justify the 1 percent classic strain we feel needs further support, and GE -- GEH I should say - actually

I've used to calling them G&F, but GEH -- has indicated that they have some uniform strain data from the Japanese counterparts which they will be providing to close out this open item.

MR. ARMIJO: is that your understanding, the GEH will move toward the uniform strain, and we'll close it out that way? Is that your expectation?

MR. CLIFFORD: That is my expectation. And also, that gets onto another slide here, they will be providing corrosion limits and hydrogen limits from which will be the basis of the uniform strength.

MR. ARMIJO: What is this word, prefers uniform strain? Is the limit on the uniform strain, or is it on the ultimate strain?

MR. CLIFFORD: The SRP, which is our standard, provides a steady stream. This criterion goes back more than 25 years. So I think we have seen some mechanical testing data that has caused us to rethink the previous acceptance criteria from many many decades ago, and now we are moving toward uniform stress based on other testings.

MR. MAYNARD: Are we changing the requirement?

MR. CLIFFORD: We are not changing the requirement. They are specifying the requirement. I guess our open item is, we don't see that they have the capability of demonstrating that they meet their own criteria.

We don't necessarily tell them that they -- they define their own samples, when the point of cladding failure occurs. And they specify this 1 percent plastic strain. And based on ultimate tensile.

And we asked them to demonstrate that they can meet that with their current cladding. And I don't believe to this point that they provide enough evidence.

And as I indicated, they have stated that there is additional test data in their Japanese counterparts which they will use to close this open item.

MR. MAYNARD: And it's an important issue. But you talk about the staff prefers. We are dealing in a regulatory environment, there should be a requirement, and are they meeting the requirements or not, as opposed to redefining what the staff may want.

Is this stuff that is just not very well covered in the regulations?

MR. CLIFFORD: There are is no regulation specifying --

MR. MAYNARD: Reg guides, sort of thing?

MR. CLIFFORD: The SRP, which was recently updated, provides for clarification on what staff would like to see.

MR. MAYNARD: Yes, but the SRP applies to the staff review. What is the requirement on the applicant? I just wondered whether we are going beyond what the regulation requires just because -- I want to make sure that when we have different staff members that may come in to all of a sudden start changing, say now, we really prefer this, or we really prefer that.

MR. CLIFFORD: That's a very good point. I think that that's one of the reasons we added further details to the SRP so that we don't get into different regulatory instability I guess you would call it.

MR. SHACK: But there is this interpretation. I mean you have a GAC requirement, then what do you use to demonstrate that you are meeting that requirement I think is where we begin to get these interpretative differences.

MR. MAYNARD: That's where most of them come.

MR. CLIFFORD: And now we are moving on to the hardware section, the actual -- there are four topical reports that were submitted, two for the fuel assembly design, and two for the control blade design.

The two topical reports which were submitted for GE14E were reviewed, and in addition, the staff performed some FRAPCON benchmark or independent calculations to verify that they met the design requirements. And we performed an audit down in GE Wilmington their engineering calculations.

GE previously identified that the GE14E is almost identical to the GE14, except it's slightly shorter components, materials, et cetera.

Of course that was important for the staff to ensure that there was applicable operating experience.

During the course of the interview we identified a couple of open items with the GE14E. The first is although the components are identical, the space -- the distance between the spacers in effect flow induced vibrations, and we have asked GE to perform some full flow testing, and they agreed to. And we are still waiting for the results. They may have already performed it; I'm not sure. They are due any time now.

The second is that we expected them to

provide us with the corrosion limits for both oxides and hydrogen uptake.

The third item is that during the FRAPCON benchmark we identified some discrepancies between the JESTER-M model and the FRAPCON model, and subsequently GE issued an evaluation, and the staff is reviewing that.

And based upon these changes and potential changes to the DCE requirements, we would expect that both of these GE14E topical reports to be revised in the very near future.

MR. ARMIJO: To that point, I looked at one of the topical reports, and looked at the composition of the liner, and it's different from what I think GEH actually uses. It has -- and I don't know, I don't want to mention numbers, because that might be proprietary.

When can we talk about that?

MR. CLIFFORD: We could have a closed session I guess, whenever we do that.

MR. ARMIJO: The topical report is the basis for the DCP, which is the basis for the SER. I just wondering if we've got the right material defined here.

MR. CLIFFORD: It was our understanding,

based on what was described in the topical report, that the fuel design and the fuel barrier are identical to the GE14.

MR. ARMIJO: The top report, it does give specific composition, but I think it is different from what is actually being used. Maybe GE --

(Simultaneous voices)

MR. CLIFFORD: Right, well, I'm going to have to defer to GE.

MS. CUBBAGE: Does GE have an answer for that at this time? Or is that a take away?

MR. ARMIJO: It may be just something that we missed in updating that topical report.

MR. KINSEY: This is Jim Kinsey from GEH. Maybe to help us address the question, what I think I heard you say is that something that is depicted in our topical is different from what you think we may be doing. I just want to clarify that.

MR. ARMIJO: Let me just show you the table that I copied. I don't think that is the composition you wanted.

MS. CUBBAGE: Maybe sometime before the end of the day tomorrow we could come back to that.

MR. ARMIJO: Is there a limiting location for a fuel induced vibrations? And is that the same location in GE14E as it is in GE14?

MR. CLIFFORD: I'm not sure if it's the same location. I mean I'm sure it depends on the hydraulic characteristics of the assembly between the spacers, and maybe the introduction of different rods. And that is really we asked for specific testing.

Initially GE's position was that the testing that was done for GE14 was applicable to GE14, and there were also other compensatory issues, such as the flow in the core is significantly lower than the porous flow. So they were saying it's really not -- it is not expected to be a damage mechanism, because of the lower flow. And they have testing on similar bundles, but we asked for them to validate that, and then they said okay, we'll run the test. So I guess we'll have a sense of the demonstrations whenever we get the test results.

MR. BANERJEE: What are the vibration frequencies?

MR. CLIFFORD: I don't know off the top of my head.

MR. BANERJEE: How do these do these tests?

MR. CLIFFORD: They have a chamber where they insert a full bundle, and they perform full flow testing. The test rig is in Wilmington.

MR. BANERJEE: The reason I ask is, in the chimney you get a frequency do to the chugging of -- appeared at one to two seconds. Any potential for the pressure waves coupling?

MR. CLIFFORD: I'm not sure. We have asked GE -- the tests which were done in the past were done -- were just broader. It wasn't done with two-phase flow.

We've asked GE to either consider running tests for two-phase flow, or to justify the use of just saturated liquid.

CHAIRMAN CORRADINI: But the chugging phenomena that at least to my understanding, the chugging phenomena that Sandra is talking about is as you're coming up the power, and you are going to be doing full flow test at full power flow conditions.

MR. BANERJEE: It could be at power, too, because a void fraction in the chimney is such that you are in the channel turbulence regime. So you will stop --

CHAIRMAN CORRADINI: It's not an instability chugging. It's just a churn turbulence --

MR. BANERJEE: It is the full regime,

which is why I gave the one to two second period. So and that's why I was asking what the frequency is likely to be.

MR. CLIFFORD: We have asked that the test encompass the full range of flow, and also we have inquired about the quality.

MR. BANERJEE: Can GE give us an idea of what the frequency is?

MR. MARQUINO: Are you asking about flow induced vibration?

MR. BANERJEE: Yeah or frequency, what is the peak frequency or mean, whatever.

MR. MARQUINO: Well, you have the natural frequency of the bundle, right, to see if it couples with the forcing frequency.

MR. BANERJEE: Well, natural frequency without the added mass, because it is going to be a high void fraction.

MR. DERWER: This is Jerry Derwer with GEH. When we did the flow testing in the chimney, they determined the frequency of the fluid going through the chamber, and that was 2 Hertz, that's what we reported.

MR. BANERJEE: Well, that I know. These are the Ontario hydro tests, right?

MR. DERWER: No, this is what Hitachi did on the partitions.

MR. BANERJEE: You're doing a different set of tests on the partition? The only void fraction oscillation tests are the Ontario hydro ones. Is that a different set?

MR. DERWER: It's a different test. I'm not familiar with that test, though.

MR. BANERJEE: Who knows about the current set? Where was this done?

Anyway I accept the 2 Hertz, because it's in the range of what I know. But it's a question of what is the bundle frequency which clarifies the issue.

MR. MARQUINO: The bundle frequencies are given in the DCB along with the decay ratio.

CHAIRMAN CORRADINI: For flow and -- I just want to make sure we're talking about the same thing. For flow induced vibration? That is what Sanjoy is asking.

MR. WALLIS: Can they look it up and tell us later?

CHAIRMAN CORRADINI: Can we just take it and get back to it and move on for the moment.

MR. CLIFFORD: And I just would like to

add, I think we will be in a better position to talk about this once we have received the sample test data, and that will probably be presented in a future meeting.

I'd just briefly mention the two topical reports which were submitted, which document the Marathon control blade design. Which was the original Rev. 0 of these documents was almost identical to the current generation Marathon which is in operation right now.

The staff completed a review of topical reports and performed an audit down at GE of the engineering calculations. We identified several open items. Most of them were related to some operating experience that we've see in the fleet, and we believe it has to do with some assumptions in their design analysis due to reasons I've already stated and some of the irradiated stainless steel properties related to strain capabilities, for the irradiated stainless steel.

This remains an open item, and as a result of some of these issues, GE has redesigned the ESBWR Marathon control blade, and Rev. 1 was just received a couple of weeks ago, and the staff is beginning its review of Rev. 1 which has a slightly new design.

MR. WALLIS: Now this business of channel bow, is it just the channels that bow? Or do these control rods themselves have some dimensional changes over the length of the rod?

MR. CLIFFORD: I think in general the channels are flexible, but there is bowing on them as a result of peaking, hydrogen corrosion, or differential flow.

MR. WALLIS: Do the rods change their dimension at all? Do they bow or swell?

MR. CLIFFORD: What we are concerned with is that there is internal swelling in the chambers that hold the B4C powder such that you can crack the control blade, not necessarily -- -

(Simultaneous voices)

MR. WALLIS: -- changing their bowing, and it's just cracking that you are worried about?

MR. CLIFFORD: That's what we are primarily concerned with, yes.

MR. BANERJEE: And this Japanese earthquake, there was some problem with one or more of the control blades getting stuck. Have you heard about that, and what happened, an understanding of that?

This was a little bit beyond their safe

shutdown earthquake as you know of course; it went beyond. But nonetheless, most of the systems were okay. But there was something to do with control rod getting stuck.

I only heard this at a presentation by Commissioner Soda. I can probably give you a copy of the slide

MR. CLIFFORD: Okay, in summary, we have identified multiple issues, which should necessitate revisions to both, some of the ESBWR design criteria, and into the four topical reports which support the hardware.

Further questions?

MR. WALLIS: These issues seem to be completion issues. They don't seem to be something that is really fundamental, show-stopping type problems. It's just that they haven't done the complete job of design yet, haven't completely resolved some things. But it's not as though there is a huge extrapolation from present practices for this design.

MR. CLIFFORD: Right.

MR. WALLIS: So there is no real fundamental question, is there? I think that's what we should probably focus on, not all the details that have to satisfy you for completeness. But something which is a fundamental new question about ESBWR.

MR. CLIFFORD: As you mentioned, the designs are extremely similar to what they've had years of interactive experience with. So these designs we've seen, there is nothing fundamentally flawed in them that would prevent them from being approved by the staff.

MR. BANERJEE: I guess one issue would be if there is any coupling with this chimney.

MR. CLIFFORD: And that is maybe an area we didn't look at, because it's similar to unique designs, and the test rates we've seen for other vendors and for GE, so it is limited.

MR. WALLIS: Well, it gets back to the question that my colleague, Said, earlier that if you get some channels which are exhausting into the same chimney, with really conditions coming out of the channel, some kind of adjustment goes on at the bottom of the chimney. Does this produce some kind of frequency, some sort of driving force from what's happening at the bottom of the chimney, as it's adjusting itself to being nonuniform.

You have a much greater flow coming out of one passage, one channel, than another one, you can use vortices and things at the bottom of the chimney, which hopefully will die away when you go --

CHAIRMAN CORRADINI: The next presentation will be given by George Thomas of NRO, and we are going to move right into 4.6, which is the control drive system which we just were talking about.

MR. THOMAS: Good morning. Throughout the system in ESBWR is very similar to the ABWR, approved in 1997 and there are only very minor differences, like the induction model, it has not changed. And there is now high pressure coolant injection in the reactor. There are only minor difference in the ESBWR compared to the ABWR and now, as you know, in Japan ESBWR operating this system now for some time. So there is a good operating experience now, so based on that experience, we know that system can be built and operated to satisfy all the analysis.

Also they submitted the ABWR, they submitted a thorough analysis. So they wanted to take apart that one and they also identified all the differences between the ABWR and the ESBWR. So based on that we redid the CRD design.

Now he have only a few open items, basically only two of them. And one of them is related to the currect GE tech for the information system.

CHAIRMAN CORRADINI: And we are going to talk about these open items in Chapter 15?

MR. THOMAS: We don't have any plans to go into detail, but if you want to, basically we got an open item basically because --

MR. CLIFFORD: When the staff reviews the internal drive system, the first thing which seems apparent is, you want to ensure that all the design characteristics, how is moves the blade, et cetera. Anything that is credited in Chapter 15 is specifically captured in a testing for both tier one ITAC, in other words, they'll test each blade, each drive to ensure that it can meet the requirements as assumed in Chapter 15.

And there will be tech specs and future surveillance to make sure that the performance is maintained for future cycles.

That is the obvious.

The next thing you always look at, if you have a new system, you want to make sure that there are not any new characters of that system that could cause a transient, or cause the system to introduce like a new anomaly that wasn't there in the previous design.

And really the REIs that are open right now are really the second part. It's really that we have asked some questions that, okay, here's the new future of this new design. Could this cause a different accident than we've previously analyzed? And we are still waiting for some of the responses, and waiting to go through some of the responses.

MR. KRESS: Do those have anything to do with the induction motors as being a difference?

MR. CLIFFORD: No. One of them, for instance, is the ability to move many rods at the same time, whether or not that's been considered in the accident analysis.

MR. ABDEL-KHALIK: You mean the fine rod control?

MR. CLIFFORD: Right. And another one is the control -- but there are drawbacks, and as you know, as a limited reactivity initiated accident. And there is many enhanced features of this design which have been credited, and GE's position is that -- or GEH's position is that that accident has now moved beyond design space.

And the staff is questioning that position, whether or not it is beyond design basis, or whether it has to be or not.

We can talk more about that.

CHAIRMAN CORRADINI: At that time I think we'll wait, unless you really want to talk about it here.

MS. CUBBAGE: If you want to discuss this issue, this is the time.

CHAIRMAN CORRADINI: This is the time?

MR. ARMIJO: What is the GEH basis for saying it's moved off the table that the rod dropped? I mean what mechanical changes or logical changes?

MR. CLIFFORD: For instance in order for today's plants to get a control rod drop accident, they've got to move the control blade up during normal power, and then it's got to stick, and then it's got to physically separate from the decoupling device, and you withdraw the control arm, and then eventually it just falls. It falls out of the core.

Some of it is unique design -- well, they are all detailed in the DCD. But like for instance, they have changed the coupling such that it is physically impossible to decouple the control blade from what they call the hollow piston. You would actually have to rotate it 45 degrees, and you couldn't do that when it's in the core and surrounding by a shield.

MR. ARMIJO: So they have a mechanical change?

MR. CLIFFORD: They have a mechanical change, went through a coupling, a bayonet coupling they call it. And there are other features too.

And I guess the staff -- we have an open REI on this -- but we have kind of looked at probabilities, and more so deterministically, if you don't analyze this event, if you just say it's beyond design basis and you never look at it, in a sense you have given up on any control blade worth.

You know there is no limit on control area worth. You could have four high enrichment bundles in the same control cell, and you could have significant delta ro over H worth if something were to happen, and our position is that even though the probability may be slightly less for ESBWR than for the current plant, still it's something that should be analyzed, since the consequences are potentially so severe.

MR. MARQUINO: I can add something to what Mr. Clifford said. We do have an REI in the process. We start with REIs about the probability and failure modes and effects analyses. We responded to that.

We quantified the probability, and now as Mr. Clifford said, they are asking us about the consequences, and our plan is to compare the ESBWR to other control rod drop accident evaluations that we have done on a rod work basis to show that our rod works are similar to those for plants where we have evaluated the consequences control rod drop, and when that is the case, the rod drop is a local event.

We expect to be able to show that it is bounded by the dose evaluation we provided for infrequent events, which is 1,000 rod failures.

CHAIRMAN CORRADINI: So can I just get a clarification? Because the way you discuss it, this actually brings up this new categorization.

So is the GEH position that it moves out of the DBA space or moves out of the AOO space into the DBA space?

MR. CLIFFORD: Out of the DBA space.

CHAIRMAN CORRADINI: Okay, so we're not in this new categorization, infrequent events.

MR. BLEY: May I ask you a question about it? Because looking at the pictures it's hard for me to fully understand the physical mechanisms of how that rod drive works.

If it's explained that there is a clutch that allows the hydraulic air to drive the rod in for a scram, is there any way that clutch could fail and the rod drop out when you are not facing a scram criteria? Have you looked at that?

MR. CLIFFORD: There's two mechanisms there, I can kind of visualize it and that is how you have your control blade, which has a long what they call hollow piston. And that thing is resting on a small shelf which they call the ball nut.

And that's driven by an induction motor which turns a screw which raises the shelf up and down. And in the event of a scram you inject the high pressure water into the system, and that then lifts because of the hollow piston design, lifts the piston off that shelf up into the core really fast.

And as soon as it gets into the core there are latching mechanisms that will hold it in place in its fully inserted position. And also during a scram there is a signal sent to the motor to drive that shelf up, and for whatever reason it wasn't to be inserted, that's like an odd diverse scram in a sense.

MR. BLEY: And show the shelf is a physical thing, so the rod can't go past that shelf?

MR. CLIFFORD: It doesn't -- correct. But as they mentioned, there is a break, and the break does have testing requirements to ensure that during a full pressurization event the pressure on the rod wouldn't cause that motor to turn backward in a sense to try to push it out. And we have captioned those testing requirements.

MR. BANERJEE: So more of these control rod slip accidents were because of the flow control valve being open, or does it have to be closed or something?

MR. CLIFFORD: For the current flow, you mean?

MR. BANERJEE: Yeah.

MR. CLIFFORD: Right. I mean there have been incidents where flow control valves have essentially decreased the pressure in the piston region which caused the rod to drop up; we've seen those in Japan the last couple of years -- or actually it was about a dozen years ago; it was just reported.

But the classic event is that of it sticking in the floor. And in that situation the operators don't know where it is. As far as they're concerned, it's been withdrawn. But it's sitting up there and it falls at a future time; that is the classic event.

I don't think we have had one of those.

CHAIRMAN CORRADINI: And that's -- by this new design, I just want to make sure we get back to it, so I understand -- in the new design there is some sort of physical connection and turning; the point is that it can't be unhitched once it's in the core?

MR. CLIFFORD: The new design has some unique features that make the problem less, but there are a couple of features which could make the probability.

For instance, the only thing holding the control blade and the hollow piston on that shelf is its weight; gravity. So you could argue that if there was a lot of channel bow, as soon as you move that down it would stick. The shelf would go down, but the hollow piston and the blade attached would stay there. That was one of our concerns.

So you don't need it to decouple for it to hang up into the core. You would still have the hollow piston. The hollow piston can't physically decouple from the blade, but the blade and the hollow piston as one unit would hang up.

But they've introduced -- to counteract that they've introduced redundant load sensors which would identify if it were -- the hollow piston were to leave that shelf, the weight sensors would say, oops, it's not there anymore. Set off a rod block alarm; set off an alarm into the control room, and the operators would respond.

MR. BLEY: So the issue is how much credit can you give for an improved design and still address the issues that you had?

MR. CLIFFORD: Right, exactly.

MR. CLIFFORD: This is a very gray area, because the ABWR was approved. Acknowledging that the event was non-design basis. On ESBWR the staff has said, well, we think the way it was done before maybe wasn't the right way.

CHAIRMAN CORRADINI: I missed that.

(Simultaneous voices)

MR. CLIFFORD: We should have known that part. I don't think we knew that part. I didn't know that part.

CHAIRMAN CORRADINI: DCD, the ABWR which was approved what year?

MR. CLIFFORD: Ten years ago.

CHAIRMAN CORRADINI: Ten years ago, sorry, the DCD took credit for all these advanced features, and stated that the event was beyond design basis.

Now when the staff was evaluating it, the staff didn't fully disagree with that position. However, they did do an independent dose calculation. They did an analysis of rod worths and they did the transient, and then they determined what the dose would be. And they said, well, since the dose is acceptable, the design was acceptable.

It's kind of a gray area, because the SE is not the DCD. The DCD is captured in the rule; the SE isn't necessarily captured in the rule. I think it's kind of a gray area how that was approved.

And I don't think we wanted to do the same thing here, because it leads to confusion, future -- regulatory confusion when you implement this decision whether or not they have to maintain a dose calc in the future, or whether or not they have to maintain rod worth limits in the future.

So a regulatory gray area, and we didn't want to repeat that; we wanted to have a definitive regulatory position.

MR. SHUAIBI: Hey Paul, if I could -- this Mohammed Shuaibi from the staff. I guess what we are looking for is for GE to justify their position that this does not to be addressed. We are looking for them to do the analyses that were previously done on the ABWR design by the staff, and then show us or convince us that this is okay.

Where we will end up on this I don't know. I guess we will be back to brief you on the closure of these open items at a future meeting. But that's what we're waiting for is for them to provide that information to show that the probability is what it is; the consequences are what they are; and then based on probability and consequences together, we will decide whether this is okay or not, and then you'll hear about it at a future meeting.

MR. THOMAS: I want to say, my worst problem with the review is the ABWR. CHAIRMAN CORRADINI: Just to end this so we can let you go on, just to repeat what you said, is even though that might be in your heart, the DCD doesn't reflect it.

MR. THOMAS: That's my conclusion. If you got any questions.

MR. ARMIJO: I just had one quick question on the open items on the control blade design.

You have a statement, irradiated stainless steel properties in question. Exactly what are you concerned about there?

MR. CLIFFORD: We reviewed several calculations to find that element analysis calculations for the control blade design, and there were some conflicting statements and different design calcs as opposed to strain capability of the irradiated stainless steel, what we call square tubes.

MR. ARMIJO: The square tube, these are just mechanical limits, or related to stress corrosion cracking susceptibility? Or just straight mechanical?

MR. CLIFFORD: This is straight mechanical. MR. ARMIJO: Okay.

MR. CLIFFORD: The stress corrosion cracking was addressed with material changes where they changed the recipe of the 304 stainless steel.

MR. ARMIJO: Okay.

MR. CLIFFORD: But the new design, the rev one design, is -- provides a lot more margin in the sense that the maximum depletion of the B4C, the maximum B force in swelling, they will maintain margins. In other words there will be no contact between the two capsules and other square tube.

So by not having contact or having stress or strain, you don't have to worry about what the strain capability of that cladding is. That's one way of resolving that open issue.

MR. THOMAS: I will introduce Mr. Yarsey who are we talking about Point 3.

MR. YARSKY: Yes, some will be talking about our review of 4.3. Most of the review is related to the review of these four topical reports here, which is the gamma thermometer system for LPRM calibration and power shape monitoring; the nuclear design report; initial core nuclear design report; and as you heard about earlier the feedwater temperature power operating domain transient accident analysis.

So I'm going to focus on the presentation of significant open items related to those topical reports, and each is really unique to ESBWR.

The first would be the in-core instrumentation design, which is how you meet general design criteria 13. The ESBWR has a unique design feature relative to operating BWRs, which is to eliminate the traversing in-core probe system for conventional BWRs, which allows complete axial mapping of the axial power shape and replace that system with an automated fixed import probe system.

That is currently under review, and has a significant number of open items related to that review.

The second open item in regards to review is the applicability of neutronic methods and historically determined uncertainties for establishing safety and operating limits. And that is also currently under review.

Next slide. Our plan for resolution of these open items is, we'll be conducting an audit of the core monitoring software method, and moving from a traversing import probe type system to the automated fixed import probe system. The staff right now is reviewing -- relying more heavily on the neutronic methods to characterize the axial power shape versus direct measurement.

So in that review we are going to be highly scrutinizing and reviewing the core monitoring methods as they will be implemented.

And two, in the area of methods, apply appropriate conservatisms where required to resolve those issues.

MR. SIEBER: I have a couple of questions. It seems to me this is a fixed system composed of gamma thermometers, and also fission chambers; is that correct?

MR. YARSKY: There are still going to be local power range monitors, which are similar to the local power range monitors in the operating fleet, which are going to be neutron sensitive fission chambers.

MR. SIEBER: Okay, so they deplete the core. How do you accommodate calibration of those? Is it just purely the depletion that you think is going on?

MR. YARSKY: Well, talking about the calibration would require going to core session.

MR. SIEBER: Right.

MR. YARSKY: So they are calibrated.

MR. SIEBER: Okay.

MR. ABDEL-KHALIK: How about OPRMs?

MR. YARSKY: The OPRMs right now -- right now the DSS solution for ESBWR is still being developed by GE, and will be reviewed by the staff. I imagine that it will be based on the DSS CD --

MR. ABDEL-KHALIK: Is there an open item with regard to them, considering the fact that there is no detail?

MR. YARSKY: Well, as you'll recall from this morning the licensing basis for ESBWR stability is not the detect and suppress solution. So to date our, when our review has been focused on, is the ESBWR stable versus does the ESBWR have an acceptable means for detecting and suppressing an oscillation.

Right now we have an open item, I believe, which is for GE to provide the detect and suppress solution. But that is a backup to the ESBWR just being stable.

The ESBWR is stable, and that is their licensing basis, then there is no regulatory requirement for detect and suppress solution.

MR. ABDEL-KHALIK: Okay.

MR. YARSKY: Okay. I hope that answers your question.

MR. ABDEL-KHALIK: I guess we will wait for GE's response.

MR. YARSKY: Yes. I think, yes, also we had identified several COL action items in regard to the initial core design. Many of these open items have been identified and are now being resolved in the design certification space, and are no longer COL items. They are now being addressed through the IEI process, since GE submitted the initial core nuclear design; report initial core transient accident analysis.

So we intend to resolve those previous identified COL items through the RIF process related to the recent submittal of topical reports.

And just the significant design changes in the submittals that were in one case we're reviewing for substance, in another case beginning the review for are the feedwater temperature power operating domain which you have heard about I believe briefly this morning.

MR. WALLIS: We still haven't seen what it is. We just heard the words.

MR. YARSKY: There will be a presentation I believe being made by GE at some point. I don't know when that is scheduled.

MS. CUBBAGE: At the end of the day.

MR. WALLIS: End of the day?

MR. YARSKY: But this particular topical report which describes the operating domain is currently under review by the staff for acceptance. So it's not been formally accepted to date. It's just to let you know that there is this new operating domain, which we consider a significant design change.

And also the initial core nuclear design is a significant addition to the review in the area of the nuclear design.

So if you have any questions?

MR. BAVOL: At this point I'd like to change out the team up here at the front table.

(Simultaneous voices)

MR. WALLIS: guys, get on the record if you talk.

MR. BAVOL: Okay, I'd like to introduce James Gilmer. He's going to be reviewing Chapter 4.4 for thermal and hydraulic design.

MR. GILMER: As Mr. Fawcett discussed

earlier this morning, the proposed fuel is the GE14E which is essentially identical to the current operating fleet GE14 which we will accept the shorten to optimize the natural circulation flow, and because of the shortening the print spacers are closer, separation, and in addition the rod heights are shorter.

The staff has reviewed the method GE proposes to use to evaluate core --

MR. WALLIS: did they have orifices at the bottom of these channels to control the distribution?

MR. GILMER: Yes.

MR. WALLIS: Are they less restrictive in order to promote natural circulation?

MR. GILMER: I believe they are identical to the GE --

MR. WALLIS: They are identical to what they have already?

MR. GILMER: Yes.

MR. WALLIS: So they haven't changed them?

MR. GILMER: Correct. And the debris filters are the same.

MR. SIEBER: But they did have a slightly different spacing between assemblies.

Well, the fuel assembly itself, the

nozzles, is the same. But I think the gap between them is different to allow -- is that correct?

MR. WALLIS: But that's in the assembly itself.

MR. FAWCETT: Hi, this is Russ Fawcett, yes. Assembly hardware is the same. The bundle pitch is increased by 100 mils, or a tenth of an inch.

MR. WALLIS: So there is no bypass flow or something?

MR. FAWCETT: I'm sorry, what was the question?

MR. WALLIS: Is there anymore bypass flow in this than usual?

MR. FAWCETT: There is slightly more bypass flow just looking at the assembly pitch relative to, say, a C-lattice, which is six inches bundle to bundle hitch.

The N-lattice was originally developed to -- for nuclear reasons to reduce the magnitude of the void reactivity coefficient in concert with BWR development. It has other good characteristics associated with the shutdown margin and control blade spacing between channels.

MR. SIEBER: Is it undermoderated or overmoderated? My suspicion is it's undermoderated.

MR. FAWCETT: The void reactivity coefficient is negative under all reactor conditions. Specifically looking at what we call the isothermal temperature coefficient in which at cold conditions the temperature is increased. We can insert some positive reactivity so the temperature coefficient can be positive, and is allowed to be positive --

MR. SIEBER: But the void coefficient is negative?

MR. FAWCETT: The void coefficient is always negative, as is the prompt power coefficient, as is the Doppler coefficient.

MR. SIEBER: Can you ever under any circumstance -- that you can think of?

MR. FAWCETT: I know of no circumstance.

MR. SIEBER: So even if you have an excursion you will get to some point and it will -- and that's below the power range?

MR. GILMER: Any others before we continue?

Okay, the TRACG code is being used to evaluate the core thermal hydraulics, and ACRS has seen that before in the preauthorization phase, and we will be discussing it further during tomorrow's presentation.

MR. WALLIS: How far across is this TRACE code model of this?

MR. GILMER: We are doing some independent calculations with Trace Nuclear Development, versions --

MR. WALLIS: It models the core and the chimney and all that the same way that TRAC II does?

MR. GILMER: Yes.

MR. WALLIS: So some time we can see comparisons?

MR. DONOGHUE: There is a commitment from staff to show us a set of accidents.

MR. WALLIS: Okay, when are they going to do that? They committed at some time in the future?

MR. DONOGHUE: Yes. This is Joe Donoghue. There is a lot of work going on, as I mentioned in my opening remarks, and there are calculations. There are results that the staff is still evaluating.

MR. SIEBER: But the analysis of record is TRACG.

MR. GILMER: Okay, the staff review of Section 4.4 mainly consists of determining if all the conditions and limitations of the current safety evaluations for TRACG applications have been met.

And also looking at the input parameters, especially the local pressure drop measurements which are documented in a separate topical report which I didn't get the number of, I believe it's 333238 on pressure drop characteristics.

The staff has proposed a safety evaluation to apply an operating limit within the critical power ratio penalty similar to what's currently being used in the operating fleet to account for uncertainties such as the power measurement, flow measurement, feedwater temperature measurement, and others.

MR. WALLIS: Void fraction prediction?

MR. GILMER: Yes. The values are still yet to be determined, because we have some open REIs on void fraction and others that we will reserve the determination of the final value.

MR. BANERJEE: So you only decided that there will be a penalty?

MR. GILMER: Yes.

MR. BANERJEE: Not how much?

MR. WALLIS: I thought you said it was .01 or something, or you don't know what it is yet?

MR. GILMER: Well, that is what is in the operating fleet, and it probably will be in the same ballpark.

The GEXL14 correlation was based on the

improved method for the GE14 fuel. If there is a topical report, I didn't put the numbers 32851.

As Mr. Fawcett mentioned this morning, the correlation uncertainties are based on the ATLAS facility testing in San Jose, and also the STERN Laboratory in Ontario.

MR. BANERJEE: But now your spaces are a little different, right?

MR. GILMER: That's correct. Actually it enhances the critical power performance with the short part length per hour because of the stagnation effects.

MR. WALLIS: But they have done experiments -- yes, they have done experiments of GE or TE?

MR. GILMER: Yes -- well, just recently --

MR. WALLIS: And I guess we're going to get to look at the results some time?

MR. GILMER: Yes, that's still to be determined. They have to look at them first, I think.

MR. BANERJEE: But were these done at the STERN? The ATLAS is shut down, correct?

MR. GILMER: Yes.

MR. BANERJEE: They were done at the STERN labs?

MR. GILMER: The new tests were done at the STERN lab.

MR. WALLIS: Did you approve their test matrix at the time?

MR. GILMER: No, we haven't. Actually we have an REI 4.4-1.

(Simultaneous voices)

MR. WALLIS: -- before they responded to the REI?

MR. GILMER: Yes.

CHAIRMAN CORRADINI: How large is that database?

MR. GILMER: Can GE address that?

MR. FAWCETT: Hi, this is Russ Fawcett.

The test that we just completed, the full scale test of GE14E I think in qualitative terms it is consistent with a full test of steady state data covering the entire range of ESBWR under steady state and transient conditions including transient tests.

MR. BANERJEE: What was the maximum power that you get out of this facility?

MR. FAWCETT: I'm sorry, what was the question?

MR. BANERJEE: Maximum power in the facility?

MR. FAWCETT: The name plate rating on the power supplies is about 16 megawatts. We have delivered power to the assembly in excess of 13 megawatts for a full-length assembly.

MR. ABDEL-KHALIK: Is the database large enough so that you would not have to rely on prior data for GE14 to establish the uncertainties?

MR. FAWCETT: In my judgment it is sufficient to establish a correlation for GE14E.

I think we will conclude that the GEXL14 is adequate, and there is no need to make any changes.

MR. BANERJEE: Did you take any void fraction data?

MR. FAWCETT: Not direct measurements, no. By virtue of having assembly pressure drop data, and we have done this, elsewhere, it is an indirect affirmation of the void fraction predictions.

MR. BANERJEE: You didn't put a chimney on top?

MR. FAWCETT: No, we didn't.

MR. BANERJEE: What a pity.

(Laughter)

MR. BANERJEE: The facility is run by one of my ex-students, you know, Gord Hadalla.

CHAIRMAN CORRADINI: You should have taught him better.

(Laughter)

MR. GILMER: Okay, the significant -- or I should say ongoing review activities are several topical reports. The key one is the critical power correlation uncertainty of development, 33237. We have re viewed up to revision two, and just recently received revision three around Christmastime, which we have not begun review on yet.

And we have been told that the new data will be submitted as a revision to the topical report; Jim, correct me if I'm wrong.

MR. FAWCETT: This is Russ Fawcett again. Our plan is to provide a separate -- hi, this is Russ Fawcett. Our plan is to provide a separate report .

MR. GILMER: The second one has been mentioned earlier, the nature of core transients, topical. We expect there will be some effects on the core thermal hydraulics. We evaluated based on equilibrium core that --

MR. WALLIS: When I was reading all this stuff, I noticed there was an enormous number of technical reports, and I was a little uncertain about how much we are supposed to get involved, and looking at those, because it would be a huge task to go over all these topical reports.

CHAIRMAN CORRADINI: I think the way we are handling it is, we, are this point, we are looking at the open items, and if we need to delve into it -

MR. WALLIS: They keep referring to topical reports.

CHAIRMAN CORRADINI: We do have some topical reports in this.

(Simultaneous voices)

MR. WALLIS: So I mean this isn't enough to hold all the topical reports.

(Laughter)

CHAIRMAN CORRADINI: No, no, no, this one is the one we've received already, and there is more they are speaking about.

MR. GILMER: And 33237. Or the 33237, but not the next two.

MS. CUBBAGE: We did not provide those at this time because they were not included in the staff's evaluation.

CHAIRMAN CORRADINI: That's fine.

MS. CUBBAGE: But we would be happy to get you copies of those now.

CHAIRMAN CORRADINI: When it's appropriate.

MS. CUBBAGE: We didn't want you to get confused with too much information.

CHAIRMAN CORRADINI: I can't imagine us getting confused.

MR. GILMER: Okay, as mentioned, there are several open RAIs on the 33237 that are currently in the safety evaluation. The other topical report that we know will have some affects on the protocol is the order temperature operating domain, which I guess will be discussed later this afternoon.

The primary concern, we believe, is the cold water injection of feedwater for certain transients, so we expect them to be done in detail.

Summary of current open items. These are the significant ones. The critical power testing for the GE14 fuel. We will start that evaluation as soon as we receive written documentation.

The high void fraction data is basically the same issue as in the operating fleet within the Findlay-Dix and we -- the staff feels that the pressure drop indirect determination that came in with the methods topical as a supplement were the 10X10 fuel. That's nice to have. It's not all you need, since other vendors get the data, we would like to have it from GE also.

MR. WALLIS: Did you look at the chimney data? Don't they have some new data with the actual box design? We don't have the Ontario hydro data, but apparently they have some new data.

MR. BANERJEE: That was referred to. Do we really have new data?

MR. BANERJEE: Have you looked at that?

MR. CLIFFORD: No, I have not seen it.

MR. WALLIS: You haven't seen it yet? So that could be another open item that was part of the results of these chimney tests.

MR. CLIFFORD: That's correct.

MR. BANERJEE: So let's clarify this, because it wasn't clear in the statement. We are aware of the Ontario hydro data on the void fraction, but is there additional chimney void fraction data? Do we have a clear answer to that?

MR. KRESS: I think I'd like to ask GE to explain, because they were the ones who mentioned it earlier.

MR. MARQUINO: There was an RAI, and we provided data from our air-water FIV testing.

MR. WALLIS: That's all you have?

MR. BANERJEE: So it's only air-water data?

MR. MARQUINO: That's right.

MR. BANERJEE: Okay. It will be another open item.

MR. MARQUINO: Yes.

MR. GILMER: Okay, this past summer the Office of Research did a confirmatory study, or several studies, with the subchannel code COBRAG, which GE has used to evaluate the effects of those at the spacial separation and the rod height and the results of our studies studies, although they are still preliminary, that indicate that nothing is acceptable.

I included the critical power uncertainty evaluation as an open item still, because we will have to relook at it for the new test data.

Our factor method, we agree that the method is acceptable using the same method as is used for the GE 9 through 13 that we have at RAI that requested a split for GE, 14E specific confirmation based on the test data.

MR. BANERJEE: So on this you get this data from the GE14E, you don't really know what files been used and all this sort of stuff.

CHAIRMAN CORRADINI: Before you had come, there was a discussion on how they are using the GE14 fuel, and doing a back-correction which they consider conservative.

But in that discussion this is where we learned about the STERN data, STERN Lab data to look at and compare.

Did I characterize that correctly?

MR. BANERJEE: The shorter fuel with more spaces.

MR. GILMER: Fewer spacers.

MR. BANERJEE: Fewer spacers.

MR. GILMER: It was two feet shorter, so I don't think there are more spaces.

MR. BANERJEE: I mean the distance between the spaces is shorter, right?

MR. GILMER: That is what I meant.

Okay, in summary, the staff has a reasonable assurance that the methods being used by GE for the core thermal hydraulic design are acceptable. However, the actual determination of values we have to evaluate later when we get to the new data.

The same applies to the --

MR. BANERJEE: Does GE have any plans to reduce the uncertainties in the void fraction data?

Have they indicated this to you?

MR. GILMER: Not to my knowledge. We got a response to the RAI that referred to the GE methods, topical and supplement, the 10X10.

MR. FAWCETT: Hi, this is Russ Fawcett. I'll say it's in our interest and in the interests of the fleet to remove that penalty. So it's in our plan to address this issue.

MR. GILMER: Okay, any questions?

(No response)

Okay, well, I'd like to introduce Dr. Weidong Wang, and Jose March-Leuba who will talk about the appendix 4D on stability.

MR. WANG: First, stability stability review, actually the data was reviewed by Wilson, who is sitting in the back. For the rest of the presentation I would like to introduce Jose Leuba.

MR. MARCH-LEUBA: Yes, so we are going to talk about stability. And I heard the whole morning that everyone was waiting for this topic.

There are two items that we are covering. The first is Appendix D of Chapter 4, which covers the stability of ESBWR, and Chapter 21 which is the coverage of the methodology which is TRACG. And we were in there with the members especially this side of the table on the review of strategy in 2006.

We had two full committee meetings one-day long, one full committee, when we went through the stability of ESBWR and the ability of TRACG to ESBWR.

MR. BANERJEE: I was there for one.

CHAIRMAN CORRADINI: Now that I'm trying to remember it, but go ahead.

MR. MARCH-LEUBA: The issue that we had at that time I remember was the nodalization.

There was an issue -- there has been an ACRS issue from TRACG with a positive letter from this committee saying that we should be approved for use of --

MR. WALLIS: The issue was a courant number, and the artificial dumping of fluctuations.

MR. MARCH-LEUBA: The only issue remaining was the nodalization of the chimney. So let's backtrack and talk about what the regulatory guidance is, what does the law say.

And we have GDC 12 and 10 that tells us what to do. GDC 12 tells you that oscillations should not be possible. If they are possible, you should be able to detect and suppress them.

If you go the route of detect and suppression, then you invoke GDC 10 and say you suppress them, you have to suppress before SAFDL are violated.

We also have guidance from SRP 15.9 which is the BWR stability and 15.0.2 --

MR. WALLIS: When it says oscillations, presumably it means growing oscillations?

MR. MARCH-LEUBA: Actually, the possibility of --

MR. WALLIS: Because some sort of minuscule oscillation is always possible.

MR. MARCH-LEUBA: That's correct. And that's why the GDC actually says oscillations with the possibility of causing damage to the reactor. And that the deceleration is already 15.9 because you always have noise. You always have oscillations.

The ESBWR designed team at GE has decided to go the route of GDC 12 to demonstrate by analysis that instabilities are not possible. And they do this becuase in the most unstable point in the ESBWR is actually the normal operating condition. So if you don't design this reactor to be stable it will never work. And the operating fleet, indeed, most reactors now have a calculated deviation of greater than 1. The reactors that are operating right now are unstable at some operating condition which is very unlikely to be reached.

So the ESBWR team decided to prove by analysis that it's stable. The downside of that is, any change they make like for example in the review of GE14E they changed a spacer. You have to redo the analysis again, and demonstrate with new spacer design you are unstable. Let's go to the next slide.

MR. BANERJEE: There is nothing like making assurance doubly sure.

MR. MARCH-LEUBA: I'm going to move on two or three slides, there is a defense in depth in which the DCD has committed to have an OPRM-type scram, and the DCD actually mentions the SSCD. There is an RAI open to specify exactly what I mean by that.

Do you want DSS/CD or what is it that you are going to use, because it is only one sentence in the DSS/CD.

But there is a commitment, and there will be a defense in that with an OPRM scram, which answers your question this morning that protection against the out-of-phase type of instability will be produced in case it happens, in case TRACG was mistaken, in case our analysis is mistaken and we do have an instability, it will be provided by the OPRM scram.

MR. BANERJEE: Will that guard against

also single channel type instability or small groups of channels?

MR. MARCH-LEUBA: Without getting into proprietary nature of all the presentations we have seen in the last month, the argument on the long term solution to stability is that before you have a single channel instability, you have original instability. So the issue you remember as you're trajecting, you become unstable originally out of phase. A little later, in addition to that --

CHAIRMAN CORRADINI: Well, if it is proprietary we can go off the record in a closed session.

MR. MARCH-LEUBA: It's not proprietary. The proprietary is the use. So the argument is that if a channel is going to become unstable, the likelihood is that the whole core become unstable before the channel becomes unstable, and therefore it would be protected.

Or MR. BANERJEE: Not just a likelihood; it's a certainty, right?

MR. MARCH-LEUBA: Certainty is such a strong word. There have been two channel instabilities in history. They were both because one channel broke down. So if you -- you can have physical changes to one particular channel and make it unstable with the core being stable. But you require some accident or mismanagement of the loading.

So during the review we concentrated on three items. First we have what we call the core stability, which is what we are aware of. It's the density-wave instability that all operating reactors would worry about, and you have the channel core 1 and regional oscillation.

But in addition because of the specific features of the ESBWR which are new, we have to study the stability of the chimney and the stability of the stack.

MR. BANERJEE: The loop oscillation is driven by the chimney.

MR. MARCH-LEUBA: In the chimney we were worried about three types of instability modes. One of them is a loop instability, which is a kind of a normative type of instability where the down-comer oscillates against the chimney. We were worried about the floor region use instability. And thirdly, we were worried about the fact that the chimney itself could enhance the density- wave instability.

All three were evaluated and came out to be that in the chimney place had no dynamic role in the ESBWR.

The biggest recommendation from the previous review of this --

MR. BANERJEE: Were there any -- there were some experiments, or there is even a reactor in the Netherlands which has a chimney, doesn't it?

MR. MARCH-LEUBA: There was a reactor in the Netherlands, which was a nuclear reactor that operated for in the U.S. about five or 10 years ago.

MR. BANERJEE: How big was the chimney?

MR. MARCH-LEUBA: Four or five meters, I don't remember.

MR. BANERJEE: Comparable?

MR. MARCH-LEUBA: Comparable. It's a smaller reactor, much smaller reactor.

(Simultaneous voices)

MR. MARCH-LEUBA: It was natural circulation. It operated safely for many, many years.

Recently there was some experiments conducted in the --

MR. WALLIS: The Genesis.

MR. MARCH-LEUBA: The Genesis, which showed some different results. That's a separate item.

On the startup stability issues -- all

reactors, I mean Brown's Ferry, Susquehanna, starts up, and they're all there. The difference between ESBWR and the operating fleet is that ESBWR is started with a nuclear hit so your reactor is critical when you are at low pressure.

So therefore you operate -- and during low pressure the difference in density between water and steam is enormous. So any boiling that you produce produces a tremendous feedback on the density, and you can have very large oscillations on low pressure. You should not operate on low pressure.

The solution to this for the ESBWR design team was to start them very slowly. And the idea is to startup and to produce flashing at the top of the chimney by the difference in density -- in pressure, and never ever get voids into the core while you are at low pressure.

MR. WALLIS: The slow upgrades seem to be very, very slow to me. I mean they seem to be so much slower than any of the time constants for the system. I didn't understand why it had to be so slow.

MR. MARCH-LEUBA: Well, I'll tell you, the biggest constraint, and the reason they did it, is for the heat uprate of the vessel. It's at 100 degrees per hour.

MR. WALLIS: Well, that dominates everything then. But the hydrodynamic transients are so much quicker.

MR. MARCH-LEUBA: They are but because the vessels have to heat up so slowly, they have to produce heat very slowly, and that prevents having boiling in the core.

So there will be instabilities during startup. It's a Type I instability.

MR. WALLIS: In the chimney?

MR. MARCH-LEUBA: In the chimney. Whenever you flash, you get more flow, and you collapse.

MR. WALLIS: In fact, there is no way around it.

MR. MARCH-LEUBA: There is no way around it, but it has no consequence. As long as you are still cooling the core, and your CPR is 20 to 40, who cares.

MR. SIEBER: Well, they're not divergent.

MR. MARCH-LEUBA: They are not divergent. They are not divergent.

And all these areas, like I said, we are TRACG SER, which was presented this morning.

MR. BANERJEE: The concern is, I agree

with everything you've said except what -- how did you resolve the flow regime instability issue?

MR. MARCH-LEUBA: We resolved it, but we analyzed and we have a small disagreement. We have an RAI issue that has never been resolved. The flow regime instability issue is like for example is when you have bistable flow in the feedwater loop in operating reactors, where you have two possible solutions.

Imagine that you are in transition flow, and you could be laminar or turbulent. So you have two possible solutions. Then you have a flow regime instability. You are jumping from laminar to turbulent or from annular flow to slide, and you have different void fractions on the two solutions. And you could be jumping between the two.

We calculated a transition of the flow regime, the staff did. And we estimated that the transitions to the annular flow at about 60 percent power. So when you operate at full power --

MR. WALLIS: In the chimney?

MR. MARCH-LEUBA: In the chimney.

MR. WALLIS: You do get annular flow in the chimney, really? I don't think -- that doesn't seem believable.

MR. MARCH-LEUBA: Tracking claims you don't transition --

CHAIRMAN CORRADINI: You do or do not?

MR. MARCH-LEUBA: Do not.

CHAIRMAN CORRADINI: Good. It doesn't sound like you would to me. I don't see how.

MR. MARCH-LEUBA: So you have slide four, and is, you're far away from the transition rate.

MR. WALLIS: Well, the issue there in the limited amount of data that we have seen in steam water was that you see frequencies of oscillations because of the slugging or whatever. I mean it's more churn turbulent that slugging.

MR. MARCH-LEUBA: Which are, as I say, we don't know --

MR. WALLIS: I think, according to Ishi, you can never get slugging, so it's a big challenge.

MR. BANERJEE: Yes, you get churn turbulent flow. It gives you oscillations.

CHAIRMAN CORRADINI: This is the concern that you had expressed before, Sanjoy?

MR. BANERJEE: Yes, but I was asking how has it been resolved, or is it still an open item.

MR. MARCH-LEUBA: The resolution is, whenever you have two-phase flow, if you were to look at an operating reactor now, you would see that the power of oscillating about 3 percent, and it is because the two-phase flow inside the core is producing the noise, which is the slugging you are talking about. It is the randomness of the voids are causing changes in buoyancy, changes in friction. And the flow is oscillating 3 percent. You will have some noise.

MR. BANERJEE: Now you have a large system there which could lead to somewhat larger oscillations.

MR. MARCH-LEUBA: Or, well, because of that, we do have oscillations that might cancel out --

MR. BANERJEE: This was the issue, really, an issue that if you look back there was a question as to whether these were correlated or not. And Ontario hydro data was taken with two gamma densitometers, and one of the issues really was whether cross-correlation were done between those two.

Now apparently they weren't. They had these data, but they didn't -- they have the real-time signals, but they did not cross-correlate it to get whether there was a concerted motion going on.

And the issue would be if there is a

concerted motion, because then you would get fairly -- you'd get oscillations which are roughly the same frequency as your core.

CHAIRMAN CORRADINI: We are running behind a bit, so I'm -- I'll let you decide. But I guess just one thing to take away, we may have to get back to that, we may have to ask you, Sanjoy, so you think one channel of the 16 could actually synergistically feed the chimney or vice versa? That's what I'm struggling with. You got 16 to 1?

MR. BANERJEE: No, it's not that. All of them are feeding it, but in the chimney itself you can start to get oscillations which are pretty -- you know it's a question of how random they are, as you were saying. It's correlated, the whole thing is jogging up and down. It's different from --

CHAIRMAN CORRADINI: But the characteristic natural frequency of one would have to somehow intersect with the other to create some sort of synergistic effect, right?

MR. BANERJEE: Well, in the chimney itself, you could feed back a pressure wave.

MR. WALLIS: Maybe we just have to list these things for our subcommittee meeting.

MR. BANERJEE: I think what probably needs to be done at some point when these RAIs have been answered or something, or even before. Some of these topics will have to be looked at in more detail once again. Maybe they are put to bed, maybe they're not, I don't know.

MS. CUBBAGE: Are your questions associated with open items?

MR. BANERJEE: I don't know if it's an open item. That's why I asked, is it still an open item, the floor regime stability, or have you closed it?

MR. MARCH-LEUBA: We believe we closed it.

MR. WALLIS: Then we probably need to know how it was closed.

MR. BANERJEE: It may be perfectly fine, we just want to know how it was closed.

MR. MARCH-LEUBA: So all of these -- there are two SERs associated with this review. One is the TRACG SER which was previously issued, and it was a very large, topical report, 33083, which covered a large -- of applications of TRACG.

But in the staff SER for TRACG, we approved the use of TRACG for decay ratio calculations in steady state, and we did -- because of the nature of the calculation, you cannot calculate a decay ratio during a transient, but we approved that you can use it to demonstrate that the decay ratio in the transient was less than 1.0. So if you run the transient with the proper numerics, and the proper nodalization, and the oscillation does not develop itself, then you can guarantee the decay ratio is less than one, you just don't know how much less than one.

MR. BANERJEE: How do you guarantee that the numerical damping isn't actually playing a role here? By just changing the nodalization?

MR. MARCH-LEUBA: Two things, changing the nodalization, see that it doesn't go, and do benchmark against real, planned data.

MR. BANERJEE: Has there been any confirmatory analysis done with trace?

(Simultaneous voices)

CHAIRMAN CORRADINI: That is one of the promised calculations in Chapter 15 and 21 that will be done. Audit calculations, is that what you're asking about?

MR. BANERJEE: Yes.

(Simultaneous voices)

MS. WILSON: This is Veronica, I'm just going to correct you for a second. I do believe Trace is capable of doing stability, as our friends in research have told us, but it's not planned for the DCD -- to support the DCD in the area of stability at this time, although we've been told --

MR. WALLIS: Well, the trace is modeling the tractor who probably --

(Simultaneous voices)

CHAIRMAN CORRADINI: This is on Chapter 6, so we are going to get to it this afternoon. But what I have written down from the staff SER was main steam line both feedwater rate GDCS injection lines, a number of LOC (phonetic) design basis, is that correct?

MR. MARCH-LEUBA: Correct.

MR. BANERJEE: So what is the plan again? I missed it.

MS. WILSON: LOCUS, AOOs and ATLAS.

MR. WALLIS: Once you have those running, you can probably investigate stability without much trouble.

MS. WILSON: At the time we did some calculations to support the initial review trace was not available to us as a tool for stability, but Jose used LAPUR.

MR. MARCH-LEUBA: The confirmatories were done with LAPUR. The LAPUR is a frequency domain code.

Next slide, please. This one in conclusion is of the TRACG SER, and you can read them on the SER. Next slide.

And all those conclusions were based on the follow-up review of the physical walls inside TRACG, and we did some of the numerical vamping evaluation answering the questions by the members, especially the finalized assessment of the chimney.

MR. WALLIS: Did you find that you did not get the void fraction wave attenuating artificially, that propagated all the way down the chimney?

MR. MARCH-LEUBA: This was cooler number one.

MR. WALLIS: So it didn't change?

MR. MARCH-LEUBA: And the most important analysis was the characterization with core organization and the characterization with finalization in that change.

MR. WALLIS: Because the core dominated succinctly?

MR. WALLIS: Neutronic feedback, the void dominated --

MR. MARCH-LEUBA: There's no friction

pressure at all for the chimney. It's only buoyancy. And in addition to those, we do have a very large TRACG qualification that I include in lateral systems and benchmarks against operating reactors.

MR. ABDEL-KHALIK: Now in these numerical simulations was each super cell modeled as a one-dimensional cell -- as a one-dimensional channel?

MR. MARCH-LEUBA: Well, the chimneys are a one-dimensional channel, yes.

MR. ABDEL-KHALIK: Okay, so the effect of radial variation in power within an individual super cell has not been explored?

MR. MARCH-LEUBA: No. No. The issue per cell is held by sixteen channels.

MR. ABDEL-KHALIK: Right.

MR. MARCH-LEUBA: And there will be a radio power distribution, a significant radio power distribution.

MR. ABDEL-KHALIK: Yes.

MR. MARCH-LEUBA: The expectation is that all that power will mix shortly after --

MR. MARQUINO: Excuse me, are you asking about the staff evaluation, or the GE evaluation?

MR. ABDEL-KHALIK: Both. I mean we haven't seen any evaluation of this issue by either

GEH or the staff.

MR. MARQUINO: In the GE calculations in the DCD there are 16 super bundles or partitions modeled. So we grouped -- we have a grouping. We modeled some individually and we lumped some together.

MR. ABDEL-KHALIK: Well, I'm talking about an individual super channel

(Simultaneous voices)

CHAIRMAN CORRADINI: I think what he's looking for is that, did somebody do an analysis of the 16 flowing into the one, and looking at the entry length where it essentially eventually becomes one dimensional? That's what he's looking for.

MR. MARQUINO: We looked at one -- we have one super channel modeled with 15 other ones -- actually we have six individual super channels modeled with 10 other ones lumped ones, and we've executed simulations where we perturbed one to come up with the decay ratio. That was part of the LTR evaluation.

MR. ABDEL-KHALIK: I guess you are not really answering the question that was posed, what happens with an individual super cell.

MR. MARQUINO: You mean within one of them --

MR. ABDEL-KHALIK: Right.

MR. MARQUINO: -- we have -- it's a one-dimensional model, and there is something like -- well, we discussed finer and coarser nodalization within that one-dimensional model.

MR. ABDEL-KHALIK: So no three-dimensional effect within an individual super cell has either been done by GEH or the staff; is that correct?

MR. MARQUINO: That's true for GE, yes.

MR. ABDEL-KHALIK: Okay.

MS. WILSON: This is Veronica Wilson, and this is something I'm going to have to get back to you on, but the staff did do -- in preapplication, a CFD analysis of a super channel. And I unfortunately don't remember the details. So I'll have to look at that and get back to you.

But we did look at that in pre-application.

CHAIRMAN CORRADINI: Well, we would appreciate that. Thank you.

MR. ABDEL-KHALIK: Thank you.

MR. MARCH-LEUBA: Now, once we have a TRACG methodology approved, that has been applied to the ESBWR design, and the conclusions of their applications of the ESBWR design is a stable -- as advertised, and that is confirmed by the TRACG calculations on our confirmatory LAPUR calculations.

The regional stability mode is the dominant mode for several reasons. Number one is because that's what the code says it is.

(Laughter)

MR. MARCH-LEUBA: You can generalize with why, because it has a very large diameter. And the decay ratio is approximately of the order of zero point four, which was the design idea.

The acceptance criteria is zero point eight. So that gives us a very large margin for stability under the nominal conditions. And there was a CSAU analysis performed on these numbers. I'm sure that the error is less than the point four margin they have.

The calculation I'm sure the chimney has a very small effect on stability, and no loop flow type of instabilities have been predicted.

And during the startup, as long as we keep the heat-up rate at the prescribed limits, which is of the order or 50 megawatts, and it's 100 degrees an hour, you do not get so cool boiling into the core, and there is no reactivity feedback involved, and the flow oscillations that will happen have no consequence.

MR. WALLIS: Now when you shut off -- when it is subcritical, you've still got decay heat, and you are cooling this thing. Now you have the opportunity for loop oscillations, but you don't have the feedback from neutron.

MR. MARCH-LEUBA: I would say yes.

MR. WALLIS: Has anyone looked at oscillations during the long-term cooling or the post-LOCA cooling, when you don't have the neutron feedback which drives these other oscillations?

MR. MARCH-LEUBA: To my knowledge, we have not done that.

MR. BANERJEE: Is there boiling in the core in these situations?

MR. WALLIS: Maybe it's all single phase. Well, they're boiling off, aren't they? So there must be boiling presumably.

MR. BANERJEE: There is boiling somewhere.

MR. WALLIS: Boiling somewhere.

(Simultaneous voices)

MR. MARCH-LEUBA: So the conclusions for the SER are the GDCS pool will be satisfied because the stability is a highly unlikely in ESBWR, and by going through this route, we have to demonstrate that instabilities are highly unlikely for every core boiling, and indeed GD plans to calculate every core boiling and guarantees compliance for future course, and in addition we have a defense in there mechanism which is a detecting supersolution.

MR. BANERJEE: Now this is still an open item?

MR. MARCH-LEUBA: It is an open item for a couple of reasons. Number one, the DSS/CD has not been approved for use on the ESBWR.

MR. WALLIS: Nothing has been approved.

MR. MARCH-LEUBA: Yes, but specifically it's mentioned in the last systemic report that is not applicable to anything beyond BWR6s. I think it was an oversight.

MR. BANERJEE: We get to approved it then?

MR. MARCH-LEUBA: We get to review it, that's correct. We get to review why that statement was made.

MR. BANERJEE: Well, we never reviewed the SSCD. It never came to ACRS.

MR. MARCH-LEUBA: Maybe not in detail, correct.

MR. BANERJEE: We reviewed everything else in detail.

MR. MARCH-LEUBA: I know. So there are a number of open items which are really not related to stability. They are related more to the input parameters that we go into TRACG calculations.

So the staff has a number of reviews going with physics -- directions of cross sections that are now under review. And if those change significantly then the stability operation have to be redone. And that's why it's being tracked as the stability of an item.

There is an issue with the dynamic of conductance model. GE14E has been under review, and should they come out with an GEXY, the reevaluation of stability will have to be done.

So this is a type of stability oversight that we have. The obvious stability analysis is not complete. There was an RAI issue because they had performed and now was transient, and so there is no oscillation. So the characterization was less than one. But we didn't know how much margin we had. So they are supposed to do some steady state calculations of several points and tell us how much margin we have.

And there was another question --

MR. BANERJEE: Is that analysis available at the moment?

MR. MARCH-LEUBA: Being performed.

MR. BANERJEE: Being performed?

MR. MARCH-LEUBA: That is a truly open item.

MR. BANERJEE: And that -- preliminary indications is there is no ATWAS instability?

MR. MARCH-LEUBA: Correct, because there is no recirculation.

MR. BANERJEE: Right.

CHAIRMAN CORRADINI: Say it again.

MR. MARCH-LEUBA: There is no recirculation.

MR. BANERJEE: Yes, you are all in natural circulation.

MR. MARCH-LEUBA: Yes, you are already there.

MR. BANERJEE: That would be a great --

MR. MARCH-LEUBA: It's a big selling point.

MR. MARCH-LEUBA: It's a big selling point. Finally, during the startup analysis, the analysis assumes constant serum. And because it's so slow, serum exchange. And so have issued some REI for them to justify or do calculations.

MR. ABDEL-KHALIK: Now, what are the

operability requirements for this detect and suppress stability solution?

MR. MARCH-LEUBA: I do not know, because, again, that's part of the REI. It's not the licensing basis. It's a defense in depth. So we have not seen the tech specs, proposed tech specs. But they might be different.

MR. BANERJEE: So you are basically excluding the normal -- almost every situation from stability problem, the wholesale map. If you get into it, it's a good idea to have something.

MR. MARCH-LEUBA: It's a good thing to have just in case.

MR. BANERJEE: You never know.

MR. MARCH-LEUBA: So it is a defense in depth, so we are waiting for a proposal on the tech specs.

MR. WALLIS: But this looks like the other issues we heard about today. I mean there isn't any sort of show stopper. There is nothing big. It's just tidying up the issues which you think have already been resolved.

MR. MARCH-LEUBA: That is correct.

MR. BANERJEE: The only thing that bothers me is that we don't have a flow loop with even a small number of channels that actually show this thing in some sort of typical way. It's all calculations.

MR. WALLIS: This is this Genesis thing, which is a Freon loop.

MR. MARCH-LEUBA: Near the land slope, yes?

CHAIRMAN CORRADINI: You are more worried about the coupling, Sanjoy? What are you worried about?

MR. BANERJEE: I'm worried about everything.

(Simultaneous voices)

MR. BANERJEE: There are so many things that bite you in complicated systems.

(Simultaneous voices)

CHAIRMAN CORRADINI: Given that it behaves as a one-dimensional system, there doesn't appear to be a show stopper. And you are still concerned about recoupling in between.

MR. BANERJEE: Yes.

CHAIRMAN CORRADINI: If I understand.

MR. BANERJEE: It would have been nice to have had a facility like the stone facility with the chimney running full height bundles. A bit of assurance that the thing would work.

CHAIRMAN CORRADINI: Other comments? Thank you very much. We are due to come back at 1:00.

Are we going to discuss Chapter 6?

MR. ARMIJO: Before we leave Chapter 4 I just have one thing. And that was, we didn't talk about the conclusion on the materials.

CHAIRMAN CORRADINI: That was purposefully -- I think they mentioned --

MR. ARMIJO: They are going to whip by that?

CHAIRMAN CORRADINI: They said materials won't be part of today's presentation, but we can ask questions.

MS. CUBBAGE: And I will caution you as we speak that our materials lead is going to be back this afternoon as part of the Chapter 6 presentation, but they are not here at the moment.

MR. ARMIJO: I'll hold it to Chapter 6.

CHAIRMAN CORRADINI: So let's adjourn, and we'll get back at 1:00 o'clock.

(Whereupon at 12:12 p.m. the proceeding in the above-entitled matter went off the record to return on the record at 1:05 p.m.)

CHAIRMAN CORRADINI: So let's go back into session.

And we have GEH here to talk to us about the engineered safety features.

Is it Mr. Watkins who is going to kick off?

OVERVIEW DCD CHAPTER 6 - ENGINEERED SAFETY FEATURES

MR. WATKINS: Good afternoon. My name is George Watkins. I am the regulatory affairs engineer for Chapter 6, Engineered Safety Features.

Today we are going to present a brief overview of the material section, the presource and insource inspection program for the ESF system.

We will discuss containment design and the containment performance analyses, and our emergency core cooling system design features and performance analysis.

I have Jerry Deaver here. We will be primarily discussing system design features. We have Brian Frew, who is our materials expert, who will talk about material section in ESF materials.

And Dr. Chung (phonetic), who is the performance analysis guru for us, who will discuss our containment and ECCS performance analysis.

We are going to start with the materials discussions and the preservice and inservice testing programs. And then we're going to move to the containment systems and emergency core cooling systems.

So with that, Jerry, you can begin.

MR. DEAVER: I guess, maybe, before we start here, there were at least one question from this morning's session related to carbon content of alloy 600 materials. And Brian with the code case.

MR. FREW: The code case specifies maximum carbon content of .050 percent.

MR. DEAVER: Okay, in 6.1, basically this section covers engineered materials for engineered safety systems, and the intent of this section is to ensure that material interactions do not occur that impair the operation of the safety related systems.

And related to that it wants to make sure that the material selection also isn't impacted by environmental conditions during either normal operation or postulated accident events.

Basically materials with the engineered safety systems and containment are fundamentally the same as we did in the past. Specifically due to debris, we specified that like for insulation, for piping and for the vessel and so forth, that only metallic insulation is allowed in containment. And so this hopefully will take care of issues related to debris issues and that.

With regard to protected coatings, we to the maximum extent possible will be meeting the requirements of Reg Guide 154. But there are small exceptions, things like valve handles and face plates and things like that that come with standard equipment, and in some cases may not have the approved materials. But those should be very small.

And we basically have been minimizing the amount of equipment in containment. It's pretty much limited to valves and so forth.

MR. ABDEL-KHALIK: So you would depend on these requirements that you list suppliers; is that what you are saying?

MR. DEAVER: Definitely, yes. You know the bigger surfaces are the containment liners and surfaces like that that need to be painted. So we would be using a glue epoxy material for that. But in the procurement of valves we will, to the maximum extent possible, try to limit the materials that are not allowed.

So anyway, that's the material covered in

6.1.

Going on to 6.6, which is the preservice and inservice inspection, that's an area where basically this section covers Class 2 and Class 3. Class 1 was, the content of that is contained in Chapter 5. So this pertains only to Class 2 and 3.

Fundamentally the approach is that we are meeting the requirements and specifying the requirements of ASME Section 11 as preservice and inservice inspection, and because we are a new plant, the inspection access, all those areas we expect to fully comply with those kind of topics so that there won't be any exceptions.

So there's quite a few topics covered in this section, but they pretty much boil down to that we're following the ASME code as a standard, and fully expect to meet those requirements.

MR. SHACK: Okay, so you are saying you are going to fully meet the accessibility requirements?

MR. DEAVER: That is basically what we are attempting to do. I don't know of any circumstances at the moment where we wouldn't be able to meet them. But we haven't gone through the detailed design yet. So, but that --

MR. SHACK: But that was an issue in Chapter 5, right, with some of the pressure bound components?

MR. DEAVER: Well, that was a point of discussion. Remember, we talked about a code case that for ISI purposes narrowed the inspection area down.

So using that code case we are fully compliant with the pressure vessel.

So there was an issue of preservice inspections. In some cases we are going to have to do inspections from inside the vessel on the nozzle, the feedwater nozzle.

But when it then goes to Section 11 for ISI then the code case is invoked, and we are fully committed to the requirements.

MR. MAYNARD: Due to the taller vessel and similar components in there, will the existing ISI type equipment, examination equipment, work? Or are you going to have to design or build any new equipment for testing?

MR. DEAVER: No, the same basic approach will apply. The insulation will be a stand-off insulation that will give us space of basically we've been using automated inspection equipment that tracks on the weld seams, and there is no reason that we won't be able to use that same type of equipment.

You know our round nozzles and stuff, they typically put tracks to go around. Actually a point that we are stressing, and we're buying pressure nozzles right now, is that we want everything associated with ISI to be the same, so that if somebody is going to an ESBWR plant they can fully expect all weld seams to be in the same location, and nozzle diameters and everything to be the same, such that they can go in with standard equipment. Okay?

Any other questions on 6.6? Okay then, now we move on to 6.2, which is containment systems. Basically our containment system is typical of past containment systems in that they include a dry well, a wet well space. In our case we have the PCCS system, the Passive Containment Cooling System, is part of our containment boundary, and function of the containment.

We have the containment isolation valves, which are typical.

So I'll describe the next figure.

MR. WALLIS: So you say PCCS is part of the containment. That means each tube is part of the containment?

MR. DEAVER: Basically it's part of the containment valve.

MR. WALLIS: It's true it's part of the containment.

MR. DEAVER: And in 6.2 we also cover the performance analysis.

MR. WALLIS: The isolation condenser has penetrations then, or how does that work?

MR. DEAVER: Yes, it has piping penetrations. That is a little different scenario, in that that's a system that is under full pressure, sees the full pressure of the vessel. Whereas the PCCS system only sees the containment conditions.

CHAIRMAN CORRADINI: But to follow up Graham's question, that still penetrates and therefore is part of the containment boundary, the IC?

MR. DEAVER: The IC system is, yes.

Okay, as I mentioned another part of 6.2 is the analysis of the containment systems, and that will be covered by Mr. Chung later on.

The ESBWR incorporates a pressure suppression containment design that has been used on prior plants.

Next figure, let me see.

MR. WALLIS: This is peculiar. This is

probably about the PCCS. And the PCCS doesn't have a box around it like that.

MR. DEAVER: Well, here is the figure that --

(Simultaneous voices)

MR. DEAVER: Basically --

MR. WALLIS: There is no box there.

MR. DEAVER: Well, the boundary, we have defined the boundary to go around the PCCS.

MR. WALLIS: If you put a box in there, then the water can't get to it. So I mean there is no box around the tubes, right?

MR. DEAVER: No.

MR. WALLIS: No physical boundary like that.

MR. DEAVER: The boundary is the tubes.

MR. WALLIS: It's misleading. It looks as though you put a box around the whole thing.

CHAIRMAN CORRADINI: I think that's just -- the let the artist have too much license.

(Simultaneous voices)

MR. DEAVER: But basically the boundary is the -- you have a dome of the containment head here, and so we have a little line around the PCCS condensers. But in fact there is the penetration and the tubes.

And then we have the upper dry well, the suppression pool and wet well area, and the lower dry well area. A little different in the ESBWR design is the fact that the upper and lower dry well areas communicated; previously we had a skirt that blocked those two areas.

And the other key feature is that the suppression pool is an elevated suppression pool as compared to prior designs, which allows us some ability to transport water into the vessel if necessary under accident conditions.

What's also unique is the GDCS pool, which is a capacity system which will inject water.

MR. WALLIS: There is no isolation of the PCCS system?

CHAIRMAN CORRADINI: That is a matter of debate for an open item, I think.

MR. WALLIS: In this design so far there isn't?

MR. DEAVER: No, there are no valves. It's truly a passive system in that it's an open system, it'll function without any moving parts currently.

And that -- we feel that that is a good

way to design the system.

Fundamentally with the low pressure that the containment would experience, of the components that make up the condenser are at very significant design margins because --

MR. WALLIS: I think they are designed to 100 and something PSI, aren't they?

MR. DEAVER: Well, that is the containment design pressure. But the components themselves, the piping components, are fully capable of going up to 1000 psi. I mean there is no reason --

CHAIRMAN CORRADINI: You mean the piping itself?

MR. DEAVER: The piping itself, yes. Because they meet heavy duty components.

CHAIRMAN CORRADINI: So I guess I was looking for this, and if this is the wrong time, eventually. I'm curious on how you couple the piping through the concrete pressure boundary and the shall I say the details of how I take thousands of pipes through a pressure boundary and they hit the next pressure boundary.

That made me curious, and I couldn't find a drawing of that. Where should I look?

MR. WALLIS: Is it thousands of pipes? Or is it just one?

CHAIRMAN CORRADINI: Is it one big header?

MR. DEAVER: Well, are you talking specifically the XE unit? The PCCS.

CHAIRMAN CORRADINI: Is there one big header?

MR. DEAVER: There is one pipe, basically you have an open-ended pipe in the containment here, and that is the seed path into the unit. A little hard to see.

CHAIRMAN CORRADINI: And then so that is the transition. Then from then on it's essentially a main header that goes into the actual tubing.

MR. DEAVER: Well, it's channeled to the top, and then there is piping that goes across and goes into the upper header and channels the steam down into the unit itself.

So -- is that kind of clear then? Okay.

So that is the containment system. Then this is a little more detail of the PCCS system. This is the condenser unit itself. It's in the upper part of the containment. We have two lines that come from this unit, one that is the condensate water that comes out of the unit, and it's taken to the GDCS pool where it replenishes water supply in that pool. And the other line is one that goes to the suppression pool. This is where any non-condensable gases are vented in the case of an accumulation of gases.

MR. WALLIS: Only if the drywell pressure exceeds the suppression co-pressure.

MR. DEAVER: Yes.

MR. WALLIS: And can overcome the hydrostatic head in the suppression pool?

MR. DEAVER: Right.

CHAIRMAN CORRADINI: We're talking a blow down into a suppression pool, right?

MR. DEAVER: That is the venting of gases we are talking about at the moment, yes.

CHAIRMAN CORRADINI: The initial phase?

MR. CHEUNG: In the long term phase.

CHAIRMAN CORRADINI: I'm sorry, could you repeat it? I apologize, I misunderstood. I'm sorry.

MR. DEAVER: I was just discussing the fact that there is a vent system for nondensables, because that would affect the performance of the condenser itself. So we have a -- we can open up the system to be --

MR. WALLIS: But again, your analysis has done something very strange. And in fact the big pipe goes through the containment. The big pipe there.

MR. DEAVER: This is the inlet.

CHAIRMAN CORRADINI: But that is a big pipe.

MR. DEAVER: Concrete was across the bottom.

CHAIRMAN CORRADINI: But that is the pressure boundary.

MR. DEAVER: Yes.

CHAIRMAN CORRADINI: That's what I guess I'm still looking for.

MR. DEAVER: The passive boundary is the unit pipe, the branch piping, the IC unit itself, and it clearly penetrates back into --

CHAIRMAN CORRADINI: So there is a main header inlet and then two main header outlets that essentially reconnect back up to the concrete pressure valves?

MR. DEAVER: Yes.

CHAIRMAN CORRADINI: Okay.

MR. DEAVER: One additional feature that is not shown on this figure that will be on revision five of our DCD is a blower that will be installed in the noncondensable side, gas side of this system. And that's being put in there to facilitate, you know, once everything reaches equilibrium condition, we still want to facilitate the PCCS condensers to operate, and with a blower it'll facilitate seed flow or flow into the condenser, and it'll continue to provide cooling within the containment.

And that's a feature we are depending on between three and seven days.

CHAIRMAN CORRADINI: Can we just go back to that branch coming out of the 300 BD (phonetic) line?

MR. DEAVER: Yes.

CHAIRMAN CORRADINI: So one is a 100 AB line and a 200 EB line, and there is a straight there where the condensate will drain to the GDCS pool, and supposedly the noncondensers will go into the suppression pool?

MR. DEAVER: That's correct.

CHAIRMAN CORRADINI: And that is accomplished how? By just drainage?

MR. DEAVER: Yes, of just natural --

CHAIRMAN CORRADINI: It's like a wet -- or like a hot well collection point for the water, and the gases will go in a separate direction? I'm just trying to envisage -- not the inlet. I'm talking the outlet. You've got a line draining through the suppression pool which takes the non-condensable gases. And you've got a line which is the condensate drain line back to the GDCS, right?

MR. DEAVER: I'll have Mr. Gels, he's the system engineer for the system. He can better explain that.

MR. GELS: My name is John Gels. The physical arrangement is that the condensate line comes off the bottom of the lower drome, returns to the upper drywall to the GDCS pools. The event comes off the upper portion of that drome, so the fluid will collect in the bottom.

CHAIRMAN CORRADINI: So it's essentially like a steam drome?

MR. GELS: Yes.

MR. WALLIS: So it's not as drawn here?

MR. GELS: Yes.

MR. ABDEL-KHALIK: Could you tell us something about the flow water? You just mentioned that you will add in?

MR. DEAVER: Yes, we are finalizing some of the details on that. The fundamentals are that it is to facilitate a forced flow to be able to pull flow into the inlet of the IC unit. '

MR. ABDEL-KHALIK: Physically where is that blower going to be mounted, where on the line at the inlet?

MR. DEAVER: John, can you help me with some of the details? We've had a couple of options. One is to power it from the outside, or inside, and so forth.

MR. GELS: Well, I believe the current thinking, and I think Wayne can correct me if I'm wrong, but the blower will be installed to come off of the vent line, and there will be downstream from the TM vent line, and it will blow its discharge into the GDCS pool area.

CHAIRMAN CORRADINI: I'm not understanding -- so one what you are talking about is not on the picture.

MR. GELS: That's correct.

CHAIRMAN CORRADINI: Okay, and two, the flow path is to the GDCS pool, not to the suppression pool?

MR. GELS: That is correct.

MR. WALLIS: It seems strange.

CHAIRMAN CORRADINI: I'm confused then, I'm really confused.

So this is an active system?

MR. DEAVER: You're going to start up the blower when we have power.

MR. MARQUINO: When we get to some response codes, Dr. Cheung will show --

(Simultaneous voices)

MR. MARQUINO: So the function of the blower is to rapidly reduce the pressure in the containment at three days, and it does this by actively purging the condenser of non-condensable gas.

Without the blower the condenser will exactly match the steam generated from the core. So you will always match the core steam generation, but you move -- drop the pressure --

CHAIRMAN CORRADINI: So can I say it to you backwards?

MR. MARQUINO: Yes.

CHAIRMAN CORRADINI: So when the staff asked you in the REI questions saying, how come it's not coming down, to bring it down, what you are really saying is you are coming to an equilibrium at a high pressure. And without this you will never come down?

MR. MARQUINO: Bingo.

CHAIRMAN CORRADINI: Thank you.

MR. MAYNARD: But that only comes into play after 72 hours, after three days?

MR. MARQUINO: Yes.

CHAIRMAN CORRADINI: I just want to make sure we are clear. All your curves are doing this where the slope looks asymptotically going to zero in their result.

So the question about why isn't it negative. And the answer is, you are achieving a new equilibrium in the containment by this passive approach. You would just raise the whole atmospheric condition up, and it would not come back down, save heat leak out of the building which is almost zip. So it would very slowly creep down.

MR. WALLIS: I think it's worse; at 72 it was still going up.

CHAIRMAN CORRADINI: Well, that -- the staff asked the question is it up, is it down. M R . KINSEY: This is Jim Kinsey from GE Hitachi. In about two or three slides further into this presentation I think you will see some of that detail.

MR. DEAVER: Yes, this was meant to be a little bit of an introduction of what we have added to this.

CHAIRMAN CORRADINI: That helps, thank you.

MR. DEAVER: Okay, next we'll turn it over to Chester to talk about the containment performance.

MR. CHEUNG: We will use the summary of the containment performance analysis.

GEH uses the TRACG to analyze containment analysis of performance. The TRACG have been rebuilt in 2003, and the application for U.S. performance have been approved, accepted in 2004.

Since then we have performed additional study to address the SER confirmation items. We also have performed quite a bit of parametric cases to address an issue that relates to the design change and also the nodalization change.

And the performance system -- containment system performance analysis includes the containment pressure, temperature, the nominal condition as well as bounding conditions, and also TRACG is used to analyze the negative pressure between the drywell and wetwell.

MR. WALLIS: This is 1D code or is it 3D code?

MR. CHEUNG: TRACG is a 3D code.

MR. WALLIS: But you don't do much 3D analysis of the containment, do you?

MR. CHEUNG: We model the containment with TRACG. We did a TRACG. We have a radial and axial margin more or less like a pseudo --

MR. WALLIS: Oh, you do? Okay.

MR. CHEUNG: And to go back a little bit, we use the TRACG to model the whole containment. And we believe that we have the --

MR. WALLIS: So it will show stratification on the containment? It will model stratification and the containment? Or is the containment supposed to be mixed?

MR. CHEUNG: That's the next slide. We forced it to maximize the pressure.

MR. WALLIS: To stratify?

MR. CHEUNG: We forced it to.

MR. WALLIS: You forced it to stratify. So TRACG doesn't do that itself?

MR. CHEUNG: TRACG doesn't do a good job on that. And we may have a hard time to certify how much stratification is going to be forced.

CHAIRMAN CORRADINI: Hundred percent stratification of what?

MR. CHEUNG: In a suppression pool surface, and also in a wetwall top area. We are going to the next slide.

MR. WALLIS: Because he will show us. Is that in the containment vessel itself, you put the steam on the top or something?

MR. CHEUNG: Within the containment, we have. MR. WALLIS: But they are all separate nodes. And then the drywall is no node, or is it lots of nodes?

MR. CHEUNG: No, the drywall is in the order of 30 or 40 nodes.

MR. WALLIS: And it can model stratification in the drywall?

CHAIRMAN CORRADINI: No, no, no, that isn't what they -- now I understand what he said. It wants to make it two phase with the flow regime, and they forced it to be a pool MR. CHEUNG: No.

CHAIRMAN CORRADINI: I thought that's what I interpreted you --

MR. CHEUNG: The suppression pool is single phase. We force the suppression pool -- energy cool in the suppression pool, stay at the top of the layer.

MR. WALLIS: Unrealistic.

MR. CHEUNG: You will also force the leakage from the drywell in the wet well, stay on top of the wet well -- the layer.

MR. BANERJEE: Was this methodology outlined in the application that was --

(Simultaneous voices)

MR. BANERJEE: So do we have a document to look at?

MR. CHEUNG: It was outlined in the application report. The relaxation somewhat change in the code because one of the SER , that we need to have a unique one modeled. And use the same nodalization for containment analysis and also as well as for UCCS analysis.

So it's one containment nodalization for all applications.

MR. WALLIS: But what's conservative isn't very clear. If you have too high a pressure on the dry well then you pop the containment. But if you have too low a pressure you don't work the PCCS very well. So that's sort of iffy, isn't it?

MR. CHEUNG: No. The -- well, let me go back. The containment pressure is simple way to describe it, because -- give me one sec -- only three things, the total amount of gas.

MR. WALLIS: We should have dropped into the wet well.

MR. CHEUNG: Then you would really get a maximized test. It also depends on the service temperature in the suppression pool which gives you the partial steam pressure that amount to that wet well pressure.

It also depends on when there is leakage from the drywell into the wet well, and the leakage creates a high energy for the dry well, and how they will mix. The contribution of that leakage or energy will be lost.

Now going back to the performance of PCC. The wet well always need a pressure. The dry well trying to push same thing into it. If the steam not condense the wet well pressure will be higher. It'll push something into it, and you push too much in the PCC tube, then the PCC can condense more steam than the wet wall.

MR. WALLIS: It stops the steam source.

MR. CHEUNG: The cell adjust in the sense that whatever amount of steam is generated, you push a certain amount of non-condensable gas accumulating to. You have to keep on going because there is always seventy-two hour cases. You keep on going because there is always small amount of non-condensable gas generated in the core, and find a way to try to adjust the amount being condensed and generated.

CHAIRMAN CORRADINI: So the last statement you made is the reason I don't see a zero slip at 72 hours is radiolytic decomposition?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: And there is that large amount of radiolytic decomposition that essentially it's degrading the performance, or lessening the performance of the PCCS? Because I'm always achieving a new equilibrium and it's slightly higher, slightly higher?

MR. CHEUNG: No, the equilibrium - whatever is generated is always condensed. The PCC about six hours, the PCC compartment always higher than indicated.

CHAIRMAN CORRADINI: I understand that. But when I said an equilibrium is that you are saying you are generating more non-condensable gas, and enough of it, that it is perceptibly higher and higher pressure. MR. CHEUNG: Because it going into the wet wall --

MR. WALLIS: So the pressure on the wet wall is governing.

CHAIRMAN CORRADINI: Well, sure. If they are within delta P, they are in equilibrium.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: But your performance could be degraded by two things. One is leakage not through the PCCS but undetermined leakage between the dry wall and the wet wall. And second is degradation of the tubes -- degradation of the heat transfer in the tubes by other means.

MR. CHEUNG: Test data show that degradation, we already account for that.

CHAIRMAN CORRADINI: So I have one question here, but not to be answered here. So you went through a lot of work in 6.1 talking about how you are minimizing stuff. So if I create stuff from a blow down like the main steam line break in containment and generate debris, would it be transported into PCCS tubes, and therefore create an additional heat transfer resistance?

MR. DEAVER: Well, what we are doing, just as a protection, we are putting a shield on the inlet to the PCCS system such that debris can't basically go up there and block it. So it's going to be a shield, and it will enable the steam flow to go through it, but it will shield and prevent stuff from getting into the system.

MR. WALLIS: A screen?

MR. DEAVER: No, well, I envision maybe more like a cone that -- if you come up and hit it it will deflect off, but it won't go around and get sucked into the pipe itself. It'll have -- that is the visual picture I have that it's going to look like.

CHAIRMAN CORRADINI: To be designed. So there are no debris sources about the entry point?

MR. DEAVER: Well, initially things are going to be flying around. But you know gravity is going to settle everything down ultimately.

So because it's right in the top of the containment, anything that would go up in the area would simply be deflected away, and then it would just drop down.

MR. BANERJEE: But even if it was dust.

MR. DEAVER: Dust?

MR. BANERJEE: Yes, really fine stuff. I mean I guess the concern is whether some of this could get into the tube.

CHAIRMAN CORRADINI: So let me tell you where I am going with this, and then you can pick -- you choose to talk about it now or later.

But you went through a great amount of effort at 6.1 to convince me that you have minimized places that you could generate debris. And I kept on asking myself a question: Why? Where? Why?

And then we talk about the performance of this, and I have this vision of having such a pipe break pointed at something where I generate debris. I don't -- I don't want to use the word, aerosolize, but creating a lot of stuff. And the stuff gets transported in your PCCS, and essentially it creates a fouling factor.

Now you are telling me you're going to put in a shield so it doesn't follow it. But then I ask myself, how small of a debris can pass through the fouling, and therefore, what fouling factor penalty must I have to consider. Because you are going to have some; it's a heat exchanger, and with an action such as this, it will follow to some extent.

MR. DEAVER: Well, we are basically putting metallic components in containment. And the other reason for minimizing debris is the strains that we would have in the suppression rate.

MR. BANERJEE: Who designed the PCCS?

MR. CHEUNG: PCCS in the first six hours is not mentioned, then after six hours it's over the line.

CHAIRMAN CORRADINI: By how much?

MR. CHEUNG: By a factor of two.

MR. MARQUINO: This is Wayne Marquino of GEH. As was said we have a fouling factor that is included, and the spec on the PCCE transfer. The system will be designed to provide more heat transfer initially so that the end of its life, considering fouling, it will perform per spec.

MR. BANERJEE: And then establishing this fouling what did you take into account? Did you just pick a number? Or did you do some evaluation?

MR. MARQUINO: We picked a number based on the containment pressure analysis that's being discussed.

MR. BANERJEE: You did some experiments, and these were pretty close to full scale, right, of PCCS, if I remember?

MR. DEAVER: We did one half.

MR. BANERJEE: Right.

MR. DEAVER: And created a mock up and tested it.

MR. BANERJEE: Now did you -- remind me what happened with the noncondensables? Did they actually get pushed out? Or what happened there? Because this was an issue which I remember back from SBWR days.

What happened to the non-condensables?

MR. CHEUNG: They are pushed out.

MR. BANERJEE: They are all pushed out?

MR. CHEUNG: They get swept out.

MR. BANERJEE: And it doesn't matter what they are, if there is a bit of hydrogen or something, it doesn't matter.

MR. CHEUNG: Doesn't matter. But in effect, we depend on the drywell, depend on the location. Some air or some non-condensable do hide in those walls. It takes a long time to mix with the steam.

MR. WALLIS: But then they get pushed out? I mean the steam that is pushing them gets condensed, and then it doesn't do much pushing, does it? Because you stick there. As long as the steam keeps condensing, the non-condensables stay there too. They don't have any effect because the steam is still being condensed.

If it doesn't get condensed, then it pushes out non-condensable --

(Simultaneous voices)

CHAIRMAN CORRADINI: If you plotted it down to the non-condensable gas fraction, it starts off high, and it starts coming down. But then it comes to some point, and it now comes to an equilibrium.

MR. WALLIS: And the thing could be off

code with non-condensables.

MR. BANERJEE: In fact, that is exactly what happens.

MR. BLEY: So then why do you need the blowers if it still works?

MR. WALLIS: It's a self-correcting system. (Laughter)

MR. CHEUNG: I will explain that in about two slides.

MR. WALLIS: It was trying to self correct and didn't succeed?

(Simultaneous voices)

CHAIRMAN CORRADINI: Give us a slide number.

MR. CHEUNG: Slide number eight. At least the lower portion of it. We have performed a percentage spectrum of rate that include the medium RAI rate, which is the largest brake in the system and the highest elevation.

CHAIRMAN CORRADINI: But smallest sizes?

MR. CHEUNG: Smallest sizes. And GDC, you can keep in mind, is somewhere in the middle and medium sized, and pre-waterline break is high elevation, slightly higher flow air pickup rate area.

CHAIRMAN CORRADINI: If I might just make sure I understand.

So these are design basis accidents, but particularly challenging given the design to the containment rather than the reactor, because with these, as I understood in a subsequent chapter, you don't get core uncovery. These are ones that are really determining the design basis for the containment systems.

MR. CHEUNG: Let me go back. Let me iterate, there is no charge in core. We analyzed all nine elevations, or nine penetrations; we analyzed it. Then for containment we picked four, and then we realized that the limiting case would be mentioned right there.

CHAIRMAN CORRADINI: So that's how I understood it. But thank you, I appreciate it.

MR. CHEUNG: Because we analyzed the spectrum, high or low, and liquid break, steam migrate.

Now the key measure for this analysis is to -- is the dry wall pressure. For that matter we have to try to maximize the effect that will give the higher drive of pressure. And in that we assume in the model, in a calculation, we force all the non-condensable emissary in a dry well into the wet well -

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MR. WALLIS: All is a big word.

MR. CHEUNG: All.

MR. WALLIS: All is a big word.

MR. CHEUNG: Yes, sir.

(Laughter)

MR. CHEUNG: And also, all this subsequent generating radial -- generating in the core, find its way into the wet well.

CHAIRMAN CORRADINI: But is it a fair -- I just want to make sure we're communicating -- but it's a fair characterization what Graham said before which is, you get this initial discharge, which blows your noxious emissible gases through your system, and then eventually makes it to the suppression pool.

But then you come to a point where you are still feeding it gases, which are still some fraction non-condensable, because that is the driving flow, right? You are not going to go to vacuum, so you are driving it with some non-condensable, at some rate.

We are communicating there? Because the way you explained it I guess I thought it was exactly the same way.

MR. BANERJEE: I think it would be nice if we had a diagram, and you showed us exactly what you are doing. Very confusing in words. I don't know what all non-condensables means.

MR. CHEUNG: The non-condensable gas usually in the dry well, lower dry well --

MR. WALLIS: But it goes through the vents, the big vents.

(Simultaneous voices)

MR. WALLIS: And stays in there because the valves don't leak.

MR. BANERJEE: The vacuum breakers.

MR. WALLIS: Don't open?

MR. CHEUNG: The vacuum breakers don't open. Well, it opens, come back, and then you go back into it. Because we used a multiple pipe -- we used the nodalization that during the transient alteration, we'll introduce additional force, too.

MR. WALLIS: Well, what do you do about condensation in the wet well? I think you assume that all the steam that goes in condenses.

MR. CHEUNG: Not all the --

MR. WALLIS: You say it is conservative to say all the gas goes in there and pressurizes the wet well. But you could get steam which goes in and isn't condensed.

MR. CHEUNG: It stays on the top.

MR. WALLIS: Stays on the top, and that pressurizes away. I don't think you consider that, do you? I think you consider it to be all condensed.

MR. CHEUNG: No.

MR. WALLIS: No? How do you know how much is condensed?

MR. CHEUNG: It depends on the calculation in the amount of steam processing pressure; it depends on the temperature in the code calculation.

MR. WALLIS: The code calculation of how much is condensed?

MR. UPTON: Chester, this is Hugh Upton with GEH. Maybe it would be better if we walk you through what's done on a containment system diagram. Maybe that will give you a better feel for what's happening.

MR. BANERJEE: You have to have a mike.

MR. DEAVER: One thing I didn't cover earlier that I should have, and it's probably important to this argument is, we have vacuum breakers. We have three vacuum breakers that relieve pressure between the wet well and dry well. And so that is part of the -- of the interaction that is going on.

(Simultaneous voices)

MR. SIEBER: If I could have your attention, it would be good if in your explanation to tell us what happens --

MR. CHEUNG: Okay, let me try to go through a little bit. In the very beginning we didn't go out from the wet -- and flow out into the dry well. And what it does is, you mix -- the steam we mix with the initial non- condensable gas in the dry well, and forces it -- the majority will force it through the main way.

MR. BANERJEE: Can you stay to the side so we can see?

MR. CHEUNG: And so this operation prove that steam condense.

MR. WALLIS: But does it?

MR. CHEUNG: And the --

MR. WALLIS: Does it condense or not?

MR. CHEUNG: -- non-condensable gas goes into the dry well.

MR. WALLIS: I'm concerned about the condensing models in the wet well. Because you have a big bubble comes out.

It can go to the surface without condensing all that much. In which case you get two feet of steam up above, which isn't going to condense very readily.

I've never been very happy about the way that is modeled.

(Simultaneous voices)

MR. CHEUNG: Because the tract is calculated so that these will overpressurize, go right to a dry well, for a time period and then you actually get to an equilibrium point.

Now, that process go into -- roll down process go into about a couple of hundred, one or two hundred seconds.

MR. ABDEL-KHALIK: What is the volume ratio between the dry well and the wet well?

MR. CHEUNG: The dry well is about 7,000 cubic meter; the wet well is about 5,000 cubic meter.

MR. ABDEL-KHALIK: The gas space in the wet well.

MR. CHEUNG: The gas space in the wet well, 5,000.

After a short time period, the water level dropped, dropped to level one. Commencing RAI rate is about five per second. Once the Level A initiate the ADS, that means further depressurized RPV, and you set upon that the RPV pressure is lower than the static here, and the water will form. That will go on for some time period. That's called GDCS period.

And what it does is that because --

MR. WALLIS: What comes out of the ADS? Is it just steam? Or is it a mixture of steam and water?

MR. CHEUNG: Pardon me?

MR. WALLIS: What comes out of the ADS? Is it just steam? Or is it a mixture of steam and water?

MR. CHEUNG: The ADS --

MR. WALLIS: It's up there, but you've got a full swell in the vessel, too. So what comes out of the ADS?

MR. CHEUNG: The SRV will see only steam. At that point in time the compressor is steam pressurized.

MR. WALLIS: The swell doesn't rise up that high?

MR. CHEUNG: No.

MR. DEAVER: The RPV part of it just vents to the upper driver.

MR. BANERJEE: Now do you have experience of that? Or is it just a calculation, whether the pool swelling will reach the SRV?

MR. MARAQUINO: Excuse me. The pool swell is in the suppression pool.

MR. WALLIS: No, we are talking within the vessel.

MR. MARAQUINO: The level swell within the vessel?

MR. WALLIS: Level swell, yes.

MR. CHEUNG: That -- one -- the reason that the RPV in the SDS is tall. When it fresh, the level not coming up all the way to the line.

MR. BANERJEE: But that depends on a lot of things. Because even a small amount of surfactant there would get it right to the top.

MR. CHEUNG: The TRACG code having qualified against data on the swell rate.

MR. BANERJEE: Right, but this is very tricky. In fact there is a very similar problem that occurs during emergency relief of chemical reactors. And what has been found is even tiny amounts of impurities of one sort or another can change the level swell enormously, because of its surfactant effect.

CHAIRMAN CORRADINI: Can I ask a question?

So you are talking us through the process. So putting that issue aside for the moment, so I discharge a GDCS pool in, and then can you just shut down?

MR. CHEUNG: Okay, for some time period, because it's cold water going into the RPV, and then no steam coming out of the RPV. In the sense the steam available in the dry well now is become less and less. And no way to break it open because the PCC condense more steam than a variable.

Now if I can break it open then the --

MR. DEAVER: (off mic)

MR. BLEY: Not anymore.

MR. CHEUNG: Some of the non-condensable gas from the wet well going back into the dry well. Now start over again the process.

Now you've got in a one hour period, couple hour period, that this air, non-condensable gas and steam, keep mixing and you're going to send that because the system, the PCCS, the dry well pressure always higher than the wet well pressure by amount of that stirred-up heat, and the push, the mixture of non-condensable gas and steam into these wet wells, in the suppression board --

MR. WALLIS: It's possible the vent valves of the vacuum breakers have closed.

MR. CHEUNG: Yes, because once at higher pressure, then vacuum breakers that closed were knocked open again.

Now going back to one of those questions, we keep saying that why we want to force --

MR. WALLIS: Something by the GDC as it's trying to open the vacuum breakers, including while the PCC is trying to close them.

MR. CHEUNG: Yes.

MR. WALLIS: So it's sort of a battle between the two.

MR. CHEUNG: Yes, but after the GDC injection period, no more sub-cooling in the core, then the vacuum breaker will not openfor a long, long time unless external cold water like spray or things like that.

Now where one -- a moment ago we keep seeing that we forced all air, on account of a guess, one other thing is one the GDC approved drain -- created drain down water and suck whatever things stuck in the dry well into it. And this is a hideout area because this is a very small opening --

PARTICIPANT: High what?

MR. CHEUNG: This other level will stay about the pressurization elevation with about 22 meter, and that creates water from here to here, about three or four meter; that is 12 feet, and the steam in here is keep going, going, going, and physically we will have a hard time to go in and make steam and come back out because only one way in. Then the pressure would be lower because that amount of air a long time ago is not going into the dry or wet well.

So what we've done is, in the model, is by calculation, we put in another pair of pipes to get some steam into and try to mix it and come back out, and it's exactly purge, all the hideout non-condensable gas in this water and then get it out in here and get into a PCC and eventually get into the wet well. So at the end of the calculation, 72 hours, we can see that no more non-condensable gas in this area or in all these areas.

MR. WALLIS: That's probably being conservative.

MR. CHEUNG: Very conservative, but to demonstrate that --

MR. WALLIS: It's pretty close.

MR. CHEUNG: Now that's the main steam line on low air region break to prove we drop all the way to this air region, the hideout void even bigger, in over 15,000 kilometers. And the height, six meters, two stories high. And in that situation, the mixing of the steam with the non-condensable get high and dry, will be even harder for this kind of gas to get out.

CHAIRMAN CORRADINI: Which means that -- I just want to make sure I understand -- your point is the fact that it's hiding out there reduces the amount of non-condensable, which sets the pressure on the volume?

MR. CHEUNG: Yes.

MR. WALLIS: He's doing that anyway to be conservative.

CHAIRMAN CORRADINI: That's what he does. But just to be clear it's still improving a driving flow for the circulation to the PCCS. So you still have some small amount of non-condensable gas fraction that is driving the flow through the PCCS.

MR. CHEUNG: Yes, because it's a continued channel, yes.

CHAIRMAN CORRADINI: And the difference by letting it hide out versus forcing it to mix into the suppression fuel is, what, a few PSI?

MR. CHEUNG: A few PSI.

CHAIRMAN CORRADINI: Okay. Then the uncertainty of the following of the PCCS?

MR. WALLIS: It's a lot, if you take all those non-condensables in the GDCS pool and put it in the suppression pool you are going to get a fair amount of low pressure, aren't you?

MR. CHEUNG: That's what we did. That's what we saw --

MR. BANERJEE: Now when you say there is no mixing in the gas space of the wet well --

MR. CHEUNG: Now the vacuum breaker is at this elevation, and we assume the leakage. The leakage could be anywhere, but we assume at the top of it, and the hot energy go into it and stay in this layer. It not mix, not mix with this water. Once it mix it, then we have chance that the energy will go down the suppression pool into the surface.

MR. WALLIS: If it sticks open then the PCCS pool doesn't work; is that right?

MR. CHEUNG: What open?

MR. WALLIS: If the vacuum break sticks open it doesn't work?

MR. CHEUNG: Oh, yes. It won't work because vacuum breaker has about one square foot of flow air in --

CHAIRMAN CORRADINI: Let's hold off on picking on the vacuum breakers. That's Chapter 3. We're still -- we don't want to go there just yet.

MR. WALLIS: We're going to give that to

another meeting?

MR. CHEUNG: Let me go back --

MR. BANERJEE: I'm beginning to understand what the effect is.

CHAIRMAN CORRADINI: I understand.

MR. CHEUNG: So we know the assumption is the energy going into a pool. Think about it: 72 hour. We assume the non-condensable gas is coming in with slightly higher temperature, and it will stay in this layer. That means keep higher, partial pressure, steam pressure, into the wet well. That's another conservative assumption.

MR. BANERJEE: So you're saying it's all coming out at saturation? Or what sort of -- your end game, is it at saturation terms --

MR. CHEUNG: The energy goes into this layer.

MR. WALLIS: So your bottom layer for the suppression pool doesn't do you any good at all.

CHAIRMAN CORRADINI: Yes, well, they force it not to do any good at all.

MR. CHEUNG: Yes. I can call you a number. We have --

MR. WALLIS: Until you drain it, until you equalize and even though it doesn't do you any good at all.

CHAIRMAN CORRADINI: You do in the beginning.

MR. WALLIS: It doesn't even happen in the beginning, because they don't mix them.

(Simultaneous voices)

CHAIRMAN CORRADINI: The main steam line break, that is the only time when they are using the full volume for essentially condensing. They need it.

MR. CHEUNG: Because in the beginning, the physical distance is a blow-down force. You blow it down.

MR. WALLIS: You use the liquid below the bottom vent? You still use that?

MR. CHEUNG: No, after a couple of hours. Now we have performed prime education. Physically after a couple of hours, or 72 hours for that matter, these pools were mixed by itself. If we turn on the, take out the stratification model, that's 6.5 percent margin we can gain. When we turn off --

MR. BANERJEE: Well, what would mix it physically? You have hot liquid on the top. Now why would it mix?

MR. CHEUNG: Know why, because this is

concrete wall. It doesn't transfer much energy from here to here, but the concrete wall will induce an action flow. This is a large flow area, large water area --

MR. BANERJEE: Is it because of heat conduction or what?

MR. CHEUNG: The heat conduction from here into the concrete wall. It's small amount, but small amount and long time period, you will induce flow naturally.

MR. UPTON: Chester, this is Hugh Upton with GEH. We also have a stainless steel liner inside the suppression pool, which also adds to conduction.

MR. CHEUNG: Does that answer your question?

MR. ABDEL-KHALIK: Timeline, how long does it take to force the non-condensable from the dry well to the wet well?

MR. CHEUNG: In the calculation, it takes about 22 hours.

MR. ABDEL-KHALIK: But there must be a very high rate initially. So the initial period --

MR. CHEUNG: Initial period about half of the mass went into the wet well.

MR. ABDEL-KHALIK: In an hour?

MR. CHEUNG: In a matter of a couple of hundred seconds.

CHAIRMAN CORRADINI: Just so to make sure each question is understood, his point is, if you take your limiting case, which is the main steam line break, you dump 50 percent of it in the matter of two or three minutes.

MR. CHEUNG: Yes, but then later on the vacuum breaker open, and it come back.

Now let's move on a little bit before I go on. The pressure keep going at 72 hour without any active system. Now we have put in the PCC vent line. You put in the vent fan from here, branch out, put a blower or fan, and detach it back into the GDC pool, up apart from it because any longer, the other part of it will be drained down, and we'll see --

MR. BANERJEE: Now why is that necessary? I mean, I can see it may improve things but is it necessary?

MR. CHEUNG: I can give you a couple of examples. The vent fan takes very little power, very little. And what it does is blow the charge the water valve accumulated in a tube to suck it out. When it suck it out, the tube condensation power increase.

MR. BANERJEE: But is it necessary?

MR. CHEUNG: Well, if we don't have that fan, we don't have another active means. The pressure will keep going slowly and slowly because in a model we assume the RAI gas keep generating, even a small amount.

CHAIRMAN CORRADINI: And you are generating. So here is where I'm confused. You are generating more of a radio ID composition and you have a huge leak out of the building through the concrete?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: And you've done a hand calculation, those two things are not crossing some time?

MR. CHEUNG: Well, it takes a long long time, because this is two meter; two meter of concrete, and the thermal layer, what's the conduction in that only one foot in maybe a couple of days. That means outside doesn't see anything happening inside.

MR. BANERJEE: Well, that's why you need to suck it out.

MR. CHEUNG: Suck it out? Well, two effect. Once you create -- suck the air out, then the PCC condensation will increase right away and then condense all the steam. Once it condense the steam, then the dry well pressure will be lower than wet well pressure. Vacuum breaker open. Once they're open, the air -- the amount of gas goes from wet well into dry well. We make the pressure drop further until we get the equilibrium point at the mixture, the non-condensable gas and steam mixture, get into the system, get to another equilibrium point.

MR. BANERJEE: But now let's say you didn't have the fan, okay. There would be no equilibrium because you are always getting a little bit of addition of noncondensables.

MR. CHEUNG: Yes, that's the reason.

MR. WALLIS: From slowly rising.

MR. CHEUNG: Yes.

MR. MARQUINO: This is Wayne Marquino from GEH. We also added in rev three I think it was gas or oil catalytic recombiners to address the continuing radiolytic gas generation.

But again that stabilizes at a high pressure, and the fan allows us to drop the pressure at three days.

CHAIRMAN CORRADINI: So there is another, just to make sure I understand all this, what is the state of the pool above the containment shell, which I guess is a steel liner? Is there water above that?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: And then you also have a filter -- I want to call it a filter vented, but you can call it whatever you want -- when you get to above a certain pressure you are actually then discharged into another system. Or am I getting this confused with some other design? There's a vent valve, is there not?

MR. CHEUNG: I don't see it.

MR. UPTON: This is Hugh Upton with GEH. We have a manual containment vent. Is that what you are talking about, in the event, yes? But that's an unfiltered vent.

CHAIRMAN CORRADINI: Oh, excuse me.

MR. UPTON: No, it's not filtered.

CHAIRMAN CORRADINI: It's not filtered?

MR. UPTON: No, it's not filtered.

CHAIRMAN CORRADINI: Okay. The thing that concerns me is you've gone through all this effort to make this passive. And now all of a sudden at 72 hours, bang, you need active. It sounds a bit incredulous.

And I'd also I wonder about if it starts operating somewhere else in the system when you don't want it to operate, does it make it worse? What if I turn it on when I don't want it on? Is there a time when that might occur?

MR. BLEY: You'd be pumping steam then.

MR. CHEUNG: The only true thing I can think of, with the pool doesn't drain. You turn on the fan, the air cannot go in because of a high static head. Now --

MR. MAYNARD: I don't think GEH ever represented that they could last forever; 72 hours without active equipment and without operator action, but at that point there would be action needed.

MR. UPTON: This is Hugh Upton with GEH. The design assumption has always been that it would be passive for 72 hours, and then we would have active systems to deal with the transient.

CHAIRMAN CORRADINI: Okay, thank you.

MR. BANERJEE: Now if you just use catalytic recombiners, how high does the pressure get?

MR. UPTON: It would not increase much over the 72 hour pressure.

MR. BANERJEE: Which would be what?

MS. CUBBAGE: You might want to go to the slide presentation.

(Simultaneous voices)

MR. CHEUNG: The key thing now is, the

next thing is in all the DCD calculations, we assume a design base of one square centimeter of leakage. As a design basis.

MR. WALLIS: There's a mystery to me. How can you just assume something.

MR. CHEUNG: The design base.

MR. WALLIS: I mean that must have some basis, beyond those words.

MR. UPTON: This is Huge Upton with GEH. Based on his assumption, one square centimeter, the SBWR and the ESBWR team went off with a design requirement to come up with, well, the current configuration that we have in the vacuum break or end of the diaphragm floor to try and minimize the leakage across the diaphragm floor. And we can address that here or elsewhere if you want.

We have done extensive tests -- well, do you want me to continue on on this subject?

CHAIRMAN CORRADINI: Well, I think if you can quickly do it, but we are going to have to come back to it, because this was something that I had on my list of questions, which is, isn't it assumed? And then you went through and said, well, even given that it could be as big as X, and we would still have performance.

So the basis on how you come up with this is bypassed, which I think eventually it's going to be brought up.

There is a short answer, and we will come back to it later.

MS. CUBBAGE: And that is a significant staff open item at this point; we are waiting for information from GE on that.

MR. UPTON: Let me give you a brief answer then to it. The diaphragm floor itself has been designed to minimize the number of penetrations across the diaphragm floor. That's the critical are in the containment.

We have -- the diaphragm floor itself is a composite structure of steel, concrete and steel. We have minimized the number of penetrations through the diaphragm floor. We only have three vacuum breaker penetrations, which are 24 inches. Then we've got six PCCS penetrations, which are 10 inches; and we've got four IC vent fans, net penetrations, which are one inch penetrations.

These are the only penetrations coming through the diaphragm floor that could possibly leak. The most credible source of leakage would be through the vacuum breaker. And we can go into the tests of the vacuum breaker and the design of the vacuum breaker later.

MR. WALLIS: It's a big vacuum breaker.

MR. UPTON: The vacuum breaker is 24 inches; that's correct.

MR. WALLIS: And they don't work very well.

MR. UPTON: What you have to do is you have to understand that the design of a vacuum breaker is different than anything you have seen so far.

CHAIRMAN CORRADINI: It's like a pocket --

MR. UPTON: It's a pocket valve, that's correct. And within full qualification testing on the vacuum breaker.

CHAIRMAN CORRADINI: I guess if we get to that, I'd like to wait. Because we have already asked about the fact that there were three other meetings, and and we've been told that Chapter 3 -- I learned. So this is leakage, back leakage is the issue.

MR. WALLIS: This is all the other leakage besides the vacuum break.

CHAIRMAN CORRADINI: Why don't we proceed on? We are going to come back through the vacuum and at least discuss this further.

MR. CHEUNG: We have performed zero to 72 hours three-day calculation based on percentage of the DCD. And to highlight or to summarize it, normal conditions, normal calculations, and maximum dry well pressure with all these no mixing, all condensable gases going to the wet well, we have about a 19 percent margin.

The bounding calculation, which is all the bounding model and bounding initial condition, operating conditions, we have 9 percent.

MR. WALLIS: What do you mean by margin? What do you mean by 9 percent, means what divided by what?

MR. CHEUNG: The fortified PSI G.

MR. WALLIS: The G part --

MR. CHEUNG: Yes.

MR. WALLIS: -- divided by the --

MR. CHEUNG: Divided by the calculated pressure.

So you can see that the nominal value they have about 19 percent margin; the bounding case on top of our -- we put it on our conservative model, penalize ourselves, we still have 9 percent margin.

MR. ABDEL-KHALIK: So the bounding calculation is sort of the fudge calculation that you are talking about where you force the pool to be stratified?

MR. CHEUNG: No, the pool certification and the wet well stratification, these are conservative models.

MR. WALLIS: So realistic is probably much lower.

MR. CHEUNG: Much lower, yes.

MR. ARMIJO: If your bypass leakage was greater than one square centimeter -- let's say it was two or five -- how sensitive is that? When does your margin disappear?

MR. CHEUNG: At two square centimeters, we are just slightly below the design margin; 2.5, slightly above the design margin. So it's somewhere between two and 2.5.

MR. WALLIS: Well, it's important to get that leakage right?

MR. CHEUNG: Yes. Now the next slide says patient number 10. This table summarized what system we have credited in a calculation. For the first three days, we only credit the PCCS with a passive ADS, GDCS, and the inventory in IC drain line, we do not credit any IC heat transfer. We credit the scram liquid void in a SLC system. The calculation of percentage in DCD 6.2; three day press and on.

MR. WALLIS: What do you do about the noncondensables that dried the SLCS system? Do you let them come in?

MR. CHEUNG: No, the SLCS system has a ms2 failure proof. That means the N nitrogen would not go into the --

MR. WALLIS: So what happens if your calculation, if it did go in?

MR. CHEUNG: That would be a very high pressure.

MR. WALLIS: That's not desirable, then?

MR. CHEUNG: Not desirable.

CHAIRMAN CORRADINI: There is an open item on this also.

MR. WALLIS: Another open item?

CHAIRMAN CORRADINI: I'm pretty sure if I remember correctly.

MS. CUBBAGE: Right, we were planning to talk about that briefly.

MR. CHEUNG: At three days, the first thing we can do, simple thing to do, is to make up, to review the ICCG pool, we have cold water. And so we can do it before that, but in the calculation, we do it in three days. We can turn on the dry well fan, the dry well gas and circulating fan at three hours. And we are still in the process of doing the analysis and seeing whether that would -- we could have, the system with the fan thing, to have the system such as FAPCS algorithmic system, which these two systems have large capacity to heat changer. Take out the energy from the containment and dump it outside.

MR. BLEY: Do you need all of these after three days? Or will one or two of them suffice?

MR. CHEUNG: The next slide will show in case the calculations, with no credit for past, with no FAPCS or WCU, only at the fan and the refilling of the pool.

Now I would like to explain a little bit more. Now this is the calculations, bounding calculations, presented in DCD from several days to 72 hours. If no additional system like the fan or whatever, this will slowly graduate, keep going up and up, and eventually cross the line of the design threshold.

In 72 hours, when we fill the pool which enhance the top condensation capacity, they turn on a fan. Now in this calculation we have from three days to seven days. We present two sets of calculations, the upper set with dry well/wet well pressure for four systems, four fans. Each fan has 700 cubic feet per minute, per line. The lower set has six systems, six vent line systems. And each system has 700 cubic feet per minute.

And you can see that that's so in this calculation, right on the 72 hour, we turn on, initiate the system. The pressure, the dry well pressure, drop rapidly, and continue to drop.

MR. WALLIS: Is it your intention to switch these things on at 72 hours, or to wait until something happens and then switch them on.

MR. CHEUNG: In the calculation, we assume 72 hours --

MR. WALLIS: What is the operator supposed to do? Is he supposed to switch the fans on?

MR. MARQUINO: Excuse me, this is Wayne Marquino, GEH. And we had to develop the emergency procedures in much detail. We expect that these active systems will be employed as they are available to mitigate the event.

We will develop emergency procedures that do that, certainly.

MR. ABDEL-KHALIK: It's remarkable that there is such a huge difference between the case of four vent fans and six vent fans. The only reason that could be true is if you are generating so much gas that for such a long, long time we continue to have a difference.

Now I would have expected that once you pulled the uncondensable gases out of that heat exchanger, within a few minutes, you know, it wouldn't make any difference.

If your explanation of the function of these fans is correct, then there shouldn't be a steady state difference between the case of four fans and six fans.

MR. BANERJEE: Well let's ask how many cubic feet per minute of noncondensables generates it.

(Simultaneous voices)

MR. BANERJEE: So you multiply that by six, and you get about -- how much is being generated? Cubic feet per minutes from --

MR. CHEUNG: Going through the system. That air has to go through that --

MR. BANERJEE: No, we're just asking how much is being generated by radiolytic decomposition.

PARTICIPANT: Just hydrogen and oxygen, that's all we're talking about.

MR. BANERJEE: How much is that? How many cubic feet per minute?

MR. CHEUNG: I don't have the number off my head.

MR. BANERJEE: Maybe we should ask that.

CHAIRMAN CORRADINI: I guess that -- you guys have probably done all these calculations, but you may not have -- but the first question I ask is, let me magically shut off radiolytic decomposition. Do you come to a steady state?

MR. CHEUNG: Yes, we did that.

CHAIRMAN CORRADINI: Okay, and then the second question was what Sanjoy and Said were asking is what is the production rate relative to this. But I have to admit, that doesn't strike you as odd that you add the 50 percent capacity and you get more than 50 percent effect, if I understand this curve right.

MR. WALLIS: Something doesn't look right.

MR. CHEUNG: No, no, the fan only circulates through the PCC2, and hands the -- you can see that -- pick one set. It says wet well pressure is slightly higher than the dry well pressure.

MR. WALLIS: Not much.

MR. CHEUNG: Not much. So that means some of the air, trying to find a way from the dry well going into the wet well. Now once it goes into the wet well, it will find a way back in the PCC because everything mix.

MR. ABDEL-KHALIK: But you're saying that the pressure in the dry well comes down because you get better heat transfer in those heat exchanges. And therefore the time constant for the decrease in pressure depends on how fast you brow the gas out of those heat exchangers. And to me, if you are pulling gas at 4 times 700 cfm or six times 700 --

MR. CHEUNG: Let me try to explain to you. I have not finished the arrangement. Let me try again.

The noncondensable gas in the dry well move from the dry well. Once it gets into -- finds a way into the PCC, and then the PCC will degrade but that way there will be mixture going in and eventually get to an equilibrium point. That why this thing tries to get to an equilibrium point. I mean, the gas mixture, the noncondensable portion of it, is higher than the fan, keep circulating the same amount, keep circulating.

MR. MARQUINO: So that was a good clarification, that the fans are circulating the noncondensable gas through the dry well, so they are clearing it, but then it has the opportunity to go back in the PCC. So that's one factor.

My mental picture of this is what the fan is doing is stabilizing at a different noncondensable gas pressure and the containment. So without a fan we stabilize with zero-noncondensable mass fraction in the dry well with a high pressure with six fans we stabilize at a lower pressure and a higher noncondensable gas fraction, and you see with four flans there is an intermediate pressure and noncondensable gas fraction.

The good thing abou8t these calculations is, we are doing them with our TRAC code, but I think there -- we'd get similar results by using Excel spreadsheets.

MR. CHEUNG: Let me go on a little.

MR. BANERJEE: Well, there was a question asked of you, almost answered, but you didn't. If there is no radiolithic hydrogen and oxygen generated, what happens to that curve? Can you describe it?

MR. CHEUNG: The curve will stay flat.

MR. BANERJEE: Where will it stay flat?

MR. CHEUNG: We need fifty hours of recording, clean up all the air, noncondensable gas, in the drywell with no more noncondensable gas in the wet well, then wet well gas is not going up --

MR. BANERJEE: So find the equilibrium point in the PCCS. And what you are doing by blowing -- sucking stuff out is just dropping that --

MR. CHEUNG: Equilibrium point.

MR. BANERJEE: -- level. So you still have noncondensable material. You are just getting it lower.

So your flow of noncondensables is a pretty high amount for this, is that it? I think you ought to equalize this.

CHAIRMAN CORRADINI: Can I just say it back to you, because I want to make sure -- we're going to come back to this anyway; we should move on anyway.

It's not just -- it's not just the noncondensable gas fractions. It's also the flow to the PCCS by you moving the van fan, you are changing the delta mass fraction, and the heat transfer coefficient of condensation ought to be essentially linearly proportional to the mass fraction, approximately.

MR. BANERJEE: Approximately.

CHAIRMAN CORRADINI: Approximately, so the energy pulled off. Because the condensation transfer coefficient at these very high mass fractions is like small. And so like small times a delta X. So you increase the delta X.

But the other thing is, the flow through the PCC. And that is the only way I can explain this nonlinear effect, is that you have almost very little flow when you are stagnant, and by moving the vent fan you are getting more flow through.

So some layer, at some time, not now, I'd like to investigate that, just to make sure that I feel all this is kosher, because it does look a bit odd.

MR. BANERJEE: You need to look at the heat transfer.

CHAIRMAN CORRADINI: Yes, and the other thing is, the decomposition rate. I guess I'm still surprised --

(Simultaneous voices)

CHAIRMAN CORRADINI: - it sounds to me really large.

MR. CHEUNG: It's an indicator effect, from --

(Simultaneous voices)

MR. BANERJEE: But we need to sit and look at it in detail.

MEMBER BLEY: I know you told us once, but would you tell me again exactly where is this fan drawing suction from, and exactly where is it discharging?

MR. CHEUNG: Can we have the other picture?

(Off the record comments.)

MEMBER ARMIJO: We're essentially creating a forced flow through the PCCS.

MR. DEAVER: I don't know if it was clear, but we have one dedicated fan per PCCS unit.

MR. CHEUNG: Okay. That will do it.

MR. WALLIS: Well, that figure, where is it?

MR. CHEUNG: This is the vent line. We have a fan going from the vent line for the blower or fan, and then they chart into this area.

MR. WALLIS: Flows into the --

MEMBER BLEY: Into the air space of the --

MR. CHEUNG: Air space of the pool. The air space will be created in the case of LOCA.

MEMBER BLEY: From the vent line into the air space.

MR. CHEUNG: Yes.

MEMBER BLEY: Can we pressurize that air space?

MR. CHEUNG: No.

MEMBER BLEY: Or is that in free communication with the drywell?

MR. CHEUNG: Because it's free communication between the wetwell and --

MR. WALLIS: It's part of the drywell then.

MR. CHEUNG: There's a little opening here.

MEMBER BANERJEE: Now if you just had the recombiners, what would the pressure stabilizer --

MR. CHEUNG: Well, in the calculation we saw, we didn't recombine --

MEMBER BANERJEE: These slides?

MR. CHEUNG: Well, I do not have that. In the calculation we saw that we recombine what is generally after 72 hour, but actually in reality, in the real world, once you put a pass in a wet well, whatever hydrogen, oxygen prior to 72 hours, they all combine, so actually the amount of non-condensible gas in the wet well is going to drop real fast, but in proportion to the integrated effect of the time.

MEMBER BANERJEE: So if you go back to

slide on page 11 or whatever it is, I can't see without my glasses, 11. What happens to the special curves if you have recombiners?

MR. CHEUNG: We have the recombiner. The wet well pressure will go down, because of the effect in the non-condensible gas.

MEMBER BANERJEE: Right.

MR. CHEUNG: We'll go down in proportion to whatever lap over, that cannot be combined because of a fraction of the hydrogen or oxygen. So we have brought it down to, I would say somewhere around here, is not going to drop down to atmospheric pressure.

MEMBER BANERJEE: The drywell?

MR. CHEUNG: The drywell.

MEMBER BANERJEE: So you don't have a calculation done just with recombiners?

MR. CHEUNG: We have calculation. We have recombiner, but only combine whatever is generated out of the 72 hours.

MEMBER BANERJEE: Okay. Then what happens if you just do it after 72 hours?

MR. CHEUNG: Then we have a curve that look like this, drop down to here.

MR. WALLIS: What's the volume of this drywell, again?

MR. CHEUNG: Seven thousand cubic meter.

MR. WALLIS: Seven thousand cubic meters.

MR. CHEUNG: Yes.

MR. WALLIS: What's that in cubic feet?

MR. CHEUNG: Cubic meter.

PARTICIPANT: Multiply by 27.

MEMBER BANERJEE: It is not cubic feet per minute then.

MR. CHEUNG: Cubic feet per --

MR. WALLIS: Cubic feet per minute.

MEMBER BANERJEE: Now going back to, why do you want these fans if your recombiners do the jobs?

MR. CHEUNG: Well, I'm going to complete it in two sentence saying that it's a defense-in-depth system. Power is one thing, vent fan is another. The vent fan is very easy to install, very low power, only couple of horsepower would do it.

MEMBER BANERJEE: These vent fans.

MR. CHEUNG: Vent fans.

MEMBER BANERJEE: But you're going to put recombiners, anyway, no?

MR. CHEUNG: Yes.

MEMBER BANERJEE: I mean, if you have the recombiners anyway, what difference does it make?

MR. CHEUNG: It is not me to answer that question.

MEMBER BLEY: The mechanics like the fans --

PARTICIPANT: Mine just to do and die.

(Laughter.)

MR. CHEUNG: Let me -- a little bit more. The vent fan have been tested in the PANDA test, in the PANDA facility.

MEMBER BANERJEE: I know, but that doesn't mean you install them --

MR. WALLIS: So four vent fans punched down the entire drywell in an hour, even if it's all full of gas.

MEMBER BLEY: But it's pumping back to itself.

MR. WALLIS: It's just circulating.

(Simultaneous speech.)

CHAIRMAN CORRADINI: All it is is a forced flow vacuum breaker right through the PCCS. They basically have turned on a pump through the PCCS.

MR. WALLIS: All it does is pump gas through it with no steam left. There should be no pressure in there. It doesn't make any sense.

(Simultaneous speech.)

MR. UPTON: Gentlemen, this is GEH. This is Hugh Upton with GEH. I guess the question on the table, I was in a separate discussion, but one of the reasons why we do have the vent fans is we have to show a dramatic drop in containment pressure at 72 hours to meet the GDC requirements, and so if we just had PARS, it would go to a steady state condition at high pressure. And here, with the vent fans, we show a dramatic drop.

CHAIRMAN CORRADINI: So let me -- I was hoping you wouldn't say that, but since you did, all you've shown us was six fans. You went down 20 percent. Now if you want to call that dramatic, okay, but you went from 3.7 bars to 3 bars.

MEMBER BANERJEE: Drama is the eye of the beholder.

CHAIRMAN CORRADINI: I guess, when I saw the open item originally, I had a feeling you guys were going to answer it somehow. I find it very creative, but if rather you come to some steady state, I guess personally, I guess I would argue that you've done -- personally, I was looking for what's happening here. And after this, I wasn't so concerned, if I could understand why you're coming to some equilibrium. And so, your passive recombiners, you've answered that part of the question of how you could come to an equilibrium.

MEMBER BANERJEE: It will be below the design pressure. Right?

MR. CHEUNG: Well, from 90 percent down to 30 percent, and we have -- the other system will come out.

MEMBER BANERJEE: Well, you've taken a very elegant design and you really made --

PARTICIPANT: We're going to have to look at this separately, I think.

MR. WALLIS: It doesn't make any sense to me.

MEMBER ARMIJO: In this analysis, the recombiners are not operational.

MR. CHEUNG: No.

MEMBER ARMIJO: But if they're truly passive recombiners, they are operational.

MR. CHEUNG: Yes.

MEMBER BANERJEE: They have to be there.

(Simultaneous speech.)

MR. MARQUINO: Dr. Armijo, let me give you some background on why. We started out with a passive design for three days, and GE expected that we'd apply our active systems at three days. After submitting

Rev 0, we learned about the regulatory treatment of non-safety systems, the fact that makes systems tech spec. If we want to use diesel generators we have to have a four-day supply of fuel on site, so we apologize for addressing some of these to the staff in piecemeal fashion, but we first added the passive recombiners to address the source of the pressurization, the radiolytic gases. And then when we showed the results for that, the GEC 38 concern came up, and the staff will expand on what their concerns are there. We've added the fans, so we retain a design that's passive for three days, and it minimizes the regulatory burden on the utilities in terms of RTNA systems, so we use these small fans which will be pretty easy to check, versus using the standby diesel generators and their fuel supplies.

MEMBER ARMIJO: Yes, I see that, but it seems like you have a passive recombiner. You're going to put that in anyway. You ought to take credit for it from day one, because it's there. That's the whole idea of passive. Right? You can't stop it from working.

MR. MARQUINO: The regulatory oversight is higher if we credit it immediately versus at seven days. The regulatory burden for having it, to get credit for it is so severe that you --

MEMBER MAYNARD: Well, you're talking about credit. They still -- it doesn't mean they won't use their active systems during the first 72 hours. So from a safety standpoint, they're going to have available anything that they've got. It's just what they --

MR. MARQUINO: The recombiner does not have a clock in it, so it won't know that it's 72 hours or not.

CHAIRMAN CORRADINI: Does staff want to say something to this point?

MS. CUBBAGE: I was just going to say it's up to the vendor and their customers to make some of these economic decisions, and they'd certainly be welcome to credit anything they want early on with the appropriate regulatory control, and before 72 hours it would be safety related, and that was a burden they weren't willing to take on.

MR. SNODDERLY: Also, Chairman Corradini, this is Mike Snodderly from the staff. The Committee in the letter concerning the AP-1000 in its review pointed out uncertainties associated with the PARS, and the fact that there had not been integrated testing done in a post-accident atmosphere. And, also into the Phebus test where that had been done, and showed some poisoning, so there is some uncertainty associated with the PARS.

MEMBER ARMIJO: Is that still the case, these things are --

MR. SNODDERLY: Right now, we are aware of some Phebus testing with PARS that has shown poisoning and a detrimental effect. They still function, but there was some --

MEMBER ARMIJO: Not as well.

MR. SNODDERLY: Yes. So I just wanted to remind the Committee of that uncertainty that was pointed out to us by the Committee.

MEMBER MAYNARD: Well, whether they credit them or not doesn't change the safety. I mean, that's only a matter of what shows up on the graphs or the outputs there, but they're still there.

CHAIRMAN CORRADINI: So it's our fault you're behind, but can you move along?

(Laughter.)

MR. WALLIS: Well, can we have a Subcommittee meeting on this 700 cubic feet thing, which doesn't make any sense, 700 cubic feet from --

CHAIRMAN CORRADINI: Well, I'd propose that you talk to the Chair of the Thermal Hydraulics

Committee right to your right, and we can negotiate that.

MEMBER BANERJEE: Just one last thing. I think we can accumulate a number of topics, and then set it up.

MEMBER ARMIJO: Are you guys really convinced you generate that much radiolytic gases? Did somebody triple check that?

MEMBER BANERJEE: Well, it's not the radiolytic flow. It's basically, as Mike says, a forced convection system --

MR. WALLIS: But the non-condensers have all gone into the wet well anyway, so I mean what are you circulating? You're sucking on nothing. It doesn't make any sense. Okay. You're going to be tell us all about it some other day.

MEMBER BANERJEE: Yes, I think it's --

MR. DEAVER: Okay. Section 6.3. This is the emergency core cooling system section. Basically, what we're going to go into more detail on, but we've already had a lot of discussion, is the gravity-driven cooling system, the iso condenser system, the standby LOCA control system, and the ADS system for depressurization. So I'll describe the systems, and then Chester will give you some details on the analysis performed.

Basically, the ESBWR design incorporates passive emergency core cooling systems in conjunction with traditional systems, such as ADS, which enable depressurization.

Some of these systems we've gone through before, so I'll go through some of them quickly. Gravity-driven cooling system I believe is a new system that we haven't talked about before. It basically has three sub-systems to it. The primary function of the system is to deliver injection cooling flow from the pool into the RPB, and the component that opens the system up after the vessel is depressurized is a squib valve. And another important feature is the check valve in the line, which if for some reason the system still had pressure in it, it would prevent the backflow of pressure into the pool itself.

MEMBER BANERJEE: Where is the check valve again?

MR. DEAVER: The check valve is here, just upstream of the squib valve.

This line actually branches into two lines, so for any given system or train, this will branch into two lines, and there will be two nozzles into the vessel. There are four lines to the system. There are three pools. Two pools are essentially the same dimensions, but the third one is a larger pool where we draw fluid from two pipes.

The second subsystem is what we call the equalizing line. So the initial part of the system would act early in an accident phase. The equalizing line is a way to open up the suppression pool and connect it with the reactor pressure vessel. And this, if needed, would be a longer term sort of thing. And it, likewise, is activated by a squib valve. So this is a precaution if you need more water in the core longer term.

MEMBER BANERJEE: It doesn't come on automatically then.

MR. DEAVER: No.

CHAIRMAN CORRADINI: But it's squib-related. And then if I understand it, by the elevation -- by your normal calculation of where the water is would not be needed. You would not normally -- you would have drainage from the GDCS --

MR. DEAVER: Yes, you would.

CHAIRMAN CORRADINI: -- to the reactor, and that would probably create the needed inventory. You wouldn't open that up.

MR. DEAVER: Yes. This isn't normally needed in that scenario.

MR. UPTON: Gentlemen, I want to at least clarify a point. The equalizing line is automatically initiated on level. Okay? So it's not a manual initiation.

MEMBER BANERJEE: I think that's what I --

MR. DEAVER: Okay. I forgot about that fact.

CHAIRMAN CORRADINI: But the expectation is that that level, you won't get down to that level, to finish that up.

MR. UPTON: That's correct. The level initiation for the equalizing line is below the initiation for the GDCS, so it's a backup.

MR. DEAVER: Thank you. And the third function is the deluge line, which is shown on this side of the figure. This basically, in the event there was a severe accident, where cooling was needed in the bottom of the reactor, or the bottom of the drywell, the squib valves, again, would open up the system and allow flow into the low area.

MR. WALLIS: If there's any water left in the GDCS pool by then.

MEMBER BANERJEE: And how would this logic work? When would this --

MR. DEAVER: Well, what we have in the --

MEMBER BANERJEE: What happens if it inadvertently opens, or something?

MR. UPTON: Gentlemen, this is Hugh Upton with GEH. The initiation of the deluge system, which ties to the BIMAC is coupled to extreme temperature in the lower drywell, which you'd see based on core ejection from the vessel. They're embedded thermacouples, which will initiate the system.

MEMBER BANERJEE: What happens if it inadvertently initiates? It makes a big mess. Correct?

MR. UPTON: That's correct. If it inadvertently initiates, you'll have a lot of water in the lower drywell.

MEMBER BANERJEE: And none in the --

PARTICIPANT: Where you want it.

MR. UPTON: That's correct.

MR. DEAVER: But it is --

MEMBER BANERJEE: Did you consider severe accidents?

CHAIRMAN CORRADINI: No, not today.

MEMBER BANERJEE: Why are we doing this?

CHAIRMAN CORRADINI: I was about to stop you from asking this question, but you started this.

(Laughter.)

MEMBER MAYNARD: But you do have a motor-operated valve to isolate. It looks like that's normally open, but is that something that could be closed? It would require operator action, it looks like.

PARTICIPANT: You'd have to figure out what was going on.

MEMBER MAYNARD: Yes.

PARTICIPANT: That's probably not very likely.

MR. UPTON: Right. That's correct. I mean, you can isolate that if it's draining.

MEMBER BANERJEE: But I think my question is still valid, why are you doing this? I mean, I just don't understand it.

MR. UPTON: This is defense-in-depth, that's why we have it. It's being -- it's for severe accident for core melts. And it also --

CHAIRMAN CORRADINI: This is part of their design.

MR. UPTON: It's part of the design.

CHAIRMAN CORRADINI: For their design,

they want water down there. It's not designed - just to repeat one thing I asked early in one of the things - by the way you've designed it, well, your lower cavity, or whatever you call that region below the reactor vessel, is to be dry. The only way to get water in is this way. It doesn't leak in naturally.

MR. DEAVER: That's correct.

MEMBER BANERJEE: This is not a requirement of our licensing process, is it?

MR. UPTON: Yes.

MEMBER BANERJEE: Or is it?

MS. CUBBAGE: They're required to address severe accidents. It's their option to choose a system to do that. It was their design choice. I think there's been a lot of talk about this in the PRA Subcommittee, but they were trying to avoid some uncertainty with the corium spreading area and things like that.

CHAIRMAN CORRADINI: But I think we're a bit off topic. Your biggest point is inadvertent actuation that would then limit it for normal --

PARTICIPANT: Yes, for a real emergency.

CHAIRMAN CORRADINI: More normal accident considerations.

MEMBER BANERJEE: But even a relatively

small break or something, the GDCS will be called on. Right? And you don't want this to pour water into the lower part of the floor.

MR. UPTON: It is a diverse control system, so there's no possibility that a failure in the control system could disable GDCS or during a LOCA -- there's no relation to the initiation parameters for the GDCS system core cooling function, and this BIMAC cooling function.

MEMBER BLEY: Are these down in the lower drywell?

MR. UPTON: Yes.

MR. DEAVER: Highly reliable valves built into the INC system. Okay.

Next is the iso condenser system. We've gone over this previously. I think one thing that I didn't point out earlier is that we have a vessel within the line which is, from a performance viewpoint, adds more inventory of water in the event of a LOCA accident, and so this inventory of condensed water in the line is credited in the accident analysis. So that's been an addition to the system. Otherwise, it's the same components that we've discussed earlier.

Okay. Moving ahead.

MR. WALLIS: So in the event of a small break, you only need the isolation condenser? You don't need to activate the other systems. Is that right? If you have a small enough break, you don't need to have the GDCS work at all, you don't need an ADS?

MR. CHEUNG: It would depend on whether that was very small break, and --

MR. WALLIS: You will handle it. Right.

CHAIRMAN CORRADINI: But in terms of -- so, since we're on Chapter 6, but in terms of the progression of the four accidents you mentioned, you took us through the performance of the containment, assuming a main steam line break, but you have other smaller break sizes down to the bottom drain line break.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: But all four of those, given their size, they would activate all the systems we're talking about, and challenge all the systems we're talking about.

MR. CHEUNG: Except the equalization line.

CHAIRMAN CORRADINI: Oh, except the equalization line?

MR. CHEUNG: Yes, because for all breaks, line penetration, all break within --

CHAIRMAN CORRADINI: Oh, I'm sorry. Okay. I understand your -- I'm sorry. But in terms of exercising everything --

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay. Thank you very much.

MR. DEAVER: Okay. Moving ahead, this is the standby LOCA control system. Basically, this has been revised to be a passive system. Previously, it had a pump that would initiate and inject the sodium pentaborate solution. What we do here is we basically have accumulators that have the sodium pentaborate solution with nitrogen system in these accumulators. And the normal pressure in these accumulators is 2250 psi.

Again, we have parallel squib valves that would have to open in order to initiate the system. And we have two sides to the system, we have accumulator on both sides of the reactor. The combined capacity of these two systems equals 100 percent of the capacity needed for shutdown purposes.

Also part of the system is a mixing system, and a sampling system so that we can check the solution at periodic times to make sure it's mixed.

MR. WALLIS: So they both have to work.

MR. DEAVER: Yes.

MR. WALLIS: It just equals 100 percent? There's no margin, it's not 150 percent or something? You say you just have 100 percent of what you need? I would think you'd need to have a margin, have more capacity than you need.

MR. DEAVER: Maybe, Wayne, you can address the margins available.

MR. MARQUINO: Yes. If one of them didn't work, which would require multiple failures, the core would still be covered, but we wouldn't have as much margin as we show in the LOCA analysis.

MR. WALLIS: Other flume can shut down --

MR. MARQUINO: And in terms of reactivity control in the ATWS scenario, if one of them worked we would reach a hot shutdown state, but before we cool down, we'd have to inject more boron because we wouldn't reach a cold shutdown state.

MR. DEAVER: Yes. I might explain that this system initially was only in place because of ATWS in the older plants, going forward into this plant. But what we're also crediting it for now is the water and sodium pentaborate solution as an inventory for injection into the reactor.

MEMBER SIEBER: Does that accumulator have a rubber bladder in it?

MR. DEAVER: No. It's just simply a solution gas interface. I might also mention that we have level detectors in the accumulator, and we have these two air actuated valves as shutoff valves. Once the system is open, obviously, as the accumulator gets down to a certain level, we want to shut it off, and that's what these valves do, to make sure that none of the nitrogen enters into the reactor system.

VICE CHAIRMAN ABDEL-KHALIK: Now does this use enriched boron?

MR. DEAVER: Yes, it does.

VICE CHAIRMAN ABDEL-KHALIK: So is there a trade-off between the pressure in this accumulator and the enrichment, so that you'd get --

MR. DEAVER: Yes. I guess if you had higher enrichment, you could use less pressure, but --

VICE CHAIRMAN ABDEL-KHALIK: What sets the pressure currently in the accumulators?

MR. DEAVER: 2250.

VICE CHAIRMAN ABDEL-KHALIK: I mean what sets that valve?

MR. DEAVER: Oh. That's a volume of --

MR. MARQUINO: It's sized to get -- this is Wayne Marquino. It's sized to get 86 gpm per a certain volume which is written into 10 CFR 50.36, I believe it is. So that determined what flow rate we had to produce, and we designed the pressure and flow areas of the system to meet that requirement.

VICE CHAIRMAN ABDEL-KHALIK: But that depends on which ATWS you're talking about, which pressurization ATWS.

MR. MARQUINO: Well, we'll get into that more tomorrow, but it's way over-sized because that requirement assumes like a normal water level, and we automatically reduce the water level in an ATWS, so we inject the boron into a much smaller volume. And you'll see the results in Chapter 15.

VICE CHAIRMAN ABDEL-KHALIK: Okay. MEMBER BANERJEE: You reduce the water levels by feedwater --

MR. MARQUINO: Yes. Run-back.

CHAIRMAN CORRADINI: So just so I -- I think the staff is going to mention this about an open item relative to this nitrogen going in and not being stopped, because the current -- the way this should work is you inject the liquid, and then you close off before you start having a continued injection of the nitrogen. Is that correct?

MR. DEAVER: Exactly.

CHAIRMAN CORRADINI: Okay. So just to get a rule of thumb, if I didn't, and the nitrogen went into the system, at normal containment pressure conditions what's the -- how many cubic feet, or cubic meters, or what's the inventory affect on pressurization inside containment with this? Would this be a small, insignificant amount of pressurization?

MR. CHEUNG: Would be a very significant increase in pressure.

CHAIRMAN CORRADINI: It would.

MR. WALLIS: Significant increase in non-condensables.

CHAIRMAN CORRADINI: Well, that was the second -- I was about to get there, but at least I wanted to know the pressurization. And then you're increasing your non-condensable fraction, but you're already at a very high enough non-condensable fraction, you're at the asymptote on how it affects H, the transfer --

MR. WALLIS: How does it know when it's got nitrogen instead of liquid?

MR. DEAVER: There's level sensors.

MR. WALLIS: Level sensors?

MR. DEAVER: Four levels.

MR. WALLIS: So it senses the level in the accumulator?

MR. DEAVER: Yes.

PARTICIPATION: Then it closes a valve or something. Right?

MR. DEAVER: Then it closes both of these valves.

VICE CHAIRMAN ABDEL-KHALIK: What is the volume of the accumulators?

MR. DEAVER: I think - what is it - 5.3 cubic meters, I believe is the --

MR. CHEUNG: Water volume, or the gas?

VICE CHAIRMAN ABDEL-KHALIK: No, the total volume. The gas volume. I think that would be sufficient. What's the gas volume?

MR. DEAVER: The gas volume versus the water volume?

VICE CHAIRMAN ABDEL-KHALIK: Just the gas volume.

MR. DEAVER: We'll have to look it up and get you a specific number for that.

MR. UPTON: We can pull that out of the DCD.

MR. WALLIS: It looks big in the picture.

(Off the record comments.)

MR. DEAVER: As I recall, the height of this vessel is going to be about 5 meters -- it's a fairly good size, yes.

MEMBER MAYNARD: These are operated valves in your analysis for closing?

MR. CHEUNG: Yes.

MEMBER MAYNARD: They are credited. Okay. I thought we were talking about in Chapter 9 on the standby liquid control system, that it just discharged, and you did get nitrogen in there.

MR. DEAVER: No.

MEMBER MAYNARD: Okay.

MR. MARQUINO: Okay. Shall we move on to the next --

VICE CHAIRMAN ABDEL-KHALIK: So we could translate 2250 psi, the amount of gas in those accumulators, and dump them into the containment. How much would the pressure go up?

MR. DEAVER: I don't know that number.

MR. CHEUNG: I forgot the number. It's significant. More than likely than will exceed the design pressure, because it's 22 psi.

VICE CHAIRMAN ABDEL-KHALIK: 2250.

MR. WALLIS: You'd need at least six fans running to go in the --

(Simultaneous speech.)

MS. CUBBAGE: I think I've got the right number here for you, but the DCD is talking about 14.8 cubic meters of nitrogen cover in the accumulator.

PARTICIPANT: What is that volume you said?

MS. CUBBAGE: Yes, 14.8 cubic meters of nitrogen cover.

MR. DEAVER: Yes. That's -- I probably had my numbers confused.

MR. WALLIS: Say that again.

MS. CUBBAGE: I was just reading from the DCD. It's talking about necessary to maintain 14.8 cubic meters of nitrogen cover gas at 14.82 megapascals in the accumulator for each slick train.

MR. DEAVER: That sounds like it's probably right.

MEMBER ARMIJO: 225.

(Off the record comments.)

MS. CUBBAGE: You want feet? They have it here, 523 cubic feet.

MR. WALLIS: So it's a big proportion of the amount of nitrogen in the containment to start with, looks like.

CHAIRMAN CORRADINI: Keep on going.

MR. DEAVER: Okay. The ADS system we've seen before. Again, it's just the SRV safety valves and DPVs, which we discussed before. I won't go any further into that.

Okay. Then we go into the performance side of the presentation.

MR. WALLIS: Remind me how big the ADS valves are.

MR. DEAVER: Which ones are we -- are we talking about the DPVs?

MR. WALLIS: The flow area that comes out of those DPVs.

MR. DEAVER: Oh, okay. The standpipes are eight inches.

MR. WALLIS: They're all eight inches?

MR. DEAVER: Coming up to the DPV, and it opens up to at least that much area.

MR. WALLIS: Open. Okay.

MEMBER BLEY: And the full ADV flow converter main steam flow, number you know off-hand?

MR. DEAVER: I know there's a ratio that we're required to have.

MR. CHEUNG: And, also, the --

MR. DEAVER: Both the IC and the steam line both have the same restricting orifice on the discharge. They're both upper vessel diameters with steam --

PARTICIPANT: It's going to a lower pressure, so it's a lot more flow.

MR. DEAVER: Okay?

MR. CHEUNG: For the ECCS performance, again, the ESBWR with the TRACG code: the key part is we use the same nodalization for ECCS and nodes used in containment analysis. And for ECCS at NRC we have performed more detailed time lines from zero to 2,000 seconds because during this time period all the blow-down, all the GDC injection, and the things going on, we have an interest in whether the core is covered or not covered during this time period. After the GDC injection, the core inventory increase or recover after that, and then the water stay there for long time, and we have analyzed that from zero to 72 hours, and look at the output calculation. And, also, we have evaluated the up and down to 72 hours.

The bottom line is for all breaks that no core uncovers, and there's no core heat-up --

MR. WALLIS: Now this is water above the core.

MR. CHEUNG: Water above the --

CHAIRMAN CORRADINI: Substantially above it.

MR. WALLIS: Taking credit for the voids in the core.

MR. CHEUNG: Yes.

MR. WALLIS: But if you collapse the voids in the core you'd get a different number, wouldn't you?

MEMBER BANERJEE: What's the average void fraction in the core?

MR. CHEUNG: In the core, 80 percent, 90 percent. It's high, but now let me go back a little bit.

CHAIRMAN CORRADINI: What was that number you said?

MR. CHEUNG: 80 percent, 90 percent.

CHAIRMAN CORRADINI: Oh, 80 percent.

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: I thought you said eight. Sorry.

MR. CHEUNG: Now in order to -- for a figure of merit for comparison of LOCA evaluation, using the PCT as operating parameter, is not going to change because the core is not uncovered, so we used another measure with that. We used the amount of water step up on top of the extra fuel, the amount of water in the accumulator region, and we collect it, and calculate static head, including the water, 1.5 meter, whatever that is, and stick it on top of it, and then that's the measure, the comparator from one case to --

MR. WALLIS: As long as you've calculated your core void, it's right.

MEMBER BANERJEE: And your chimney void.

MR. CHEUNG: I will calculate the amount of water in the chimney.

MEMBER BANERJEE: So you have to get the chimney right.

MR. CHEUNG: Yes.

MR. WALLIS: But, particularly, you've got to get the core right because if there were no voids in the core, that's the only water would be in the core.

MR. CHEUNG: Well, depend on the pressure during transient. Next slide, please. Okay. So we have calculate all penetrations, a total of 9 penetrations in RPV, using the three creditable single failure relays one PPV available, or one injection rod available, or one safety valve not available. So in

PCV 6.3 we have presented result maximum line break, water line break, GDL, injection line break, and point of entry line break. And for DPV Step Two, shutdown cooling suction line break or ICU return line break, or GDCS equalization line break we present in response to RAI 6.3-46 , and the slick injection line break is all presented in 6.3, RAI 6.3-65.

In summary, all this break for nominal condition, the amount of water stack up in the chimney is about 1.5 meters.

MR. WALLIS: What does this chimney static head mean?

MR. CHEUNG: It means whatever that two-phase stop in the chimney on top of the core, we calculate amount of water in that.

CHAIRMAN CORRADINI: So there's 1.5 meters of pure unadulterated liquid water.

MR. CHEUNG: Yes.

MR. WALLIS: What is 8.9 meters then? What is that?

MR. CHEUNG: That reference to the bottom of the RPV.

MR. WALLIS: The bottom of the RPV. Right. So it doesn't really mean anything.

MR. CHEUNG: It doesn't mean anything in

the case of our --

MR. WALLIS: Much better to talk about them,

talk back to --

MR. CHEUNG: Because internal calculation, we reference RPV-0. Now we try to go back and say 1.5 is the water collected, amount of water stack up on top of fuel. And after the GDCS injection, the water coming in, the water level recover. And the limiting break is the -- based on the evaluation on this nominal calculation, we select the main steam line break and the GDCS injection line break for a bounding condition calculation. And the bounding calculation so that -- which is a GDCS injection line break, we have one injection mode failure. We still have more than one liter of water on top of the field. Now that's from zero to 2,000 seconds.

MR. WALLIS: This says during the first three days.

MR. CHEUNG: No, this is during the first 2,000 seconds.

MR. WALLIS: Oh, 2,000 seconds.

MR. CHEUNG: The next slide we show the -- on the containment calculation we analyze the result. We saw that depends on what break, for all this break we evaluate that the static head is more than one meter of water from top of the field for 72 hours.

Now beyond 72 hours, we do not have an actual calculation, so we used hand calculation, we evaluate, because some of the water, some of the steam generated in RPV could have condensed in the drywell and the wall region, and then drop down to the lower drywell region, and not going back in the RPV through the recycling of the PCCS. However, we still see that based on calculation that we have more than -- it depends on the break evaluation. Is a low break aeration that acts on the annulus water, we communicate with RPV water, so the amount that would get in the coolant pump. If high aeration break, the RPV have more inventory to boil off, and not coming back.

The bottom line is, for all these things, we value the amount of water on top of the fuel of more than one liter.

MR. WALLIS: So what does the long-term cooling, is it the PCCS system with the fans, or is it the isolation condenser?

MEMBER BANERJEE: Without the fans.

MR. CHEUNG: This is not just water in --

PARTICIPANT: This is in the first 72

hours.

MR. WALLIS: The PCCS system, you refill the pool. Is that what --

MR. CHEUNG: PCCS, refill the pool, and go back to the --

MR. WALLIS: So refilling the pool is the long-term cooling.

MR. CHEUNG: Yes.

MEMBER BANERJEE: Yes, it's the boil-off.

MR. CHEUNG: It's the boil-off and coming back.

MEMBER BANERJEE: Well, what is the steam velocity here in the chimneys?

MR. CHEUNG: Steam velocity in the chimney, I don't have the number.

MR. WALLIS: In the chimney is tiny.

MEMBER BANERJEE: Well, no. I don't know. That's what I'm asking you, is it just a boil-off, because this is a fairly low pressure now. Right? So you're taking 2 or 3 percent decay heat, and you're generating steam.

MR. CHEUNG: Yes.

MEMBER BANERJEE: So that's -- just divide by the latent heat in the water, flow area you can give me a velocity. Right?

MR. CHEUNG: Yes.

MEMBER BANERJEE: I'm looking for the velocity.

CHAIRMAN CORRADINI: It's not a very high velocity, because you've got 45 megawatts divided by 2.2 megawatts per kilogram, so you're producing about 22 kilograms a second of steam by boil-off.

MR. CHEUNG: Very small amount.

VICE CHAIRMAN ABDEL-KHALIK: How many parallel channels are used in these models?

CHAIRMAN CORRADINI: You mean the TRACG?

VICE CHAIRMAN ABDEL-KHALIK: Right.

MR. CHEUNG: In the TRACG. Okay. In a core we model, we have three --

CHAIRMAN CORRADINI: I'm sorry?

MR. CHEUNG: In the TRACG, the core which we model in three rings, we call them ring one, two, three. And with each ring, we have two different -- we beat the ring, we have two different we call chimney addition. We simulate two separate partition, so each ring is a partition, but within the ring we have a single partition, chimney partition to simulate that. So in terms of chimney addition, we have a total of five group to simulate partition with different flow area, or different grouping.

CHAIRMAN CORRADINI: So three radial positions, and then within each radial position, can you repeat that part again? I'm sorry.

MR. CHEUNG: Three radial positions, one, you know, the center one and the next ring we have additional partition --

CHAIRMAN CORRADINI: Thank you.

MR. CHEUNG: So we have inside the shroud we have total of five parallel channel.

MEMBER BANERJEE: So what's the flow area in the core, and the flow area in the chimney, meters squared?

MR. CHEUNG: The core shroud diameter is about --

MEMBER BANERJEE: No, I mean the flow area.

MR. CHEUNG: I don't have the number.

VICE CHAIRMAN ABDEL-KHALIK: So the same radial nodalization, five parallel channels, does that carry over to the chimneys, as well?

MR. CHEUNG: Yes.

VICE CHAIRMAN ABDEL-KHALIK: Okay. Do you think that's adequate for determining any radial variability?

MR. CHEUNG: We look at the level response in all these five different channels. They all similar.

VICE CHAIRMAN ABDEL-KHALIK: Well, sure, because they're all smeared.

MR. CHEUNG: Well, in a real -- well, we've got two -- those channel is only 16 bundle, with 16 bundle fitting, so that's a real simulation, 16 bundle what if the power go into 16 bundle, generally the steam go in that partition.

VICE CHAIRMAN ABDEL-KHALIK: Would you say that again? So one of the two in each of the two outer radial zones corresponds to only 16 bundles?

MR. CHEUNG: We have two partitions inside, we have total of five parallel channels. Two of them -- each one of those simulates 16 bundles. And out of the 16 bundles they go into the box for this scenario, this partition. There are two.

VICE CHAIRMAN ABDEL-KHALIK: And the one in the center?

MR. CHEUNG: The one in center.

MEMBER BANERJEE: And what about the core?

VICE CHAIRMAN ABDEL-KHALIK: Thank you.

MR. WALLIS: That's what I mean.

MR. WATKINS: That concludes our presentation. I'd like to thank the ACRS Subcommittee

Members for your attention.

CHAIRMAN CORRADINI: Thank you for your patience.

MR. WATKINS: And thank you to the NRC staff for their thorough review of Chapter 6.

CHAIRMAN CORRADINI: Any other last questions before we go to a break? None. So we'll take a short break, 3:25.

(Whereupon, the proceedings went off the record at 3:12 p.m., and went back on the record at 3:27 p.m.)

CHAIRMAN CORRADINI: Okay. So let's get started. The staff will discuss their draft SER, and I was told by Amy that following that, we might go a little bit long because there is an expert here from GE that can address some of the questions by the members on the vacuum breakers. And they also want to discuss the feedwater power flow map. Since they have the ability to do that today, we want to get those questions out of the way. All right?

So, Mr. Williams, are you the lead?

MR. WILLIAMS: Yes. Good afternoon. My name is Shawn Williams, I'm the Project Manager for Chapter 6. This afternoon the staff is going to present mostly only significant open items within certain sections of Chapter 6.

This is a list of the lead technical reviewers. There were many significant contributions by staff. They're in the audience today to also speak, if necessary.

I'm going to outline the presentation. I'm going to quickly go over the RAI status, hand it over to Bob Davis to discuss his open items in 6.1 and 6.6. Hanry Wagage is going to discuss open items in Chapter 6.2. Weidong Wang is going to discuss open items in Chapter 6.3. If you recall, we've already discussed Chapter 6.4, control room habitability at an earlier ACRS meeting, and Jay Lee is going to discuss Chapter 6.5 with 15.4 tomorrow morning.

We issued a total of 306 RAIs, which 215 resolved, and right now we have 91 open items, but I do want to say GE responded to 42 out of those 91 open items just recently, so maybe the next month that's going to reduce drastically.

I'm going to hand it over to Bob Davis to discuss 6.2 and 6.6.

MR. DAVIS: My name is Bob Davis, and I'm in the Plant Integrity Branch, Division of Engineering, and I reviewed Section 6.1.1 on engineer safety features and materials. The ESF materials were found to comply with the requirements of ASME Code Section 3, with one exception, which I'll discuss as part of my description of the open items.

Fabrication of ESF components comply with the appropriate requirements of ASME Section 3, and materials and processing of stainless steels conform with the guidance in NUREG 03-13, Reg Guide 1.44, which is consistent with the reactor coolant pressure boundary, the requirements are identical, and they met all those. And the cleaning and climate controls, as with the reactor coolant pressure boundary, conform with Reg Guide 1.37.

There aren't really very many open items in this section, but some of the ones that are -- we still have a lot of issues with is the isolation condenser, material specifications, fabrication, and processing as the Niovium modified Alloy 600, which is part case, and 580. GEH has indicated that they'll using a tubing spec which is SB 163 for the Alloy 600, as modified by the code case. The code case does not include SB 163, so we're still working with GEH to try to resolve that. Because the code case only includes piping, plate, forging, and bar specs, it does not include any tubing specs; so, therefore, it's not in accordance with Section 3, or Reg Guide 1.84, which lists acceptable code cases.

We also have in addition to that material issue, we've asked GEH questions on the effect of induction bending of IC tubes. The testing following bending to confirm the acceptability of the material for use, the IC tubing support design structure to insure there's no presence of crevices, and the material properties of the most limiting vent tube. These same issues, even though it's a different material, are very similar to the CCS heat exchanger, which is made out of 304L tubing, but we have RAIs asking similar questions. And that's it for Section 6.1.

I also reviewed Section 6.6, which is pre-service and in-service inspection.

MEMBER ARMIJO: Can I interrupt?

MR. DAVIS: Yes.

MEMBER ARMIJO: In RAI 4.5-21, the staff asked questions about the adequacy of the material selected for the ESBWR with respect to the water chemistry. And then the staff closed it out with a statement that says, "The staff finds that it is appropriate for the ESBWR design to include features to facilitate future installation of hydrogen water chemistry", and by inference, that they were satisfied, the staff was satisfied that the choice of materials and fabrication was acceptable. And my question is, does the staff believe, and maybe GEH, as well, does the staff believe that the material selected for the ESBWR, primarily the stainless steels, are going to operate for 60 years with normal water chemistry without IASEC or IGSEC? Is that what the staff is saying?

MR. DAVIS: Well, I think for the IASEC, we'll have to direct that -- that probably wouldn't apply to the ESF components. I guess you're talking about reactor vessels internals for --

MEMBER ARMIJO: Yes, reactor vessel internals, as well.

MR. DAVIS: So I'll address the ESF components, and then for reactor vessel internals, we have the gentleman here who reviewed that section. But for the ESF materials, yes, we do believe that they are using -- for the stainless steel materials, they are using Category A materials per NUREG 03-13, which we recognize as not even needing any additional inspections as far as IGSEC. Now that's -- now for the question on the vessel, I guess Nahir Ray could speak to that.

MR. RAY: Hi. This is Nahir Ray from the

staff. I think this same subject we discussed as Chapter --

MEMBER ARMIJO: And we'll discuss it again, as long as I'm --

(Laughter.)

MR. RAY: And during that -- and, also, we are currently reviewing and trying to address your questions, which came to EDO's office. So to address the subject is this way. Reactor internals in the ESBWR are made up very low .02 carbon stainless steel, and that's one thing. If you --

MEMBER SHACK: That's bad for IASEC.

MR. RAY: Right. I'm coming back to that. I think they -- let's recognize one fact here. BWR plates in current plans, almost all of them having this problem of IGSEC and IASEC problems. We all know that.

Now knowing that, what we can do, or what GE can do, or what they have done - let me summarize that. First of all, the internals, they used basically the lowest possible carbon content there, and the second question that you raised, and you asked for is, are they going to do any water chemistry control?

The answer - actually, we are trying to

answer that question along with GE. We had several phone calls with them, and the answer in a summary to you is they are still thinking about it, and trying to figure out what are the best solution for that situation. And here are the four options they told us yesterday over the phone.

One is the solution, and the second solution is make it completely forged, no welding. Third is use the water chemistry control, which in their opinion, for all domestic potential customers, they already decided to put that water chemistry control in their plans, which is currently in the ESBWR as an option. And, in addition, I suggested to them what about frequent inspection of the internals, and associated components. And they didn't comment anything, so these are the four options basically on the table. And we are planning to provide you the response in that with all four options.

MEMBER ARMIJO: Okay. Well, the point about the -- thank you. If domestic customers for this plant are going to use the hydrogen water chemistry to protect against IASEC, and, frankly, I think also against IGSEC, even with the low carbon, because there have been instances of low carbon 316 failing in Swedish reactors, piping, welds, so if the

U.S. customers are going to specify that process, I don't understand why it isn't part of the -- in the DCD, and part of the design certification. Would they have to come back later and do an amendment to the certified design in order to have hydrogen water chemistry?

MS. CUBBAGE: No. And I'd actually like to turn to GE to answer that.

MR. UPTON: We don't believe that it will require us to come back. It's in the DCD as an option, and it's really an economic decision by the customer whether he wants to install it or not. We think that we recommend it, and that's our position going in from day one, but we leave it to the customer.

MEMBER ARMIJO: So GE recommends the hydrogen water chemistry for protection of the austenitic stainless steel components.

MR. UPTON: That's correct.

MEMBER ARMIJO: Okay. Thank you.

MR. DAVIS: And in addition to the -- on the rad coolant pressure boundary pipe, we have discussed with GE about information to DCD regarding service preparation when they do have to grind, and the grinding is held to a minimum. And that language that we've asked them to put in the DCD is similar to what the staff requested for the BWR PIT for addressing welds for internals.

I also reviewed Section 6.6, which is Class II and III PSI and ISI. With the exception of open items, PSI and ISI Class II and III systems were found to comply with the requirements of 10 CFR 50.55a, and ASME Code Section 11. The development of the pre-service and in-service inspection program is the responsibility of the COL holder.

All items within the Class II and III boundaries are designed to provide access for examination as required by Section 11.

Augmented examinations include augmented ISI to protect against postulated piping failure between containment isolation valves. That will be performed in accordance with the recommendations of the Standard Review Plan, as acceptable. And augmented inspections as described in Generic Letter 89-08 to detect and monitor potential wall thinning of high energy piping by erosion, corrosion will be implemented. And that will be included to all ASME Code Class I, II, and III, and non-code class piping that is susceptible.

The open items that we have, I think

somebody brought it up earlier about the accessibility of welds. Well, we still have the same open item that we had for reactor coolant pressure boundary. Yes, all the welds can be inspected by Section 11. Our concern is that those welds that cannot be inspected by UT, that would have to be inspected by RG, that later on licensees, as they do now, would come in and say it's impractical to do an RT and would want a relief request.

And the NT selected for each weld that would be ISI, you can't select a method that is going to be impractical, because you have to drain the pipe, or you have to do something that you know that that's going to be a hardship later on, so we're still working to resolve those issues.

We also have issues with the inspection for the isolation condenser and the PCCS heat exchangers. Currently, the isolation condenser, the only thing that's planned is a VT2, and we're not sure that we're going to be able to accept that. The code doesn't really address the isolation condenser, and applying rules that are meant for pipe may not be acceptable, especially given that they're submerged in water, which makes it more difficult to do a VT2 on them.

The COL action items for this section, the COL applicant will provide a description of the PSI and ISI programs for Class II and III components, and the milestones for the full program implementation.

MR. WILLIAMS: Any questions on 6.6? Then we'll move to Handry Wagage, Chapter 6.2. Handry.

MR. WAGAGE: Good afternoon. My name is Handry Wagage. I'm going to talk about the significant open items in Section 6.2. I reviewed Section 6.2.1 on containment functional design. I got support from Alan Notafrancisco of Office of Research, who is in the audience, for containment analyses. Office of Research performed confirmatory analyses with MELCOR computer code.

Andrzej Drozd, who is also in the audience, reviewed Section 6.2.2 on passive containment cooling system. Fred Goyle, who is also in the audience, performed review on Section 6.2.4 on containment isolation system, and 6.2.5 on combustible gas control in the containment.

GEH went through the design features of containment, drywell, and wetwell. I would like to remind you that what we mean by drywell and wetwell, just to make sure when I talk about bypass from drywell to wetwell. Wetwell is --

MEMBER MAYNARD: You might want the pointer with the pad on it.

MR. WAGAGE: Oh, you have one? Okay.

CHAIRMAN CORRADINI: You don't want the gas into the room. You never know what's going to happen.

(Laughter.)

MR. WAGAGE: It shakes. That's why I don't like this. This is the boundary of the -- this is the wetwell. Oh, that's much better.

This is what they call wetwell, which contain the suppression pool and the suppression pool air space. And everything else in the containment boundary, containment boundary is right here. And this is the physical containment boundary. Everything else is called drywell.

I have an open item in containment sub-compartment analysis. In this containment, GEH considered two sub-compartments. One is this drywell head region, second one is not shown here. It is reactor shield annulus. There's reactor shield around the vessel, there's the annulus. About these two sub-compartments, the first one did not have any high energy line, so there was no need to analyze that. GEH analyzed two high energy line breaks in this sub-compartment in reactor shield annulus. Those were feedwater line break and reactor water coolant unit line break. We had used TRACG computer code. Tough plan to perform confirmatory analyses of sub-compartment with TRACE computer code. To get ready for these analyses, staff requested more information on the details of GE analyses.

By reviewing the GE analyses, we found that GEH mistakenly calculated half of the mass and energy coming into the sub-compartment, so by that, it was in error. GEH had to recalculate. We have not seen the results yet.

CHAIRMAN CORRADINI: What's the error?

MR. WAGAGE: Error was that the mass and energy coming into the sub-compartment, mass and energy release head, by mistake GEH calculated half of that coming in.

MR. WALLIS: Because it's a single-ended break or something, or what is it?

MR. WAGAGE: No. What happened was that this is an annulus, this is by symmetry, the calculation assumed half of that for modeling. When they assumed half for the modeling, then they have calculated it ---- they have to get the half of the mass and energy coming in. Then they got half of the mass and energy coming in. To get the velocity of flow, they divide by the total area. Now we are modeling half of the annulus, we have to use half the area, by which they double --

CHAIRMAN CORRADINI: They dragged out the time scale of the event.

MR. WAGAGE: Yes. It's slow energy coming in, and also this is a short time scale, milliseconds time -- it's a short, very short time scale. That mean it pressurizes quickly, that mean it's completely off, that means GEH has to recalculate, and we have to see the results.

MR. MARQUINO: This is Wayne Marquino. We concur with what's been said. This has to do with the local pressures in the annulus area, and it doesn't affect the containment pressure responses that you saw earlier.

CHAIRMAN CORRADINI: Is this a qualification-related issue relative to what's in that region?

MR. WAGAGE: This is to find whether that annulus can stay in tact.

CHAIRMAN CORRADINI: So, essentially, a pressure loading, a local pressure loading.

MR. WAGAGE: Or loading on the annulus.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. WAGAGE: I have an open item on containment debris protection for ECCS strainers. There are no pumps in ESBWR for cooling for first three days, so GEH suggested that there was no need to do analyses for debris in the earlier DCD revisions.

Then we questioned that there may be possibilities also, there are no pumps, the debris may getting into water coming into the core. One possibility, that this is PCCS condenser. During the blow-down, debris may getting into these inlet pipe and go through PCCS, and get into the GDCS pool. That's one path. It gets into GDCS pool, where there is GDCS injection into the core, the debris can get in there.

CHAIRMAN CORRADINI: What would be the composition of what you're worried about? What would get in there?

MR. WAGAGE: During the blow-down, debris is produced, because of blow-down. Some may getting into this pipe.

CHAIRMAN CORRADINI: Yes.

MR. WAGAGE: And go through the condenser. And when water drains into the GDCS pool, debris may getting into GDCS pool.

CHAIRMAN CORRADINI: Were you concerned about any hold-up on the actual tubing?

MR. WAGAGE: Actually, we asked that question. What GE said was that hole size of that debris screen was one inch, whatever gets in go through the condenser because that hole is smaller than the size of the condenser. And there is another possible part debris can getting into the system. There is that opening in the GDCS air space to the drywell. We asked questions on that later. GEH added the debris screen to that so that during the blow-down debris would not get into GDCS pool.

CHAIRMAN CORRADINI: Is there any -- so let me ask the question differently, so you can see where I'm worried about it. Is there any sort of transport mechanism, that if I have small enough particles that aren't trapped by the cone screen entering the PCCS, and flow with the flow through the tubes, that they wouldn't be transported, almost like a cold trap, onto the heat transfer area. Right? I've got dust in the flow, it condenses, I bring it to the surface. What makes the dust want to stay with the liquid and not essentially start affixing itself and fouling the surface?

MR. WAGAGE: GEH used only metallic

insulation, so it will be pieces of metals, not regular dust, or any other pipe insulation. It may be possible, some of the little pieces may stuck.

CHAIRMAN CORRADINI: So because it's metallic, you don't think there would be any sort of fouling issue.

MR. WAGAGE: No. This happens only during the blow-down.

CHAIRMAN CORRADINI: No, I understand. Yes, I understand that.

MEMBER SIEBER: What about biological fouling? You've got a lot of open pools here uncirculating basically. It would seem to me it's a perfect for biological fouling.

MR. UPTON: This is Hugh Upton with GEH. Let me address that. There is a pool cooling and cleanup function for the ICPCC pools. It's demineralized water, and we maintain the clarity, so we don't believe that there's going to be biological fouling.

MEMBER SIEBER: What about these other open pools?

MR. UPTON: They're all cleaned and cool -- FAPCS, actually, that's one of the functions of that system is to cool and clean up those pools.

MEMBER SIEBER: You don't use any chemical treatment I take it.

MR. UPTON: No, it's demineralized water. We have no chemical treatment.

MEMBER SIEBER: So there's no way to kill off bacteria or anything else that's in there. Right?

MR. UPTON: The system, the FAPCS systems have demineralized filter beds, so that's where it would get caught.

MR. WAGAGE: Other features of this ESBWR is there is suppression pool liner which is made of stainless steel, and GDCS liner made of stainless steel. There is no way that rust getting into the system, like other systems.

MEMBER ARMIJO: When you look at these things, do you and GE assume that nothing will be in the containment except what they designed? I mean, people work in there, people do maintenance in there, and sometimes things get left behind. Is any of that under consideration?

MR. WAGAGE: Yes, because we are going to insist that the system has to be designed according to the guidance in Reg Guide 1.8-2, Revision 3, that has latent debris, that mean that GE has to consider latent debris.

MEMBER ARMIJO: Do you have some specification on how of that they have to consider in the containment?

MR. WAGAGE: How much -- early BWR considers certain amount, but GSI 191 issue that during the resolution of GSI 191 we learned more about this latent debris, and we are working on it, how to address those issues for BWRs.

There is suppression pool equalizers in line. When the vessel water level comes down in the long-term, water from suppression pool can inject into the vessel. We asked GEH to explain how it's going to prevent debris getting into the vessel through these GDCS equalizers and line, because during the blow-down, some of the debris can get into the suppression pool through the vertical and horizontal vents. And that debris can move into the vessel.

We have in RAI 6.2-6, GEH is working on it as we had a telephone call to GEH. You recall that GEH is going to use design this strainer according to Reg Guide 1.8-2, Revision 3.

There is an other related issue.

CHAIRMAN CORRADINI: If I could just ask a question here, just so, again for my own understanding. Is there some sort of -- in your discussions with GEH, where they think if there is debris produced, where it would end up being mainly accumulated? Will it mainly accumulate in the bottom of the suppression pool? Will it mainly be accumulated on surfaces? What is the disposition, given that the major, if I remember correctly, the major limiting accident is the main steam line break, and then feedwater. Where does the debris go, primarily?

MR. WAGAGE: This is -- we are working on it.

CHAIRMAN CORRADINI: Okay. Still in process.

MR. WAGAGE: Still in progress. The main reason was that because there are no pumps, this wasn't an important issue. And as you saw some results from GEH today, in the long term, GEH is going to use suppression pool water to inject into the vessel. Then there will be recirculation. Then we have to consider -- then we have to ask how debris is going to --

CHAIRMAN CORRADINI: You brought this up, but I guess just to clean up, because we had asked this of them earlier, maybe you weren't in the audience. What I thought I heard was that given the way they see the accident going, in the first 72 hours they're not seeing any need for the initiation of the equalization line opening, unless I misunderstood their discussion.

MR. WAGAGE: Agreed. I agree. During the first 72 hours, yes. But in response to RAI, GEH mentioned the long term, that when they use equalizing the line, how to insure that this is not an issue given the long term. For first 72 hours, yes.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. WAGAGE: There is a related open item coming from Section 6.1.1, which is on unqualified core rings, because I insist that we are going to -- according to the guidance, that debris screens had to be designed according to Reg Guide 1.82, Revision 3, that GEH has to consider unqualified core rings that are supposed to be damaged, and enter into the atmosphere and come off then maybe into the pool, so this open item is asking GEH to quantify it's unqualified core rings.

We have an open item on GDC 50. GDC 50 states that containment structure shall accommodate design leakage with sufficient margin containment pressure and temperated following a LOCA. When we saw that GEH calculated containment pressure, we found that pressure was gradually rising, and calculation stopped at 72 hours. When we looked at the results, there was no guarantee that after 72 hours the pressure would not exceed design pressure.

We asked General Electric to explain. GEH came up saying that there is a PCC pool refill after 72 hours using a FAPCS, that's supposed to solve the problem. We wanted some analysis. When we saw the analysis, we found only that PCC pool refill would not help. There was more need for other systems to be -- we did staff confirmatory analyses with MELCOR computer code. It confirmed the same. That was an issue after 72 hours, although the pressure stayed below design pressure within 72 hours, after 72 hours the issue would come up.

CHAIRMAN CORRADINI: So let me ask you about the MELCOR calculation. Does the MELCOR calculation also estimate radiolytic composition, or is that a separate calculation that's an input?

MR. WAGAGE: We use radiolytic gas production after we found that GEH used that. We had an --

CHAIRMAN CORRADINI: No. I'm asking once you did it, did you have an independent check of the rate?

MR. WAGAGE: The rate --

CHAIRMAN CORRADINI: Not use their rate, have somebody else go and do it to make sure they got the same rate?

MR. WAGAGE: The Office of Research --

MR. SNODDERLY: Handry, this is Mike Snodderly, NRC staff. I believe from our audit that took place in December of last year at GE, I believe GE said that they used the radiolytic source term that was in Reg Guide, the previous source term that was in Reg Guide 1.7 before it was updated as part of the 50.44 revision, it removed the radiolytic source term. So it's the one that was in Rev 2 of Reg Guide 1.7, I believe.

CHAIRMAN CORRADINI: Say that again slower. I don't think I got it.

MR. SNODDERLY: They used the radiolytic source term that was in Reg Guide 1.7, Revision 2, which told you how much radiolysis to consider in doing the 50.44 analysis. But when 50.44 was updated to eliminate the need for recombiners, because the risk was from the more bounding severe accident, that source term was then taken out of Revision 3. But that was my understanding of the source term that they used.

CHAIRMAN CORRADINI: So they use it from -- so let me ask a different question. So it's realistic, conservative, it's what?

MR. SNODDERLY: Conservative.

CHAIRMAN CORRADINI: How conservative?

MR. SNODDERLY: Again, I'm going by --

CHAIRMAN CORRADINI: Got six fans.

MR. SNODDERLY: I'm going by memory, but I believe it used a radiolytic factor of like .4, which is very conservative. It has to do with a number of factors, such as pH and other things, but it's a very -- it's a conservative bounding factor.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. SNODDERLY: But there is a basis for that source term. It's the staff. It was in a previous Reg Guide.

CHAIRMAN CORRADINI: But then just to --

MR. SNODDERLY: But no, it's not realistic.

CHAIRMAN CORRADINI: That's okay. But just to educate me, even though not realistic, it is the only basis that they can use?

MR. SNODDERLY: There is no guidance for that particular calculation. I mean, there was guidance, as I said, for calculating radiolysis when there was a 50.44. The new 50.44 doesn't require it. And, again, I'm speaking for GEH, and they can jump in when they would like to.

CHAIRMAN CORRADINI: You gave me the base -- you just told me --

MR. SNODDERLY: My understanding is they were looking for one, and that was one that exists, and they used it.

CHAIRMAN CORRADINI: Thank you.

MR. SNODDERLY: And we, of course, didn't have a problem with that one, because we understood it, and we knew it was conservative.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. WAGAGE: We have a policy paper, SECY 94-084 on RTNA system, figurative treatment of non-safety systems. According to this policy, advance reactors can use non-safety systems after 72 hours. That's what we saw in GEH's results that they're using non-safety systems after 72 hours.

The reason for this gradual increase of pressure is -- the main reason is that this is completely a passive containment cooling system, which is not -- which is of less capacity as compared to active system. Active system pumps start, and they dump water into the core, and also containment space coming and drop the pressure. But passive containment cooling system, depend on how much steam is produced in the core and then removed. That's one reason.

Second reason is that containment suppression pool bypass. I'm going to talk about more on suppression pool bypass later. Because of these two reasons, contain pressure was rising, this was the first time we have seen that containment pressure was rising at the end of the calculation. Other advance reactors calculated contained pressure, but they were lower because of the active systems coming in, and this was the first time, so we were asking RAI on that one. We asked RAI 6.2-140.

We saw the GEH new results, that new results are encouraging. This new system, the PCC gas recirculation system has several advantages. One, the reason that contained pressure was rising more, that PCC was degrading because of accumulation of non-condensables, and non-condensables have to be purged into the wetwell. GEH -- this gas recirculating system, what it does is that it creates a flow path through PCC condensers by which it removes the non-condensables, then it increases the PCC efficiency and increase heat transfer. And because there is higher flow rate than before, that increases heat transfer coefficient, and it increases flow to PCC. And, more importantly, that bypass will not be an issue after this new system starts working at 72 hours.

CHAIRMAN CORRADINI: Pardon me. Can I ask a question about the first of the three effects?

MR. WAGAGE: Yes.

CHAIRMAN CORRADINI: You had in your SER - now I can't find it - but you had in your SER a table where you showed timing of the TRACG calculation versus MELCOR. Maybe it was just the MELCOR calculation. In the absence of radiolytic decomposition, does MELCOR show a turn-around, or just essentially reaching a stable equilibrium pressure?

MR. WAGAGE: We did not see turn-around, even we turn off radiolytic decomposition.

CHAIRMAN CORRADINI: But was it rising? I would expect --

MR. WAGAGE: Yes, it was rising. I mean, it was not the major reason. The major reason is that the bypass, I think bypass discussion come in the earlier presentation. What bypass does is that it continually leaks steam into the wetwell air space which pressurizes the wetwell air space. And all the other BWRs, including ABWR, this bypass is an issue only during the initial blow-down, because after suppression pool sprays come in and drop, condenses the steam, that then the active systems inject water into the core. The pressure is low. But in this case, the design of PCCS is such that it depends on purging of non-condensable into the suppression pool. For that we have to have a pressure gradient between drywell and wetwell to purge non-condensables. That's why this vent line is submerged, that pressure difference is equal to that pressure different coming from the vent line submerges.

Now in this case, because there is -- the PCC depend on these pressure difference for purge of non-condensables, that works against us. Now there is a pressure gradient between drywell and wetwell. That same pressure gradient causes bypass to continue during a low time period. That's why you see there is a pressure difference. Drywell pressure is slightly higher than wetwell pressure, that difference you see because of the submerging. So bypass is a major issue in this one.

CHAIRMAN CORRADINI: So it's not -- I'm sorry. It's not the radiolytic decomposition in terms of the MELCOR analysis, it's the bypass amount? So let me ask the question slightly different. If the bypass amount in the audit calculation with MELCOR, with TRACG if you had the same bypass, would you come to the same, essentially the same qualitative behavior? It may not be the same number, but the same qualitative behavior?

MR. WAGAGE: Yes. Our analyses confirmed that decomposition concludes in same, similar results like TRACG analysis of GEH.

CHAIRMAN CORRADINI: Okay. Because your answer with bypass seems to answer what the pressure level would end up at. It doesn't answer the rate to get to it. It seems to me in the absence of adding more non-condensable gas, with bypass all I do is essentially have a less efficient heat exchanger, which means the absolute magnitude of the pressure I get to would be different. It might be higher, or lower, depending on the amount of bypass, but I eventually would get to essentially a zero slope line; whereas, with radiolytic decomposition, I'm adding mass, which has continued to pressurize. So I understand your explanation, but for a different reason.

MR. WAGAGE: I think one important point missing here is that by bypass what you mean is that some steam bypassing the suppression pool water, and without condensing, getting into this air space.

CHAIRMAN CORRADINI: Yes.

MR. WAGAGE: If you do that, then steam keeps coming into this air space, and keep pressurizing. That's the reason the pressure was going up.

CHAIRMAN CORRADINI: Right, but just to push the point one last -- I've got all that water down there, so it's a different amount of heat exchange. It's less efficient than the PCCS, but I'm still condensing it on the water of the surface of the water. It's just a slower rate, so I come to a different equilibrium value, not to a different -- not to a continually increasing slope. See my point?

MR. WAGAGE: Yes. There is some condensation at the surface. That's significantly smaller than condensing in the pool. To find the effect of this, we assumed in our confirmatory analysis -- in one case we assume there is no bypass at all. In that case, what we found was that pressure would not go higher. It was going slightly higher and higher, but at much slower rate. The reason is that although there is no bypass, still there is effect of non-condensables affecting PCCS efficiency, reducing heat transfer rate.

MEMBER BANERJEE: Now, can you give me a

physical picture of how that bypass occurs, actually, what is happening? So the pressure in the drywell is higher than the wetwell.

MR. WAGAGE: Yes.

MEMBER BANERJEE: So there's some flow, which is a mixture of steam and non-condensables flowing in. Exactly where is it flowing in?

MR. WAGAGE: Okay. That's -- unfortunately, we don't show those vacuum breaker valves. The vacuum breaker valves are between drywell and wetwell. That's the main bypass path. And in addition to that, there may be some minor openings.

CHAIRMAN CORRADINI: Some what? I'm sorry.

MR. WAGAGE: Some small openings. We don't know where the openings, cracks, or whatever.

MR. UPTON: This is Hugh Upton with GEH. In our opinion, the most credible path is through the vacuum breakers.

MR. WAGAGE: Yes, I agree with that completely. I mean, that's the most credible, but there may be other flow paths. That's the point I was making.

MEMBER BANERJEE: Now, what is the physical dimensions of the space above the water level in the wetwell?

MR. WAGAGE: I have it somewhere in a later figure.

MEMBER BANERJEE: The vacuum breakers are right on top, they're not on the side. Right?

MR. WAGAGE: Yes, right on the top, and they are to be protected from hydrodynamic loads. There is another section, hydrodynamic loads, GEH has --

MEMBER BANERJEE: Whatever is seeping through them, mixture of non-condensables and steam, you are saying accumulating at the top, and not communicating very much with the water below.

MR. WAGAGE: Yes. There is no mixing in the wetwell air space. If you had wetwell space, then --

MEMBER BANERJEE: Well, clearly because steam is a little bit lighter than air, so it tends to --

CHAIRMAN CORRADINI: It's not going to unmix.

MEMBER BANERJEE: No, it's not going to unmix. And the temperatures are the same?

MR. WAGAGE: Same, temperature were --

MEMBER BANERJEE: Drywell and wetwell?

MR. WAGAGE: The air space, consider air space here is similar, not much different. But water is much lower than that.

VICE CHAIRMAN ABDEL-KHALIK: Perhaps GE can answer this. Order of magnitude, what is the tube side volume of the PCCS heat exchanger? Order of magnitude, not exact number.

MR. CHEUNG: This is Chester Cheung. The tube water into the warmer is about couple of meter, couple of cubic meter.

VICE CHAIRMAN ABDEL-KHALIK: Okay. So let's say 50 cubic feet. And you have -- if you put one of those vent valves running at 700 CFM, how long do you think it would take to pull any and all gas out of the tubes?

MR. CHEUNG: Now it takes some time to take it out, but remember that it's coming in back from the other end and recirculate. The non-condensable gas coming from the wetwell into the drywell because vacuum breaker open, and then they will find their way into the tube again. And then you eventually get your creeping point that the gas mixture going into the tube, a certain percentage, a certain mass fraction, and then stay there.

MEMBER BANERJEE: I think, Mike, we will

need to understand this. I do agree with you that we should do --

CHAIRMAN CORRADINI: Okay. Keep on going. We've confirmed something for ourselves. Thank you very much.

MR. WAGAGE: We will have to review GEH response. We are awaiting for GEH to respond to RAI 6.2-140 on GDC 50 use. You saw some results today. When we get the results, we will review that. We will continue our MELCOR calculation for long term, and confirm --

MEMBER BANERJEE: When will you bring in rough terms this understanding of this from the staff, and your communication with GE, to some sort of a position where we can look at it more or less in its final form?

MS. CUBBAGE: We'd be planning to come back to the Committee with the final SER about a year from now, maybe a little bit less than that. If there was a need to get into a lot of detail between now and then, we could schedule a separate Subcommittee meeting, but the intent on most issues is to come back with resolution at the final SER.

MEMBER BANERJEE: But to deal with some of these subjects in a Subcommittee meeting would be -

are we talking about three months, two months, one month, six months? What is the time scale?

MS. CUBBAGE: Not one month, probably something more like six months, three to six months.

MEMBER BANERJEE: Oh.

MS. CUBBAGE: I think coming back in a month, you wouldn't probably hear much more than you're hearing now.

MR. WALLIS: Will you perhaps do some confirmatory analysis?

MR. WAGAGE: This is regards of confirmatory analyses. What you are seeing here is that sensitivity to contain suppression pool bypass. Remember that at three days, PCC pools refill, but this calculation we did not consider that PCC pool refill. That's why there is no change in gradient at three days. If you use one square centimeter, this is the pressure. That's the design value GEH used in its calculation.

VICE CHAIRMAN ABDEL-KHALIK: And what is the cause of the slope difference, rapid increase in slope at four and a half days?

MR. WAGAGE: This time, rapid increase is because of PCC pool refill, PCC pool boiling, because of boiling in the PCC pool, pool water level goes down and there is much less heat transfer.

CHAIRMAN CORRADINI: You're running out of water?

MR. WAGAGE: As I said at the beginning, this is not the way it's going to be operated. We assumed for this calculation for simplicity, there was no PCC refill. When PCC is refilled --

MEMBER BANERJEE: No refill of the PCC pool you are saying.

MR. WAGAGE: In the design, PCC pools are going to be refilled after 72 hours.

CHAIRMAN CORRADINI: Right.

MR. WAGAGE: There will be enough water after 72 hours, but we did not assume that condition in this calculation. That's why you see the -- there is no change in gradient.

MEMBER BANERJEE: That's just boiling in the PCC pool.

MR. WAGAGE: Yes. Water level coming down. As you are showing GEH results, so that there the pressure comes down right away, because that's one reason. Other one is that main system --

MR. WALLIS: The results are so sensitive to this very small leak.

MR. WAGAGE: Exactly.

MR. WALLIS: How are you going to measure it? How are you going to know what it is?

MR. WAGAGE: What we have this RAI on, that's an important question.

CHAIRMAN CORRADINI: Well, let's just take one line, the red line.

MR. WAGAGE: Okay.

CHAIRMAN CORRADINI: And then we'll stop torturing you. We're going to find another meeting to torture you on it. But at the red line, it looks like it's coming to some steady state, and you get these wiggles, and then there's a slope, and then there's another slope. So when we have the little wiggles, is that when we're starting to boil off? What's the wiggles?

MR. WAGAGE: Wiggles? Okay. We have Andre Drozd here.

CHAIRMAN CORRADINI: The wiggle explainer?

(Laughter.)

MR. DROZD: I'm Andre Drozd from Containment. The design value for the PCC pool is that at three days, the water level is going to go down to the top of heat exchanger tubes, so that's where you see how the two-phase level is dropping down and down. And that's the artifact of calculation, the water level is going up and down, and the area, transfer area is slowly diminishing.

CHAIRMAN CORRADINI: Okay. And then after the wiggles are done at 3.6 days.

MR. DROZD: Right. Just drying out. Just drying out.

CHAIRMAN CORRADINI: Right. Thank you. And that same sort of wiggling is just for seating to earlier times as we bypass.

MEMBER BANERJEE: You're not going to get off so easy. Go back to the previous slide, please, for me. Now you didn't do anything like GE did, like turning on these vent fans or anything to --

MR. WAGAGE: No, that came much later.

MEMBER BANERJEE: Okay.

CHAIRMAN CORRADINI: I think these MELCOR calculations were done many months ago.

MR. DROZD: I mean, those results are not submitted to us yet, and that --

MEMBER BANERJEE: Potentially, how -- if this is happening due to bypass, and I can see the mechanism you're talking about, I'm trying to think physically what happens if you turn the fans on, and you -- what does that do for you?

MR. WAGAGE: If you turn the fans on at

that time bypass really is not an issue, because by -- what that fan does, there is a T-connection from the vent line. There is a T-connection. It takes suction from PCC.

MEMBER BANERJEE: It just doesn't let it go into the suppression pool. Right?

MR. WAGAGE: That's right. Now what happens is that steam and water mixture -- because there's suction here, there is a T-junction. There is a fan operating. There's suction, and --

MEMBER BANERJEE: Just making a forced convection --

MR. WAGAGE: That's right, forced convection. And there is no pressure gradient now because the non-condensables goes back to the drywell. Again, it's recirculated. Stop this bypass completely when this system starts, so it's not an issue, but we have an issue before three days, before these systems come in. Then we have question how are they going to measure, how are they going to confirm that one centimeter squared assumed in the analysis is --

MS. CUBBAGE: This was an early calculation that was demonstrating, number one, the sensitivity to bypass, thinking also that there was a concern with the peak pressure that was calculated.

And now GE is addressing it, and we need to review that when it's submitted. I don't think we're going to get much more out of this right now.

MR. WAGAGE: This is sensitivity to bypass.

MEMBER BANERJEE: And, of course, it also is sensitive to the submergence of the vent line.

MR. WAGAGE: Because that bypass is going by that, too, so that gives the pressure gradient for the bypass.

MR. UPTON: Excuse me. This is Hugh Upton with GEH. I just want to put something in perspective about this leak rate. If you take a look at, say containment testing, Appendix J testing, if you have a .4 percent weight percent volume per day requirement on your Appendix J leak rate out of the containment, and that's your ELSA bay, you test at say .75 times ELSA bay. That actually is going to come out to, at a 45 PSIG leak rate, about 3 SCFM. Okay? Now we're looking at an acceptance criteria of .5 square centimeters. That actually comes out to be about 10.7 SCFM, so we believe that we have a test that's capable of, within the current technology, of measuring that one square centimeter leak rate.

CHAIRMAN CORRADINI: Okay. So you

actually have gone to where I was about to ask, which is if you really are looking at this as two attached containments, what's the equivalent of the leak rate between the drywell to the wetwell. You've got about a .15 bar delta P.

MR. UPTON: Right. The test that we're looking at using is actually pressurizing the drywell to just above the top horizontal vent, 2.2 PSIG. And that gives us an allowable leak rate into the suppression pool of about 10.7 SCFM. And, so, we know that based on the Appendix J instrumentation we can absolutely measure that.

CHAIRMAN CORRADINI: Thank you.

MR. WAGAGE: This table compares ESBWR bypass leakage to other BWRs. I have these wetwell free gas space, because it's important for bypass, because if the wetwell air space is larger, it can accommodate more bypass, more steam coming in before it pressurizes.

As you see here, that GEH used one square centimeter, assume one square centimeter bypass for analysis, compared to much larger values assumed by other BWRs.

The reason that GEH has to use smaller bypass leakage is that this bypass continues for a long duration. Other BWRs, bypass is short term issue, but in this case, it's a long term issue, continues for a long time, that's why have to use one centimeter square.

There is another important issue in this bypass. Because bypass is assumed in the safety analysis, we did that -- SRP guidance is that bypass has to be confirmed by surveillance testing. It's in tech specs. So far, the staff has accepted the lowest bypass surveillance testing value of around 3 square centimeters. There is SRP guidance to say that what the surveillance criteria has to be one-tenth or 10 percent of the value assumed for the analysis.

Operating BWRs have satisfied that requirement, that guidance. ABWR you're going to see that the value assumed for the analysis is same as the value assumed in the surveillance criteria. The reason is that ABWR has safety-related suppression pool sprays. If there is a need, then operator can activate safety-related suppression pool gas, suppression pool sprays. If they use suppression pool sprays, then this ABWR can accommodate 50 square centimeters. That mean that what is measured is one-tenth or 10 percent of what ABWR can accommodate.

The ESBWR is different. When we see in

the DCD that GEH was proposing to measure two square centimeters as the surveillance criteria, which was not acceptable to the staff, because the reason for the surveillance test is to confirm what was assumed in the analysis was correct. But there is no point of measuring higher than that value, and there is nothing to confirm. MR. WALLIS: How does that work? You want to be sure you've got one, you measure two?

MR. WAGAGE: That's for the proposed value. To be consistent with all the other operating reactors, what the SRP guidance, is that surveillance criteria has to be 0.1.

CHAIRMAN CORRADINI: What is the AB -- I understand column one and column two for the current operating ones. What is the ABWR, it's five and five? And that's acceptable to the staff?

MR. WAGAGE: Staff accepted that five and five, based on this reason, because ABWR has safety-related sprays in the wetwell. I mean, the pressurizer operators can activate safety-related sprays in the wetwell, and pressure comes down.

By analysis, showed that if ABWR used 50 square centimeter bypass and sprays, then you maintain under design pressure.

CHAIRMAN CORRADINI: And that's why you

accepted it as measuring -- testing for five, versus having a design that gives you five.

MR. WAGAGE: Yes, that was the reason staff accepted five and five, but for all the other operating reactors we have accepted 10 percent.

MR. WALLIS: Are you proposing to accept two for the ESBWR?

CHAIRMAN CORRADINI: No. That's just what he said.

MR. WAGAGE: GEH was proposing to the staff, the staff made clear that --

MR. WALLIS: You want .1, don't you?

MR. WAGAGE: We want .1, and --

CHAIRMAN CORRADINI: Don't agree with Professor Wallis. He sucked you in there.

(Laughter.)

CHAIRMAN CORRADINI: Let's just stick with the five and five for the moment, and understand that.

MEMBER BANERJEE: Under discussion.

CHAIRMAN CORRADINI: Under discussion.

MR. SNODDERLY: Yes. This is Mike Snodderly. I think the feedback to GE was that the two and the one would be unacceptable. But I think as they've said, and this is the first that we've formally heard that, but if one were to pose one and

.5, first of all, the expectation is that at least what you're testing to would be less than what is in the design basis. But the .1 is guidance in the SRP section. I think you can see that right now you're starting to get down to the physical limits, and then number two. But we would probably be willing to give some latitude to .1, knowing that this is an extremely low leakage containment.

MR. WALLIS: Aren't you concerned about a design which requires such a very small leakage in order to work? Doesn't that give you some concern?

MR. UPTON: This is GE. Can I respond?

MR. SNODDERLY: Yes.

MR. UPTON: This is Hugh Upton with GEH. This design has -- we've always known that this was a key type leakage rate, bypass leakage rate, and so in SBWR and ESBWR we've done a significant amount of work to try and minimize all of the leakage paths across the diaphragm floor to maintain a leakage rate at lower than one square centimeter. The entire vacuum breaker test and development program, which was done on SBWR, was extremely successful. And we can go into the great detail of what testing was actually done on the vacuum breaker.

But let me say this, that of the three

vacuum breakers, what we tested, and this is tested after blowing -- after 3,000 cycles thermally, radiation, seismically aging the valve, blowing four pounds of sandblasting grit into the valve that had been coated with oil to make sure that the bearing surfaces would stick. We tested the valve leak rate, and it was less than .02 square centimeters. Okay? That is after 3,000 cycles, so we have confidence that the vacuum breaker itself is an extremely reliable component.

As-built, the vacuum breaker leakage rate was bubble tight .00002 square centimeters. In addition to that, what we've done is we've committed to having an isolation valve in series with the vacuum breaker that will be bubble tight. So if there is indication of a failure of the vacuum breaker, or leakage of the vacuum breaker, based on logic, the isolation valve will shut that vacuum breaker.

The design as it stands today is N minus 2. We can fail two vacuum breakers, and still operate, and still have sufficient relief capacity, so we've done what we've tried -- by design, we've tried to make sure that that bypass leakage is achievable.

MR. WALLIS: You say fail, you mean they fail to open, they fail to --

CHAIRMAN CORRADINI: No, failed by bypass leakage and then isolate.

MR. UPTON: Yes. Right.

CHAIRMAN CORRADINI: So let me ask, or just let me put it in perspective. I guess the one thing, Graham, that I was trying to do as a calculation is that at one square centimeter, that's about .75 percent per day leakage as if this were a containment boundary, which is, as I understood, is in the ballpark of what you require, anyway, in terms of continue leak rate, of .5 percent per day? Isn't that what I remember seeing in the, not the DCD, but in the SER in terms of the limit?

MR. WAGAGE: .5 is the design leakage --

CHAIRMAN CORRADINI: Okay. Go ahead.

MR. WAGAGE: To put in perspective, ESBWR assumes one square centimeter leakage, that during the surveillance testing the acceptance criteria has to be fraction of that, that we have not seen that proposal yet.

MR. WALLIS: Are these vacuum breakers just pieces of chopped up metallic insulation?

MR. UPTON: Again, this is GEH. Let me address that.

CHAIRMAN CORRADINI: We're going to have

that at the end. There's an expert, I am told, in the audience. Let's get through this, and then we'll get to the vacuum breaker.

MEMBER SIEBER: There's also a drawing of it, it's 6.2, and it's on page 221.

CHAIRMAN CORRADINI: Yes.

MEMBER SIEBER: Looks pretty reliable to me.

MR. WALLIS: Did you test it?

MR. WAGAGE: You have seen this figure from actually a GEH chart, this is up to three days, GEH showed longer time, that the first period up to three days, you have seen the same one in these presentations.

Okay. Let's go back. I want to make one point on that figure, that you see that drywell pressure is higher than the wetwell pressure. This is pressure difference in the drywell and wetwell pressure, it is driving the bypass. Okay. Let's go back, go to the next one.

We have an open item on GDC 38. GDC 38 requires containment heat removal system, system safety function shall be rapidly reduce containment pressure and temperature after loss of coolant accident, and maintain at acceptably low levels.

During the initial phase, just after the blow-down steam is condensed in the wetwell, the pressure comes down, but after that, pressure starts rising, and pressure continue to rise. That mean that although it's dropped the pressure initially, it did not maintain at acceptably low level. It was going to pass, the pressure was going to pass the design pressure later on, unless more systems are created after 72 hours.

For first 72 hours, this is something that the feature of the PCC, PCC cannot remove significant -- rapidly like active systems. Because of the advantage of having these completely passive system, that GDC 38 not satisfying, were not dropping off within 72 hours. But after 72 hours, other systems can be used, and pressure can be dropped. But as you saw today from GE's results, that it's encouraging that PCC gas recirculation system and other systems GE is going to use, that GDC 38 will be addressed.

CHAIRMAN CORRADINI: So I think I understand your explanation, but I'm still curious, so you want them to put in the -- because I read the back and forth between the licensee and the staff, to put in an isolation valve to the PCCS.

MS. CUBBAGE: You know what, I think we

got a little confused here, because Handry was speaking to a different issue than what's behind him there.

CHAIRMAN CORRADINI: Oh.

MS. CUBBAGE: I don't think we're on to this issue yet. Right, Handry?

MR. WAGAGE: Oh, okay.

MEMBER BANERJEE: He's still talking about GDC 38.

MS. CUBBAGE: Drywell gas recirculation, yes.

MR. WAGAGE: Oh, that's coming next.

MS. CUBBAGE: All right. You want to move on to this issue now, Handry, please?

CHAIRMAN CORRADINI: Yes, that would be good. Let's move on to this issue.

MR. WAGAGE: Okay. Next one, we have an open item on PCCS isolation. PCCS system is an advanced system. It starts operating immediately after LOCA. There are no valves to open, and there is no need for electric power, no need for operator action. It start right away. But the downside is that PCCS is a penetration in the containment, as you see here. There is one pipe penetrating to take --

CHAIRMAN CORRADINI: Now, if I could just stop you. It's penetrating the containment, or it is the containment?

MS. CUBBAGE: That's the issue.

CHAIRMAN CORRADINI: I guess I'm still trying to understand that, because I read the back and forth from the staff and the licensee, and somehow I tend to fall with the left.

MEMBER MAYNARD: Several plants have a similar deal where basically, a penetration, you have a pipe that penetrates the containment, but that pipe becomes the containment.

MEMBER BLEY: It would be nice to see a detail of that connection. That's what you'd like, Mike.

MR. WAGAGE: I'm coming to that.

CHAIRMAN CORRADINI: Okay. Sorry.

MR. WAGAGE: Right now --

CHAIRMAN CORRADINI: The way you gave the preliminary discussion got me a little bit nervous.

MR. WAGAGE: Maybe have some patience.

CHAIRMAN CORRADINI: That's okay. Go ahead. I'm sorry.

MR. WAGAGE: As you see, there are three penetration in the physical containment boundary. We ask the -- according to our GDC 56, that there are penetration, and penetration has to have isolation valves. We asked GEH in an RAI.

MR. WALLIS: So you have to isolate the inlet and the outlets.

PARTICIPANT: Which defeats the purpose, doesn't it?

MR. WAGAGE: According to our GDC 56, penetrations have to have inside and outside isolation valves, that mean there are three penetrations, there has to be six isolation valves. That is GDC 56. Then GEH came up with an argument, although this is the penetration in the physical boundary, that it is closed system. And PCCS is designed to significantly higher design pressure than the containment, and GE came up with an idea that all this -- extend the containment boundary, and include that as part of the containment boundary.

MEMBER BANERJEE: It makes sense, because if you close those isolation valves, you'd lose your heat sink.

MR. WALLIS: If it's got a hole in it, too.

MR. MARQUINO: This is Wayne Marquino of GEH. I'd like to admit that in our initial submittal, it was unclear whether this heat exchanger was part of the containment, with some places we said it was extension of the containment. Our intent always was to apply the same structural codes that apply to the primary containment to evaluations of the PCC heat exchanger.

As one of the members pointed out, we have containments like the MARK II, that have a pretty complex structure, and the ducts that come off between the drywell and wetwell, we feel this is analogous to that.

There is an existing RAI on this, so that was our latest response to the staff. And we've had discussions with them since then, where they've asked us to provide a risk-based evaluation of putting isolation valves versus not -- isolation valves versus no isolation valves. Our PRA group is in the process of responding to that.

CHAIRMAN CORRADINI: So let me ask you then, since you are taking this route to discuss it, are these automatic isolation, or manual isolation? What are these valves? If they --

MR. MARQUINO: Since we don't have valves --

CHAIRMAN CORRADINI: All right. And I apologize, I turned to you.

MR. MARQUINO: GEH --

CHAIRMAN CORRADINI: Are these automatic isolation valves that concern you, or manual isolation valves?

MR. WAGAGE: There are no isolation valves at all right now in the design.

CHAIRMAN CORRADINI: Yes, I know that, but in my mind, I mean I'll just say what I'm thinking, and then you can get mad at me later. This is crazy. Right? You don't want to put a valve right where you have your only method of heat loss, heat sink, so what's the staff thinking here?

MR. WAGAGE: The purpose of isolation valve is --

CHAIRMAN CORRADINI: Sorry to say it so bluntly, but --

MR. WAGAGE: The purpose of isolation valve is to be able to isolate if there was failure in the system, if there is a failure of the valves or drop off, there will be -- if there's a failure in the system, then --

VICE CHAIRMAN ABDEL-KHALIK: What kind of signal would allow you to detect that and actuate those valves?

MR. WAGAGE: The idea is that there are

valves, if there is a need, then the system can be isolated. But as GE --

VICE CHAIRMAN ABDEL-KHALIK: I'm sorry. I don't think you answered my question. Let's say the applicant complies, how would an operator detect the need to actuate those valves?

MR. WAGAGE: Operator --

VICE CHAIRMAN ABDEL-KHALIK: Obviously, those valves would be normally open to maintain this heat sink function.

MR. WAGAGE: Yes.

VICE CHAIRMAN ABDEL-KHALIK: So how would one go about detecting, ascertaining the need to close those valves?

MR. WAGAGE: There has to be other measurements, there is the need that --

VICE CHAIRMAN ABDEL-KHALIK: Sensors in the pools?

MEMBER MAYNARD: Well, typically, you probably have radiation monitors or other things in the area. You'd have other indications that would say you had some type of containment leakage during an accident. I think what they're really trying to deal with here is how do they show compliance, or how do they justify compliance with a general design criteria, and does it need to -- and I do think that there's other precedents already set out there for addressing these types of issues. And I think we need to be careful that we don't force somebody to do something that is less safe, just to be --

MR. SNODDERLY: That's exactly the gray issue that we're trying to deal with. If you look at the ANS standard 45.2, it clearly says that -- the way it defines a closed system outside containment, one could interpret that this meets that definition, i.e., penetrations that are welded to containment, and return fluid back to containment. So it meets the definition of the standard that says you shall have at least one isolation valve.

Now the normal configuration that people are used to seeing is the pool is inside containment, so you have at least one isolation valve outside containment. This one is flipped around. Okay? So one could interpret the standard that you should have at least one isolation valve inside containment, but it would be to the applicant to determine how it should be shut.

If you're asking the question, then it would be, I would assume, remote manual, but that would be for them to decide. But, again, we have a standard that clearly says a system, a closed system outside containment that penetrates should have an -- if it returns fluid back to containment, should have an isolation valve.

MR. WALLIS: Should have?

MR. SNODDERLY: Should have, should. But we also are acknowledging -- so, for example, isolation condensers have had -- do have these isolation valves, and this design proposed I believe also has isolation valves. Okay. But, as was said before, you have high pressure fluids, here you don't, so, again, it's a gray area, but we have a question. We'd like to understand. Another thing that could justify it would be looking at what's the likelihood that you would have a failure of containment, and the one I was postulating was in that pool region, say someone were to drop a heavy load on the exchanger and damage a tube, but then you could have certain precautions that would prevent such a heavy load during operation. But things like this that can reduce that likelihood, to say -- so those are the types of arguments that we're trying to develop and justify.

CHAIRMAN CORRADINI: So let me try one on you. So why, if this is containment, not a system welded to containment, but containment, why can't it be part of the normal integrated leak rate test, and use that as the service inspection method to determine if they're above their integrated leak rate on a continuing or surveillance basis. They can then find out where it is. But if it is containment, isn't that the surveillance, or the periodic test that one would use?

MR. SNODDERLY: Right. So, periodically, they -- they don't have the diagram up there now, but the one that they did have up for the PCCS, you can see there's some temporary connections for doing pressurizing the PCCS to verify.

Of course, the problem there is, if you do your test, and you don't know how thick the -- and let's say there was corrosion going on, you do a test. It appears that it's pressurized, but you only have a small amount of material left, so that's one. But, again, the fact that you were doing that test every couple of years, yes, would give you some assurance.

CHAIRMAN CORRADINI: That's an economic issue. If they want to take the chance that they have to shut down the machine and fix containment, I mean, if it was a large dry, and I didn't make the leak rate, I don't go back up to power until I find the leak, and fix the leak, and that's it.

MR. SNODDERLY: Right, but it would be a 303 concern.

MS. CUBBAGE: I guess on this one, I'd like to just close by saying we've asked them to justify their current design. We haven't told them one way or the other that it's required.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. SNODDERLY: It's an open item. We've made you aware of it, and it's something that we have to resolve.

CHAIRMAN CORRADINI: That's helpful. Thank you so much.

MR. WALLIS: Well, is it up to you to decide, or is it possible this --

MR. SNODDERLY: Well, as Otto said, we have a GDC, and we have an ANS standard, so we're going to have to reconcile that.

MR. WALLIS: I think the man on the street might say it's not containment. It doesn't look like containment. It's piping and stuff.

MR. SNODDERLY: Yes. And that's --

MR. WALLIS: It doesn't look like containment at all.

CHAIRMAN CORRADINI: We're beyond this

one. Move on.

MR. WAGAGE: We have an open item on very fine containment of concentration. ESBWR containment is inerted by regulation, inerted mean that oxygen concentration in the containment has to be less than 4 percent. 10 CFR 50-55(c)(2) for advance reactors, state that these containers do not require inerted containments to provide methods to control combustible gas, because containment is inerted, there is no possible combustion.

Containment has flammability control system that is PARS, part of catalytic converters. There are monitors for hydrogen and oxygen in the containment. However, that oxygen monitoring, the confirmation is not in the tech spec, it's in availability controls manual. Once it's not in tech spec, there is less regulatory control because the assumption is that containment is inerted, it's less than 4 percent oxygen in the containment, but there is no verification unless it's in the tech spec. We have an open item asking GEH to have verification of oxygen concentration in the containment.

MR. WALLIS: This radiolytic generation after an accident, surely radiolytic generation is going on all the time while the reactor is operating at a higher rate, isn't it, or apparently the same rate, or something. It's not -- and that is on the control. There's not that much, is there? It seems to be such a small amount compared with the volume of the containment.

MR. WAGAGE: I think during that time that for clean up system removes that --

MR. WALLIS: But it's not that much, is it?

MR. WAGAGE: I don't know the number, how much.

MR. WALLIS: If it's enough to cause a fire in containment, then I don't see how they could handle it during normal operation. It would be much too much, wouldn't it?

MR. UPTON: This is Hugh Upton of GEH. We have a separate system called the off-gas system that deals with during normal operation --

MR. WALLIS: There's not that much gas, is there? There's no huge flow which would really -- if went into the containment, would enable a fire to occur there.

MR. UPTON: I would have to take a look at the design specification. I don't remember how much gas actually is generated.

MR. MARQUINO: Well, the flow is mainly condenser leakage, air that's leaking in from the condenser is processed by the off-gas system, and there is some hydrogen and oxygen generated by radiolytic gas. I don't know that we can -- that we've measured --

MR. WALLIS: But there have been explosions in BWRs gathering this gas and not venting. But it takes months to gather enough gas in a pipe which isn't very big in order to make an explosion, so there can't be very much of it being made. Why is there suddenly a great concern with an accident that you're going to make a lot more of it? It doesn't make any sense, just by radiolysis.

MEMBER BANERJEE: TMI got it in a different way. Metal water --

PARTICIPANT: That's different.

PARTICIPANT: It's a bigger generator.

(Off the record comments.)

MR. WAGAGE: During an accident, this adds into other pressurization from bypass and not removing heat from the containment. This adds on, it keeps on going, that may be reason.

MR. WILLIAMS: Okay. We still have one more presentation to go.

MEMBER ARMIJO: During an outage, you open up that containment, get a lot of air in there, and then when you button it up and go back, you've got to do something to verify you've got an inerted containment.

MS. CUBBAGE: Yes, they do. The question is whether it's in tech specs or not. It's just a matter of a tech spec. This is not a big technical issue.

MEMBER ARMIJO: Okay.

MR. WILLIAMS: I just wanted to make sure we didn't mislead Dr. Bley in his question about cleanliness. Right now, what the DCD says is that the GDCS pool will have a stainless steel liner, will have a screen, and will have a temporary strainer to prevent debris getting into the system, but it would be removed prior to start-up, and there would be no strainer. But they have not committed to Reg Guide 182, Rev 3 for the GDCS pool. We have a question concerning the -- meaning Reg Guide 182, Rev 3 for the suppression pool, and meeting the bullets in 95-02, but it's not clear that that -- how that applies to the GDCS pool, because it is unique. So I just wanted to make sure that that was clear, and perhaps GE can respond to you about their plans concerning cleanliness for the GDCS pool. But right now in this revision, there is no commitment for that in the GDCS, except what I just laid out.

MR. WILLIAMS: Now Weidong Wang is going to go over Chapter 6.3.

MEMBER BLEY: Let me raise a question, Mike. Given what you just told me, how do you folks convince yourself whether or not there might be a problem with debris?

MR. SNODDERLY: Well, I think as Handry said, there are some very key differences between this design and the problem we're trying to solve, and have solved for operating BWRs. Debris falls down or transfers into the suppression pool. Here you have an elevated release and a screen that prevents debris from going in. And, also, there's -- we don't anticipate as much maintenance or communication into the GDCS pool where those sources would come from. And it does have a stainless steel liner, so it's just a different system.

Now, I do believe that in pursuing this issue with the suppression pool, we will also want to know about cleanliness programs. I just wanted to say that we -- I think we gave you an impression that there will be one. Right now in the DCD there is not a formal commitment for the GDCS pool, but there are some unique differences. But I do believe that it's -- it's mainly gravitational settling. Right. The high elevated release, there is a screen to prevent the debris. And I think we also said that the diameter was one inch. The diameter is an inch and a half, and I think we're also -- so although a formal calculation in accordance with Reg Guide 182, Rev 3, it's not being performed to determine the amount of debris, it's transport and how it would get into -- I think there is a concern about downstream effects, and I believe that Jim Gilmore in Chapter 4 has asked an RAI concerning the filters for the fuel, and whether that debris would be a problem or not, so we're going to be pursuing that coordinating with Reactor Systems.

MR. WILLIAMS: You're up, Weidong.

MR. WANG: My name is Weidong Wang. I'm going to present Chapter 6.3. This section is also contributed by a team, George Thomas and Veronica Wilson, and also from Offices of Research. I'm kind of tired.

(Laughter.)

CHAIRMAN CORRADINI: That's okay. We have a lot of time tonight. Don't worry.

MR. WANG: Basically, we will go over a

little bit about the regulations, and also talk about SER topic of interest. And, again, significant open items, and answer questions.

So I'm not going to go into detail of these federal regulations, and also our review guidelines. This is a list for the LOCA.

Now for the ECCS system, this is a summary of what components for the ECCS system, basically, automatic depressurization system, which include SRVs and the DPVs, and safety relief valve, isolation condenser system, and also standby liquid control systems all went discussion in the past ACRS meetings. And gravity-driven cooling system is also part of the ECCS. And for DPV, which Jerry already went over, went through, and staff currently is reviewing a test report for this DPV.

Number four, GDCS check valve, that was changed from biased open to normal open. And the check above design is an open item. Basically, staff is concerned about what about more function, say opposed to the not open, but it's open during the LOCA, and that that might backflow through the check valve.

And also for GDCS open items, ITAAC-related, we would like to check the as-built nozzle throat lengths to be verified against TRACG input, because the --

MR. WALLIS: This is for critical flow, or what is this?

MR. WANG: Yes, check for the critical flow. And also for loss of -- flow loss coefficient needed to be verified by test against the TRACG input. Basically, we would like to make sure what as-built the same as what the TRACG input.

Staff verified all RPV penetrations, and accepted GE's eight break flow locations. In the DCDG submitted four break locations for main steam line break, gravity-driven line, cooling system line break, bottom drain line and the feedwater. And they have an extra, another four breaks, which is isolation --

MR. WALLIS: Is the bottom drain line the only line that's below the core level?

MR. WANG: Yes.

MR. WALLIS: It's the only one, is it not?

MR. WANG: Yes. And one open item is staff is asking GE to perform standby liquid coolant steam line break, and GE has revised Rev 3 under Rev 4. I don't see where this break was analyzed, so this is one open item. And for the single failure selection, basically federal regulation applies, ECCS functions accomplished with a single failure. And the staff found that GE basically considered all the systems connected to RPV, and the staff verified GDCS valve and ADS SLC and isolation condenser, they can break, bottom drain line break, and the control rod hydraulic control unit. And the final --

MR. WALLIS: But not a break of the PCCS itself?

MR. WANG: Not break of the PCCS, they are not --

CHAIRMAN CORRADINI: You're seeing PCCS or isolation condenser?

MR. WALLIS: No, a LOCA followed by a PCCS tube break.

MR. WANG: PCCS is a low pressure system, and it's very --

(Off the record comments.)

MR. WALLIS: This is a conceivable failure.

CHAIRMAN CORRADINI: It's in the PRA.

MS. WILSON: Hi, Dr. Wallis. This is Veronica Wilson. The regulations only require a single active failure, so we weren't allowed to break that, but it would be an interesting simulation.

CHAIRMAN CORRADINI: That was a cast off.

Nicely done.

MR. WANG: Yes. Thank you.

CHAIRMAN CORRADINI: Nicely done.

MR. WANG: And the final selection of the single failure is GDCS squib valve. Now one SRV or one DPV single failure was selected. Other systems are GE designed basically failure proof.

MR. WALLIS: So another failure is when the isolation valve is closed by mistake. But now you've put it in, you run the risk of having an accident when it's closed. Someone left it closed for maintenance or something.

MR. WANG: And there is, I believe, a bypass valve, so once --

MR. WALLIS: There's another valve, yet another valve.

MEMBER BANERJEE: That could be closed, too.

MR. WANG: But we only consider one single failure.

MR. WALLIS: When in doubt, put in another valve.

MR. WANG: And the open items are basically when vacuum breaker fails to close, and by design from DCD, there's an isolation valve will be used. And the staff is asking for the design of this isolation valve, and also how this isolation valve --

MR. WALLIS: Now this vacuum breaker valve opens and closes several times sometimes, so you're going to have somebody open and close the isolation valve, as well?

MR. WANG: That's what we have as a question for GE to answer the design --

MR. WALLIS: I understand the vacuum breaker opens on demand, and closes on demand. Isolation valve you tend to just close it, and then leave it. The operator isn't going to be able to know when he should be opening and closing.

MEMBER BLEY: I think they said they can live with two of them isolated.

MR. WALLIS: So that's what they do, they just isolate it and leave it.

MEMBER BLEY: One would think so.

MR. WALLIS: I think that's what you have to do, yes.

MR. UPTON: Yes, we're looking at that. This is Hugh Upton with GEH. We can tolerate for a period of time an absolute failed open vacuum breaker, and when there's indication that you actually are -- you have a failed open vacuum breaker both from seat indication and the pressure response of the containment, then we would isolate it. But it is N minus 2, and we can live with one isolated.

MR. WALLIS: Do you know which one is failed?

MR. UPTON: The valve itself is designed with indication on the disk, we've got proximity probes on the seats, so we know when the valve is stuck open or off its seat. Okay? And then you'd also have some indication on containment pressure response. Those are equalizing --

MR. WALLIS: I think my question was what will tell you which one is failed.

MR. UPTON: But containment pressure response in addition with a disk off the valve seat would give you indication that you've got a failed vacuum breaker, because you've got -- yes, it would tell you which one it was, so you've got four probes on each one of the vacuum breakers.

CHAIRMAN CORRADINI: Let me just ask one other thing, because these are -- well, we're going to have -- well, maybe not ask now, because we're going to have somebody talking about this in detail at the end. Is that correct? Right? There is somebody, because I wanted to ask a little bit more about your surveillance mechanism.

MR. WANG: Okay. Another item, I think I just went through previous GDCS check valve failure. Basically, we would like to see if that fails, and what's the design of this check valve. And if fails, what's the consequence.

CHAIRMAN CORRADINI: But there's an upstream squib that has to open for discharge.

MR. WANG: Right.

CHAIRMAN CORRADINI: So your worry is what?

MR. WANG: After the squib valve open, the check valve didn't function as it is, what about it's open also, and then flow will go back through the -- RPVs are pressurized.

MEMBER BANERJEE: Doesn't act as a check valve.

MR. WALLIS: It gets stuck.

CHAIRMAN CORRADINI: Leakage once the squib opens. Okay. Thank you.

VICE CHAIRMAN ABDEL-KHALIK: Have you looked at possible failure loss of nitrogen in combination --- as the single failure in combination with a LOCA?

MR. WANG: Loss of nitrogen --

VICE CHAIRMAN ABDEL-KHALIK: So that the water in the isolation condenser system would actually end up inside the vessel, and the total inventory that would be released into the containment would increase, so that your total containment pressure would be higher than the calculated value.

MR. WANG: So then what's --

MS. CUBBAGE: I think it's assumed that the liquid in the isolation condenser does go into the vessel.

VICE CHAIRMAN ABDEL-KHALIK: It does?

MS. CUBBAGE: Yes. That's part of the inventory that's assumed in the calculation.

MR. WANG: TRACG was used for this LOCA analysis by GEH, and this slide basically talk about a few selected input parameters. For the bounding calculation, the power is like 2 percent higher, plus 2 percent for this designed power, which is considered consistent with SRP. And we look at the maximum linear heat generation rate, and also we look at the actual power shapes, which is not important for this LOCA, since from the calculation we didn't really see core uncover, so power won't -- cladding was not where the heat up, so we would just use the one power shape.

MEMBER BANERJEE: You mean that there was no dry out anywhere in the core.

MR. WANG: No dry out is what the calculation show.

VICE CHAIRMAN ABDEL-KHALIK: I would like to just verify what Amy said. Does GE agree with what Amy said, that in the event of a LOCA, that all the inventory in the isolation condenser system will end up inside the vessel, and eventually gets into containment?

MR. MARQUINO: Yes, we agree.

VICE CHAIRMAN ABDEL-KHALIK: Thank you.

MR. WANG: And for the initial stored energy, we have an open item, which we asked GE to justify the use of the simple conductivity model they used.

MEMBER ARMIJO: Is there any difference between this model and previously used thermal conductivity model?

MR. WANG: Previous model I believe they used from the PRIMUS-II code, and that code was approved by NRC. And later, GEH, they used a later version of the TRACG, and they used the conductivity models from Time Code 4, which was not approved by NRC, so we asked --

MEMBER BANERJEE: Do you have a comment,

Veronica?

MR. JUNGEE: Yes, this is Nahim Jungee from GEH --

MS. WILSON: This is Veronica Wilson. It's correct in principle, but it was the JESTER M code that's always been used with previous LOCA analyses, and GE is using the PRIME III for the thermal conductivity, so the staff just asked them to justify that.

In addition, there was some mismatch of the models, because they used the gap contents from JESTER M, and that's a very coupled process, so the staff was interested in finding out how GE justifies the use of two different codes to calculate thermal conductivity and then gap contents.

MR. JUNGEE: Let me respond to that. This is Nahim Jungee again from GEH, and talking about the thermal conductive model in PRIME and JESTER M, the difference is we have modified the thermal conductivity model to account for the expositive index, which is reflected in the PRIME model. JESTER model didn't have that expositive index in the thermal conductivity model. That has been addressed in the Part 21 evaluation, what are the consequences of not having the expositive dependency. I think staff mentioned that. Going back to the gap contents issue, we look at the impact of gap contents if you change the thermal conductivity model, I think the impact is very negligible, so that code, if you use that gap contents from either code, should be -- the impact should be similar, no impact, basically.

MEMBER ARMIJO: So, basically, the thermal conductivity model has been --

MR. JUNGEE: Updated.

MEMBER ARMIJO: -- approved for burn-up effects.

MR. JUNGEE: Yes.

MEMBER ARMIJO: That has not been reviewed by the staff. Is that correct?

MS. WILSON: Currently under review.

MEMBER ARMIJO: Pardon?

MS. WILSON: You're correct, but it is currently under review.

MR. WANG: The PRIME code has been submitted to staff review.

MEMBER ARMIJO: Okay. Thank you.

MR. WANG: Okay. For the control rod insertion, basically, it is factored into the decay heat curve. This was selected into the assumptions. Summary of this ECCS LOCA analysis, basically, you all see this, all calculations show that the core remains covered with water. And from GE's submission, we saw that the minimum water above the top of active fuel is 1.447 meter.

MR. WALLIS: Can somebody tell me in this -- some of these LOCAs, there's a mention of the spill-over hole. I don't know what a spill-over hole is.

MR. WANG: Okay. I believe this is --

MR. WALLIS: Oh, I thought it was something to do with the vessel.

PARTICIPANT: He needs the microphone, Shawn.

MEMBER BANERJEE: Repeat what you said with the mic.

MR. WALLIS: Well, he pointed to it, so that did it. You can't do that with a mic.

MR. WANG: I'll use this. This one is the spill-over hole. Basically, when you have a lower kind of break, and the water eventually will fill, reach that level, and --

MR. WALLIS: Oh, that explains it. Thank you very much.

MEMBER BANERJEE: Now this seems very high precision on the --

(Laughter.)

CHAIRMAN CORRADINI: Let's just keep on going. He's just trying to tease you. VICE CHAIRMAN ABDEL-KHALIK: Based on the results that were presented by GE, it looks like the smallest vertical channel in their model was a 4 by 4 bundle, and there were two of them. But does that give you enough resolution to look at what happens in the hot channel, in the hot bundle, excuse me?

MR. WANG: So you are talking about the nodalization for the --

VICE CHAIRMAN ABDEL-KHALIK: Radial --

MR. WANG: Radial numbers?

VICE CHAIRMAN ABDEL-KHALIK: Yes.

MR. WANG: I believe, Veronica can correct me, we have done some sensitivity studies, and we noticed that basically from the sensitivity study with different ring, or different nodalization, we found it's acceptable.

MS. WILSON: I'm sorry. I wasn't entirely sure. What was the question again?

VICE CHAIRMAN ABDEL-KHALIK: The question pertains to the adequacy of the radial nodalization, and whether the fact that the smallest radial channel was a 4 by 4, essentially super channel. And the question is whether that gives you enough information on the performance of the hot bundle.

MS. WILSON: Yes, Weidong is correct. During the pre-application phase, they study this in great detail, and I don't know if there's anybody in the audience from that part of the review, but they did look at the different nodalization schemes, and it was actually -- they originally did not have the 4 by 4 smaller bundle, but after a few nodalization studies, the staff actually found that to be the most conservative way of measuring the minimum level. Because they found if you just assume a bunch of hot channels underneath like these larger rings that they had put in, that you end up getting this kind of drafting effect, and then it turns out to be actually less conservative, so that's why they had to switch to the smaller bundles.

VICE CHAIRMAN ABDEL-KHALIK: Is that information documented somewhere?

MS. WILSON: Yes, it is. It's in NEDERC 33083P-A, and it's in the appendix to that document.

MS. CUBBAGE: I believe that was provided to you all.

MS. WILSON: Yes. It was actually listed in the RAI section, because the staff asked that RAI during that review, so there's a detailed RAI response from GE discussion, and a kind of a back and forth from the staff on what was done to find the minimum, most conservative minimum --

VICE CHAIRMAN ABDEL-KHALIK: Thank you.

MR. WANG: Thank you for the confirmation, Veronica. You see why I bring her here.

CHAIRMAN CORRADINI: You brought her, or she agreed to come?

(Laughter.)

MR. DONOGHUE: I should have never let her leave the branch, basically.

PARTICIPANT: Why did you?

(Laughter.)

MR. WANG: Okay. So let's come back to this summary of this LOCA analysis results. GEH has concluded most limiting breaks are main steam line break, and the gravity-driven line break, and we have an open item. From GE's II response, which they had additional four LOCA analyses, and we found isolation condenser return line break looks like the number is smaller, and we are just asking them to clarify.

This is a summary of what GEH had obtained the results. The left column basically is all breaks, and EQL means equalization line break. I'm not going to read the rest of them.

MS. CUBBAGE: And those are all above vessel zero.

MR. WANG: And, also, in the middle is like single failures, one DPV or one GDCS injection line, or one SRV. And that open item we just basically asked from this reading, we saw the isolation condenser return line break looks like --

MR. WALLIS: When you give these areas, are these double-ended for some of these breaks on single and otherwise, depending on how they're connected? There's the total area of the break, or does it? It says break size. Is this the total area?

MR. WANG: It should be break area.

MR. WALLIS: Aren't some of them double, and some single, depending on how they're connected to things?

MR. WANG: I don't know if it's --

MR. MARQUINO: Dr. Cheung indicated it's single area. We don't have things like a recirc loop, where we break a pipe and we get flow from both directions.

MR. WALLIS: But they're all single area.

MR. MARQUINO: Yes.

MR. WALLIS: Okay.

PARTICIPANT: So I guess I don't understand the logic of what concerns you about the ICR. Can you explain again? I'm sorry.

MR. WANG: Okay. Basically, if you look at this number, the GEH, that ICR with one GDCS break is nine point zero zero --

MR. WALLIS: Lowest.

MR. WANG: And this one --

MEMBER SIEBER: And top of active fuel is how many meters?

MR. WANG: Top of active fuel --

MR. WALLIS: Around seven and a half.

MR. WANG: Seven and a half. And we basically look at the table and compare with the other break, and it was failures; we think that this one should be considered as the most limiting. However, if you look at a DPV, which DPV tube line break we consider as a similar break as main steam line break, so that one we were to put -- consider here, but that's from this table.

CHAIRMAN CORRADINI: Thank you.

MR. WANG: Okay. The next one, please. And the other significant open items, okay, this one is, basically, it's a regulatory issue. GE has demonstrated the core is keep covered during the whole

-- not covered -- always covered with water during the break. And federal regulation requires either do uncertainty analysis, or do a -- use Appendix K ECCS variation model, and GE actually didn't really address this tube.

MR. WALLIS: How can you use Appendix K with this design?

MR. WANG: This, basically, is the federal regulations. We would like them either to address by uncertainty, or with the other method, but we don't decide that here.

CHAIRMAN CORRADINI: So they have to choose.

MR. WANG: They have to choose.

CHAIRMAN CORRADINI: And they haven't chosen yet. Okay. Thank you.

MR. WANG: Or either they want to say apply a waiver, and they have good justification. Basically, saying that they --

MR. WALLIS: Well, they can't choose, because you can't use Appendix K with this design, can you? It doesn't make sense.

MEMBER BANERJEE: You can, but --

MR. WALLIS: You can?

CHAIRMAN CORRADINI: It's not very

applicable, but you can try.

MEMBER BANERJEE: It's not very good.

MR. WANG: For the long-term cooling calculation, GEH showed the core covered with water up to 12 hours, and the staff is asking GEH to show the results up to 72 hours.

CHAIRMAN CORRADINI: So it's that there's no concern in the time available, they just haven't run the calculation out? Is that your point?

MR. WANG: Not just the calculation. Basically, they have yet to run the calculation, and justify the results. For example, we have some concern about from this II issued to GE, where we say we don't -- staff do have concern about the non-condensable.

CHAIRMAN CORRADINI: Non-condensable where?

MR. WANG: Basically, hiding or as transportation --

MEMBER BANERJEE: In the PCCS.

MR. WANG: For the PCCS.

CHAIRMAN CORRADINI: Oh, okay. All right. But this is --

MEMBER BANERJEE: The whole thing is a coupled calculation.

CHAIRMAN CORRADINI: Right. But this is the emergency core cooling. How is the -- forget about the containment making its design margin, but taking that aside, how would the PCCS non-condensable gas affect this?

MEMBER BANERJEE: Water came back to the GDCS.

CHAIRMAN CORRADINI: But it's all gravity-driven.

MR. WALLIS: It doesn't matter. There's not much water held up in there.

CHAIRMAN CORRADINI: There's not much water held up in the isolation condenser. It's all sitting in that pool, though. That's what I'm --

MEMBER BANERJEE: And if the isolation condenser didn't work, and didn't condense any water, there would be no water coming back.

MR. WANG: We're talking about the PCCS.

MR. WALLIS: Where would the water go then? It doesn't go anywhere.

CHAIRMAN CORRADINI: I know, but this is --

MS. CUBBAGE: In the long term you could have a --

CHAIRMAN CORRADINI: This is a

quantitative question. Yes?

MS. CUBBAGE: Right. In the long term, you could have a transfer of water into the suppression pool, and not everything coming back through the GDCS, and so there's a question of whether that equalizing line is going to end up opening or not. That's part of it.

CHAIRMAN CORRADINI: Okay. Right. So now let me ask the next question. So you had audit calculations with MELCOR and the containment, which we think we would like to have a meeting and talk about that, but in this case, what are you going to look at to audit this? In other words, are you going to just ask for them to show you another calculation, or are you going to do something yourselves?

PARTICIPANT: TRACE.

CHAIRMAN CORRADINI: I didn't say that. I'm asking --

MEMBER BANERJEE: But they use TRACG for this long term cooling --

MR. WANG: For the long term cooling, GE used TRACG, and staff planned to do complimentary calculations.

MR. WALLIS: With what?

MR. WANG: With TRAC/TRACE.

MR. WALLIS: With TRACE.

MR. WANG: With TRACE.

MEMBER BANERJEE: With the non-condensables and everything?

MR. WANG: Yes.

MR. CHEUNG: This is Chester Cheung from GEH. Actually, we have response to the RAI 6.3-79 that address the long term cooling from time zero all the way to 30 days. So we have to respond to that.

MEMBER BANERJEE: You have run that now? You've run your calculations out?

MR. CHEUNG: No, we run the calculation all the way to 72 hours, and based on the result from the 72 hour, and then we project on how much, say the steam condenses, the drywell wall, breaking down to the drywell annulus and not coming back, we project the loss rate, and then we project all the way to 30 days. We still have more than one meter covering the core.

CHAIRMAN CORRADINI: But staff has yet to review or look at it.

MS. CUBBAGE: I was just going to -- I wasn't sure if you said you had submitted that, or you were getting ready to.

MR. CHEUNG: I don't know the status of

that.

MS. CUBBAGE: Okay.

MR. CHEUNG: We have finished, and --

MEMBER BANERJEE: Finished the calculations.

MR. CHEUNG: We finished writing the response.

MEMBER BANERJEE: And when is the confirmatory -- this is one of the main issues, clearly, what happens to the non-condensables.

MR. WANG: We already had some preliminary confirmatory calculations done by Office of Research -- actually Joe, because he didn't really get a chance to present, because staff is still under review the results from NRO side, but basically, Office of Research made a few calculations, and they will give us I think in the next one or two months -- I think we will have a better answer for that.

CHAIRMAN CORRADINI: Excellent. Okay.

MEMBER BANERJEE: You don't want to give us a peep at the answer at the moment? You want to evaluate them before --

MR. WANG: It's up to our manager. MR. DONOGHUE: Not now, no. We want to make sure that we understand what the results are, and that -- because

Research has performed them. They've handed them over to us in preliminary form. When they are issued in final, we'll be more than glad to send them to you. And we'll be talking to them definitely when we come back here.

MR. WANG: Other significant open items, basically GEH performed a sensitivity study for GD, gravity-driven line break, and they ran for this break up to -- it says, 20 percent of the break. And staff is asking what about say smaller than 20 percent.

MR. WALLIS: That's for the GDL based?

MR. WANG: GDL.

MR. WALLIS: And the next bullet says 80 percent size --

MR. WANG: That's -- the first --

MR. WALLIS: Which is the one where you go down through 180, 60, 40, 20, still gets worse and worse? Which one is that?

MR. WANG: That's GDL line break.

MS. WILSON: That's the main steam line. For the GDL break, it was mostly just trying to cover all of our bases, because they didn't analyze anything smaller than 20, so it's mostly just --

MR. WALLIS: It's getting worse as you --

MS. WILSON: This one it does not. The

GDL one is not -- it's the main steam line that --

MR. WALLIS: I thought it was the main steam line.

MS. WILSON: Yes. They had analyzed --

MR. WALLIS: I was wondering why he said GDLB. It's the main steam line that's the problem.

MS. WILSON: There's two different RAIs out right now. They've only -- they've performed a spectrum on the GDLB and the main steam line breaks, and so for the GDLB, this is more of a completeness issue, where we're like --

MR. WALLIS: The main steam line break gets worse and worse as it gets smaller --

MS. WILSON: Right. And that was another -- so there are two separate RAIs. This is more for completeness sake. The other one was more of a concern.

MR. WALLIS: I expected to see it here. That's why.

CHAIRMAN CORRADINI: Why is it main steam line gets worse and worse the smaller and smaller it is? I don't understand.

MR. WALLIS: But it does, apparently.

CHAIRMAN CORRADINI: But I don't understand.

MR. WALLIS: You don't have to understand, just look at the result.

CHAIRMAN CORRADINI: I'm sorry.

MR. WANG: I don't have an answer here.

MS. CUBBAGE: Is it because there's a delay in the ADS, if it's a small --

MR. WALLIS: Shouldn't extrapolate it to zero, anyway.

(Off the record comments.)

VICE CHAIRMAN ABDEL-KHALIK: What is the size, the flow limiter on the steam line?

MR. WALLIS: We don't know yet.

PARTICIPANT: It's 16 inches, or something like that.

MR. WANG: I don't know the number.

MR. MARQUINO: I don't know off the top of my head. It is documented in the DCD, the break area for the steam line break, and the flow limiter area.

VICE CHAIRMAN ABDEL-KHALIK: Well, yes. Right here it's 1.058 square feet, which is much, much less than the diameter of the --

MR. WALLIS: I read that the minimum static head in the chimney keeps dropping as you go to --

MR. MARQUINO: Definitely, yes.

MR. WALLIS: All the way down to 10 percent, it keeps dropping. Is that right?

MR. MARQUINO: Can you explain? Can you say that again, Graham? I didn't hear you.

MR. WALLIS: They did a sensitivity of the main steam line break, 180, 60, 40, 20, 10, and the minimum static head in the chimney kept dropping as they decreased the break size. So the question is what happens between 10 percent and zero?

MR. MARQUINO: We understand the concern. There is some numerical noise in these results, and we'll address the NRC's question about this, and go down to running a zero square foot break, if necessary.

(Laughter.)

(Simultaneous speech.)

VICE CHAIRMAN ABDEL-KHALIK: I hope you use long concepts.

MEMBER BANERJEE: What's the physics?

MEMBER SHACK: I don't understand it.

MR. CHEUNG: This is Chester Cheung from GEH. The basic thing is everything -- all the breaks, all you count is what happened at a point of level one, and how much inventory remaining in RPV. That's the piece measurement, because the level one is 4 meter above the top active fuel. Now, at that point, ADS open, and pretty sure memory, SRV to PV open, look like a large break -- everything fresh, and then go through DPV, we call the suppression pool, then the RPV lose inventory that way.

MR. WALLIS: So it doesn't matter how big the break is, as long as ADS opens.

MR. CHEUNG: No, it doesn't matter how big is it, but it matters in the sense that when the level one trip, now 100 percent it trip at 500 seconds. If smaller break, then the level one trip keep pushing out.

CHAIRMAN CORRADINI: So you're losing inventory. That's your point.

MR. CHEUNG: No, at the point where level one, the inventory is about the same. But the decay heat different. At the time, also the system pressure is different, say 500 second to decay heat, and so and so, 600 second to decay drop. The system pressure drop because you have a break anyway, so the way the fresh, or blow-down, or the DPV or SRV lose --

MR. WALLIS: It shouldn't matter very much, once you open ADS everything is the same.

MR. CHEUNG: Everything is the same, but the point is initiation point --

MR. WALLIS: It shouldn't matter much at all.

CHAIRMAN CORRADINI: So it's the delay time.

MEMBER BANERJEE: I still don't understand it.

MR. CHEUNG: Because at level one 500 second, the decay heat, the system pressure is observed. At 600 second, the decay is lower, the system pressure is lower. On these two case, everything blow up, that means either lower decay heat, lower system pressure, the inventory lost will be less.

MR. WALLIS: Before all the things happen.

CHAIRMAN CORRADINI: The inventory loss will be less.

MR. CHEUNG: And that means --

MEMBER BANERJEE: For a smaller break, you're getting more --

MR. CHEUNG: Smaller break, that means the level one trip would be further, further out.

MEMBER BANERJEE: But it's going to be at the same level. Right?

MR. CHEUNG: No. And ADS timing is different.

CHAIRMAN CORRADINI: That's right. That we got.

MR. WALLIS: That's what this is.

CHAIRMAN CORRADINI: And so let's just say it out loud. So if at 100 percent break it's at time one, and at 50 it's time two, time two is longer than time one.

MR. CHEUNG: Much longer.

CHAIRMAN CORRADINI: Therefore, what's different, the amount of inventory left in the --

MR. CHEUNG: After the DPV open.

CHAIRMAN CORRADINI: Okay. All right. So it's the inventory remaining. Okay.

MEMBER BANERJEE: What trips the ADS system?

MR. CHEUNG: Level one. Four meter above the top of the fuel.

CHAIRMAN CORRADINI: But you were going to do it for smaller -- so eventually it turns around and all is good. Right?

MR. CHEUNG: Yes.

CHAIRMAN CORRADINI: Okay.

MR. CHEUNG: And we have gauges.

MEMBER BANERJEE: Do you understand it?

MR. WALLIS: Yes. They tell you that it's

--

MR. WANG: Another open item is basically one category showed GD air line break, 80 percent is the most limiting using nominal, but for 100 percent size break, the most limiting for the bounding condition, and the staff is asking what's basically the reason. And the next one is, basically, staff is asking GEH to perform SLCS, standby liquid cooling system line break long-term results, with a worst single failure.

Conclusion. Basically, from the calculation results, the results show that the core is covered in all LOCA, and preliminary staff calculation also confirmed GEH's analysis. And there are major open items. This concludes my presentation.

MR. WALLIS: Are there any showstoppers? Are there really serious open items, or are these just tidying up the details, as we heard this morning?

MR. WANG: Basically, it's detail, but GE, I don't know if you have a solution for this uncertainty.

MS. CUBBAGE: But that's not a technical issue.

MR. WANG: That's not technical.

MR. WALLIS: I thought they were going to just bound it, instead of doing uncertainty analysis. They just bound it.

CHAIRMAN CORRADINI: It's in the mail.

MR. MARQUINO: Well, Professor Wallis, you're basically right. When we submitted the application methodology, we looked at the important parameters, and we set a set of very important parameters at limiting values, and we call that our bounding analysis, and we still have a meter and a half of water level. But we did not do a 95-95 Monte Carlo analysis on PCT, because the PCT is down like the initial temperature of the fuel, and the acceptance criteria is 2200 degrees.

MR. WALLIS: I'm saying it's absurd to use those rules.

MR. MARQUINO: So we will respond to the staff's --

MR. WALLIS: I thought you were doing an uncertainty analysis on the level.

CHAIRMAN CORRADINI: Yes, that's what they told -- so, thank you very much.

MR. WANG: Thank you.

CHAIRMAN CORRADINI: So I'll turn to Amy and Jim, so I understand that there is a --

MS. CUBBAGE: They actually have some

slides, so why don't we let GE take the table, and talk about vacuum breakers.

CHAIRMAN CORRADINI: So all you vacuum breaker folks.

MR. UPTON: Let me make one correct. What we'd like to do is not present slides, but I'm open for any questions and clarifications.

MR. WALLIS: No pictures?

MR. UPTON: The picture --

CHAIRMAN CORRADINI: He got you there. He got you.

(Laughter.)

MEMBER BANERJEE: We're really disappointed.

MR. UPTON: Well, we can discuss -- it's in the DCD, a rough sketch of what the vacuum breaker looks like.

MR. WALLIS: No pictures and no data, it's no good.

MR. UPTON: Oh, no.

(Laughter.)

MEMBER BLEY: When you -- earlier you said you can live with a vacuum breaker stuck open for a period of time. Can you tell us a little more about the period of time, and how effective is your passive cooling system under that --

MR. UPTON: What we've seen, and I think we have an analysis that shows, say for a two square centimeter leak, you have containment pressure and temperature is increasing, the delta P between the drywell and the wetwell is increasing at a steady rate. That period of time, if and when we see that we have zero DP between the drywell and the wetwell, and we isolate one of the vacuum breakers, it just re-establishes, it's basically another equilibrium state within the containment. So we have -- and so the change is within -- I mean, at 72 hours, that's when we see containment pressure even with excess leakage, so we think we've got time to operate, or even manually isolate if we had to.

MR. WALLIS: Do these vacuum breakers have some sort of seal material in them?

MR. UPTON: Yes. If you'd like, I can walk you through what we have done on the vacuum breaker.

CHAIRMAN CORRADINI: Yes. It's in Chapter 4, is it not?

MR. UPTON: It's in Chapter 6, isn't it?

MEMBER SIEBER: Six.

CHAIRMAN CORRADINI: Six, 228.

MR. UPTON: Right. It's in Chapter 6.

(Off the record comments.)

MR. UPTON: If I might, I might give you some of the history. The vacuum breaker design itself was developed during the SBWR program, which is the precursor to the ESBWR program. There was an extensive design and development program that went into it.

CHAIRMAN CORRADINI: Page 250.

MEMBER SIEBER: About two-thirds of the way down.

MR. UPTON: And, as a matter of fact, the prototype testing on the valve --

MS. CUBBAGE: This is the sensitive version, so I'd like to search right to it. If you have a number, do you have a figure number?

CHAIRMAN CORRADINI: Page 250, 6.2-28.

MEMBER SIEBER: That's the figure number, but the page is like 250 or something like that.

CHAIRMAN CORRADINI: The page is 250, yes. One more time.

MS. CUBBAGE: It's thinking.

CHAIRMAN CORRADINI: There you go. There it is. Okay.

PARTICIPANT: Somebody explain to us how

that thing works.

MR. UPTON: Right. Okay. Now, first of all, let me state that what's not shown on this figure are the exhaust screens, which are flanged. You see the flange connections on the valves. I'll get into that in a minute, but -- I could go up with a pointer.

MR. WALLIS: It's just a weight that jumps up and down?

MR. UPTON: That's basically what it is.

MR. WALLIS: What's the point for?

MR. UPTON: Let me give you some background. The vacuum breaker was developed specifically for the SBWR program. Okay? And the development was completed in like July of 1994. Okay? It was docketed under the SBWR program in response to an RAI. There was a complete test and development program done.

Now, I'll walk you through. It's a very simple passive device. First of all, what's not shown on here, there will be a debris screen underneath the vacuum breaker, where the screen itself is sized for a minimum particle.

The unique feature about this vacuum breaker basically is the fact that we've got two seats. You've got a non-metallic seat, and you've got a hard seat. Okay? So the non-metallic seat is an elastomer seat, which gives you extremely tight --

MR. WALLIS: That's an O-ring-like thing that goes around --

MR. UPTON: Yes. So the vacuum breaker, as tested, is effectively bubble tight. It lists just a disk. It has an anti-chatter ring here, basically, it's an increased area that once it opens up at half a PSID, will force the vacuum breaker up. But it opens at half a PSID to relieve pressure between the drywell and the wetwell, when you have a vacuum, either during the GDCS quenching phase, or during -- if you decide to use drywell spray and create a vacuum in that region.

MEMBER BANERJEE: So it's just that weight which determines what --

MR. UPTON: That's correct. It's just the weight, the weight of the disk, the weight of this disk determines the valve set point. Now, when we tested it, we tested -- a full-scale prototype was built. It was tested in FIAT in Italy in a full-scale test facility. We did -- we aged the valve, we did thermal aging, we did dynamic aging, we tested for seismic conditions, we radiation-aged it, radiation-aged the seal, then we did as-built testing on the valve before we started. We did performance testing on the valve, and then we did reliability testing on the valve.

MR. WALLIS: How about those bearings? What's in the bearings? Is this metal-on-metal?

MR. UPTON: I'd have to go back and look at the specifics of what the bearing is.

MR. WALLIS: What you worry about is bearings getting jammed up or something? It doesn't take much to jam a bearing.

MR. UPTON: Right. And that's -- one of the things we did was we looked at okay, what is the expected debris into the valve over a 60-year life, so what we did is ingest a lot of basically grit, sandblasting grit.

MR. WALLIS: Which ought to go right through the thing, but if grit gets in the bearing --

MR. UPTON: Well, what we did is we coated the inside of the valve with oil so that it would stick. And then after we ingested two pounds of sandblasting grit, we cycled the valve for 3,000 times, and basically had no failure.

CHAIRMAN CORRADINI: What is the position indicator for this valve?

MR. UPTON: What you have, you've got proximity switches in the seat area here, which determines where the seat is. There's four of them located. You can operate with one failed, and that will give you sufficient indication to determine -- in the original design, they were sufficiently sensitive enough that even if you had a particle on the seat, you would determine how much area --

MEMBER BANERJEE: What principle does the proximity sensor work from?

MR. UPTON: It's just the proximity of metal, and it gives you a voltage output.

MEMBER BANERJEE: Capacity --

MR. UPTON: I think so.

MEMBER BLEY: Is the only thing that moves that little round disk --

MR. UPTON: This disk here.

MEMBER BLEY: There's no guides for it. It's just --

MR. UPTON: No, this is the guide here. This is the guide here. There's a bearing here, and there's a bearing here.

MR. WALLIS: The shaft moves up and down.

MR. UPTON: The shaft moves up and down.

MR. WALLIS: Grit might not hurt you. I

mean, what hurts a bearing is very, very fine particles or corrosion inside the bearing, usually there's a small clearance in the bearing. I don't know what you've got in there at all, but it doesn't take much if you've got a tight clearance in a bearing to prevent it from moving.

MEMBER BANERJEE: Depends on what bearing they're using.

MR. WALLIS: Yes, I know.

MEMBER BANERJEE: What is it?

MR. UPTON: I'd have to go back and review exactly what we're using in the bearing. I don't recall. It's been a while.

CHAIRMAN CORRADINI: So now just one thing. You said you tested this under the SBWR program, so is the design in the ESBWR just more of the same, or larger?

MR. UPTON: It's identical. It's an identical valve.

CHAIRMAN CORRADINI: Same number, there's four.

MR. UPTON: Same number, there's just -- no, just same number, same size valve. It's identical. We had three on the ESBWR or on SBWR, and we've got three on ESBWR.

VICE CHAIRMAN ABDEL-KHALIK: You said the original position indicator was very sensitive.

MR. UPTON: Yes.

VICE CHAIRMAN ABDEL-KHALIK: What is the sensitivity of the current position indicator, and what --

MR. UPTON: Well, after the testing, we used proximity probes during the testing on SBWR. Okay? There was some drift associated with those proximity probes, so they recommended after the testing that we use proximity switches, which are basically the same thing, the same technology. It just shows you whether the disk is in contact or not. So we haven't actually -- in an actual production valve, we may look at those sensors and say well, maybe we can get more accurate proximity probes that don't drift. We haven't gotten there yet.

VICE CHAIRMAN ABDEL-KHALIK: I mean, the reason I'm asking is, can these things be not quite closed, but would give you an indication that they are closed?

MR. UPTON: That is not possible with the proximity sensors themselves, because it's based on the location of where the disk is, you have a voltage output, and so you would have some --

MEMBER SIEBER: You've got some calibration error.

MR. UPTON: That's true, there will be calibration error.

MEMBER SIEBER: It may be open a little bit. One of the things that's important is that that valve is normally closed.

MR. UPTON: Right.

MEMBER SIEBER: And if you're worried about debris, and the valve is normally closed, the amount of debris accumulation is pretty small.

MR. UPTON: And the filter, the discharge filters that we designed basically have a cover over the top of the filter, and the discharge port is below it, so any LOCA debris would not actually get into or on to the seat. That's by design.

VICE CHAIRMAN ABDEL-KHALIK: How much of a gap would give you a one centimeter square area?

MR. UPTON: The discharge holes on the exhaust screen are .9 millimeters.

VICE CHAIRMAN ABDEL-KHALIK: No, no. How much of the field gap on the seat?

MR. UPTON: On the hard seat, even if you had a particle on the hard seat, the soft seat still seals, so we did do testing for various particle sizes at FIAT to determine at what size would fail it. And I have the report here.

MEMBER BANERJEE: Could you give us the diameter of the circle which the O-ring makes, we can calculate it.

MS. CUBBAGE: I think you're answering a different question than was asked. They want to know how much --

VICE CHAIRMAN ABDEL-KHALIK: How much would it have to rise to equal --

MEMBER BANERJEE: Just give us the diameter.

MR. UPTON: Oh, oh, oh, oh. I don't have that off the top of my head.

MEMBER BANERJEE: Give us the diameter. How big is it?

MR. UPTON: Well, the diameter of the valve is 24 inches. Okay?

MEMBER SIEBER: Manholes. A person --

MEMBER BANERJEE: Sixty centimeters.

MR. WALLIS: Sixty centimeters, yes.

MR. UPTON: Part of the --

(Off the record comments.)

MR. UPTON: As I said, the test report for the vacuum breaker was docketed under the SBWR program, so it was in response to an RAI on the SBWR program, and we have the docket number, and the MFN letter that it was transmitted under. And as part of that testing, we used -- we did look at particles on the hard seat, and to see what the leakage rate would be.

MEMBER SIEBER: No chance for it to rattle or get --

MEMBER BANERJEE: One two-hundredth of a centimeter.

MR. WALLIS: 10,000 over 200.

MS. CUBBAGE: Were there any other points you wanted to make?

MR. UPTON: I guess the other point is that what we're currently going to do is put in an isolation valve with -- basically bubble tight isolation valve, with a scotchiogarp operator nitrogen supplied solenoid actuated. That's the current reference configuration, so that not only do we have a vacuum breaker that's extremely leak tight, but you've got an isolation valve which is also extremely leak tight, or bubble tight.

MR. WALLIS: So human error in there would --

VICE CHAIRMAN ABDEL-KHALIK: It's 2 mils.

MEMBER BLEY: If it's uniformly open.

CHAIRMAN CORRADINI: I guess I want to ask one other thing about the proximity switch, or proximity whatever they are. So are they all around the whole circumference of the manhole, or are they in precise positions?

MR. UPTON: There are four, basically one in each quadrant.

MEMBER SIEBER: Ninety degrees apart.

MR. UPTON: Ninety degrees apart. Now there's nothing that says we can't add additional proximity probes. It was just that four was felt to be sufficient to detect the seat not fully seated.

CHAIRMAN CORRADINI: And now let's talk about bypass leakage, the opposite direction. That would be the path the bypass leakage in the opposite direction, through an unseated valve this way. Yes?

MR. UPTON: Right. Right.

CHAIRMAN CORRADINI: So what's the weight of the piston or the cylindrical thingamabobber in the middle?

MR. UPTON: You'd have to calculate it. It lists at half a PSID. I don't recall exactly what the weight is.

CHAIRMAN CORRADINI: I guess what I --

maybe I should ask the question in a bit different way. When you say it's tight, do you design it to have a certain weight to cause it to essentially seal on the hard seal? I don't understand the soft seal. I understand the hard seal. How is it sealing on the soft seal above it?

MR. UPTON: Not above it. In other words, you've got a hard seat here, and then in addition to that, you've got an elastomer seat.

CHAIRMAN CORRADINI: Oh, in the middle as an O-ring.

MR. UPTON: Yes, as an O-ring.

CHAIRMAN CORRADINI: That's this little black square?

MR. UPTON: Right.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. UPTON: Right. Right. Right.

MEMBER BANERJEE: Why does it have to be --

MEMBER SIEBER: The weight of the disk is determined by how much pressure you want to have --

MR. UPTON: There is a certain relief area that's required, and I think it was 1.04 foot squared, so that defined the size of the valve. We could have done it by multiple valves.

MEMBER BANERJEE: How many of these do you have?

MR. UPTON: Three, we have three valves. We only need one, so it's like an N minus 2 type situation.

MEMBER MAYNARD: You really end up with quite a bit of force trying to shut it. I mean, the size of that valve, even fairly small differential pressure is going to be a lot of force.

MEMBER SIEBER: That disk is probably 30 or 40 pounds, too. You have to have enough force to lift it, and that's -- the weight of the disk determines when it's going to trip.

MR. UPTON: Right.

CHAIRMAN CORRADINI: It's a manhole.

MR. UPTON: Right, that's what it is.

CHAIRMAN CORRADINI: It's a manhole.

MR. UPTON: And the reason we went this way is it doesn't have the same problems that the swing checks had. You don't have -- you've got all of the force of gravity working on this plate, basically, to seal it, and it's sealed uniformly.

MEMBER MAYNARD: Now when you want it shut, it's got a lot of force shutting it. When you want it open, it ends up --

MR. UPTON: A lot of force opening it.

MEMBER SIEBER: Right. And it goes to the top.

MEMBER BLEY: How wide is the seating surface?

MR. UPTON: I've got the detail example drawing. It's about --

CHAIRMAN CORRADINI: It's probably an inch.

MR. UPTON: Yes, it's an inch and a half, an inch.

MEMBER BLEY: That's what it looks like.

MEMBER BANERJEE: It's a big valve.

MR. UPTON: It's a big valve.

VICE CHAIRMAN ABDEL-KHALIK: So how tight is the clearance on the vertical rod that's providing guidance for this valve?

MR. WALLIS: It's the bearing we're talking about.

MR. UPTON: On the bearings?

VICE CHAIRMAN ABDEL-KHALIK: No, just -- how tight -- in other words, to answer the gravity question, can this valve actually be partially seated because it's crooked?

MR. UPTON: The tolerances on the bearings are pretty tight, so we maintain the configuration, that is up and down. And I have to -- I don't have the assembly drawing with me. We can get you those numbers, because we have an assembly drawing that the valve was built by, and the tolerances are -- I don't want to guess. I'll get you the --

VICE CHAIRMAN ABDEL-KHALIK: Well, this may sound like a lot of detail, but when you figure out that it takes only 2 mils of a gap to give you one square centimeter of a leakage area, then you start worrying about things, how aligned is this valve, whether or not -- if you've got so many of them, you can actually add up to one centimeter square.

MR. UPTON: Yes, but the elastomer seal is very forgiving, too. In other words, you've got not only a hard seat, only if the hard seat didn't meet -- -- if I had a single seal, yes, I'd be concerned, because then a particle on the hard seat would then, indeed, give you leakage. But the elastomer seat is very forgiving. And, as a matter of fact, what we've seen is even if we have particles on the hard seat, the elastomer seat seal is still within tolerance. I mean, it's less than point zero -- well, it's extremely leak tight. And, again, in the testing that we did in Italy, we looked at that. And we looked at, okay, what is the leakage rate if we have something on the seal?

(Simultaneous speech.)

MEMBER BLEY: Is there a test report?

MR. UPTON: Yes, there is a test -- and that's what I was saying. On the SBWR docket in 1994, the entire test report was supplied. As part of an RAI response, we plan on also -- on ESBWR we will also provide that.

MEMBER BANERJEE: Is there a program -- you know, these are basically polymers. Right? Your elastomer.

MR. UPTON: Yes.

MEMBER BANERJEE: So they're going to age.

MR. UPTON: Yes, six years.

MEMBER BANERJEE: Yes. So the question is how often do you change them out?

MR. UPTON: We change it out six years, about.

MR. WALLIS: You check it out actually every outage or something like that?

MR. UPTON: Yes. We will be -- the plan is that every refueling outage, you will confirm the leak tightness of the valve by local leak rate test.

CHAIRMAN CORRADINI: But you'll cover it

with a housing --

MR. UPTON: Basically, take off the discharge ports, add flanges, and then pressurize over the seat, and do a pressure decay to confirm that it's not leaking.

CHAIRMAN CORRADINI: I'm sorry. One question about -- so you said it's on the SBWR, but this is not the design on the ABWR.

MR. UPTON: No, it is the design on the AB ---- it's identical. They're identical.

CHAIRMAN CORRADINI: It is, on the ABWR?

MR. UPTON: Oh, no, I'm sorry. I'm sorry. No, it's not the ABWR. On the ESBWR it is identical.

CHAIRMAN CORRADINI: Right. I understand.

MR. UPTON: Yes.

MEMBER MAYNARD: How often, if ever, will these actually be exercised?

MR. UPTON: I think the calculation predicts 37 times.

MS. CUBBAGE: Tested.

MEMBER MAYNARD: No, I mean tested. I'm sorry, tested.

MR. UPTON: Oh, when we tested it, we cycled it 3,000 times plus.

MEMBER MAYNARD: No, I'm talking about

during normal -- my concern isn't debris getting in there and stuff. It's a type of corrosion build up or something that's sitting there over a long period of time, and maybe 10, 15 years after this thing has been put in service.

MEMBER BANERJEE: Well, they change it every six years, anyway.

MR. UPTON: And we're talking about leak rate testing it, and lifting it every outage.

MEMBER MAYNARD: Okay. Lifting at each outage. Okay. The leak rate -- okay.

MEMBER BANERJEE: And changing out the O-ring.

MEMBER MAYNARD: Now that's every six years I think.

MEMBER SIEBER: How do you lift it?

CHAIRMAN CORRADINI: Carefully.

MR. UPTON: Yes, carefully.

MEMBER SIEBER: There's no handle any place.

MR. UPTON: We haven't worked that out yet, but the thinking is that you'll have something that will grab onto the stem of the valve and just lift it. Or you can come in through the top of the valve here, and lift the stem.

MEMBER BLEY: The only thing looks just a little funny to me, the stem -- given this is a manhole cover, the stem is real skinny.

MR. UPTON: Well, this may not be representative of the actual valve.

MEMBER BLEY: I'm just thinking about some kind of bending moments on there, when it -- does it bang open?

MR. UPTON: We can provide the staff the actual assembly drawing of the valve.

MS. CUBBAGE: Right. And we'll be getting that test report, and we'll send it to you guys. There's one more presentation, so if you want to get to that, we probably ought to --

CHAIRMAN CORRADINI: Yes, we do.

MS. CUBBAGE: So we'll send it.

CHAIRMAN CORRADINI: Are we done torturing Mr. Upton?

MR. UPTON: Is that it, all these questions?

CHAIRMAN CORRADINI: So just to repeat about the one thing you said, just all kidding aside. So you're planning to take the test program and give it back to the staff under the ESBWR --

MR. UPTON: Docket.

CHAIRMAN CORRADINI: -- docket.

MR. UPTON: Yes.

CHAIRMAN CORRADINI: Thank you.

MR. UPTON: That's true.

CHAIRMAN CORRADINI: Okay. And then we could look that --

mEMBER BLEY: WE can look at anything we want, but it's already filed on the SBWR docket.

MR. UPTON: Yes. In other words, we could ---- I've got the docket number, the MFN letter that it was transmitted under. You can get access to it --

CHAIRMAN CORRADINI: Pass that to Amy.

MEMBER BANERJEE: This was done in a steam --

MR. UPTON: Yes.

MEMBER BANERJEE: Where, in Kachensa, or where was it?

MR. UPTON: Fiat. Now the cycling test, the reliability test was an air test. But the valve performance test was done at full speed.

(Off the record comments.)

DR. WHITE: Are we ready?

CHAIRMAN CORRADINI: Go ahead.

DR. WHITE: Hi, I'm Dr. Frostie --

CHAIRMAN CORRADINI: Oh, I'm sorry.

DR. WHITE: We're going to go into light topics today, since we had so many wide ones over there. I'm Dr. Frostie White, and I'm the lead license engineer for the transient analysis, and we have submitted a topical report on feedwater maneuvering over the past month. It's under review right now. We've had a couple of presentations with th staff, and we thought it would be appropriate to present this also to the ACRS.

Dr. Pradip Saha will be our presenter, and go through how we looked at the analyses, and I will caution, if we get into some topics related to the actual feedwater controller, we may have to go into a closed session, because we are under a patent review right now for our feedwater control. Dr. Saha.

DR. SAHA: Okay. As Dr. White mentioned, I'm Pradip Saha, and I work for GE Nuclear Energy. I'm a principal engineer in the ESBWR engineering team. And I know it's late, but I'm sure everybody is awake. Right? You're all interested to hear this.

CHAIRMAN CORRADINI: We're all interested.

DR. SAHA: That's right. Professor Wallis, and Sanjoy, and you, Mike. Anyway, so what I will do, basically, I will just give you the concept and the overview of this feedwater temperature control system, and the operating domain. We have developed a new operating domain, because this morning we have heard, and it is rightly, that for the operating BWR reactors, we have two nice features. One is, of course, the control rod movement, and another is the cold flow changes. And in the ESBWR again this morning, we heard - we saw, even though now, of course, the natural circulation core quality is quite good, but it is really just a function of power, so there is no other method to change the reactor power other than the control rod motion. So, basically, our objective of this work is to develop a metric similar to cold flow control in operating BWRs. But this is additional to the control rod movement much like in operating reactor. And this is desired for ESBWR operational acceptability.

MEMBER ARMIJO: Is it GE's intent to make this an integral part of the design certification?

DR. SAHA: Yes.

MEMBER ARMIJO: Okay.

DR. SAHA: Right. Okay. So we actually assembled a team about a year ago, maybe a little bit more than one year ago. We assembled a team, a multi-disciplinary team of experts, and the experts were from nuclear analysis area, balance of plant area, implementation and control, mechanical design, safety analysis, and reactor operation. And all these experts, they had combined probably 200, maybe 300 man years of experience in nuclear industry. And they're all highly respected in their own field. And we looked into -- this team, actually, looked into various methods, and then finally, we decided on this feedwater temperature control. And this slide shows three bullets, and I'm more accustomed, and more at ease standing up, and using my pointer. This is good. This is all Spanish pointer that we used to use at NRC in meetings 20 years ago.

Okay. So these are three bullets, is that what we did, we reconfigured our feedwater heaters. Actually, we did it such that we have now seven feedwater heater. It's the high pressure. We basically brought one from the low pressure feedwater heater, but, of course, now this is a high pressure feedwater heater. And we allow, when we want, to have steam from the main steam bypass header, which is, of course, high pressure, and high temperature, to increase the final feedwater that is going into the reactor vessel. Okay?

And this seven feedwater heater is sized such that the feedwater temperature will increase at the right condition by 66 degree Fahrenheit, so from a nominal temperature, feedwater temperature of 420 degree Fahrenheit, it will go to 400 -- maximum of 486 degree Fahrenheit. And that lowers the reactor power, if the reactor were at 100 percent power, lowered by about 15 percent, or 85 percent rated power. Low insertion of control rod, control rod pattern stays the same. We just increase the feedwater temperature, and the power goes down.

DR. WHITE: This makes more voids in the core.

DR. SAHA: Yes, no. The reason is here, Professor Wallis. What happens when we increase the feedwater temperature, and our circulation water is, of course, in the saturation, that drops the core inlet temperature somewhat. Okay? Maybe by one-fourth of whatever increase we are doing. It increases the temperature, so that drops the volume boundary, so more parts in the core, and, again, avoid the activity feedback. That brings the power down.

MEMBER BANERJEE: Are there any stability implications of this?

DR. SAHA: Well, we have done stability analysis. I will come to that. Well, first of all, this presentation is supposed to be just an overview. I have only five slides. And as staff has mentioned many times during the whole day, that there has been, one, an EDO report is a Class I report, an EDO 3338. This is a 400-page document, and it has got all the stability, AOs, and infrequent event analysis, LOCA analysis, everything.

VICE CHAIRMAN ABDEL-KHALIK: Now your circulation ratio at full power is about 6.

DR. SAHA: I think one is to 4, because --

VICE CHAIRMAN ABDEL-KHALIK: How much?

DR. SAHA: One is to 4, about one is to 4.

VICE CHAIRMAN ABDEL-KHALIK: Four?

DR. SAHA: Four.

VICE CHAIRMAN ABDEL-KHALIK: About four. So you mean the average quality at the top of the core is 25 percent?

DR. SAHA: About 20, 25 percent, because --

VICE CHAIRMAN ABDEL-KHALIK: That is inconsistent with what we heard --

DR. SAHA: Okay. Let me -- if we go back, if we go to say feedwater flow or steam flow, and the core flow rate, if I remember, there is a table in DCD 4.4-1, that has feedwater flow rate, steam flow rate, 2,000, a little bit more than 2,000 kg plus --

CHAIRMAN CORRADINI: 2400 is a steam flow about 10,900 is your --

DR. SAHA: That's right. That's about one is to 4. Right?

VICE CHAIRMAN ABDEL-KHALIK: Okay. So what is your circulation ratio at 85 percent power at this lower feedwater temperature?

DR. SAHA: Okay. Again, this -- the EDO 3338 has that table, again. And that shows that number. I don't exactly remember the number, but the number is there. It's not much different. Bigger code, the circulation flow rate goes up a little bit, goes down, because now we have a little bit higher void fraction.

Anyway, so this is basically an opposite happens if we defeat the feedwater temperature.

DR. ALAMGIR: This is Dr. Alamgir from GEH. I did the evaluation of condition at high temperature. It's about the same, four to one.

DR. SAHA: Thank you.

MEMBER ARMIJO: Just for clarification, by this technique you can -- at any power level you can move plus, with a 15 percent range of that stated power just by this changing the feedwater temperature?

DR. SAHA: No, this is from 100 percent, it comes to 85 percent.

MEMBER ARMIJO: 85.

DR. SAHA: And I have --

mEMBER ARMIJO: But going up from low power up.

DR. SAHA: Low power up?

MEMBER ARMIJO: If you're at 10 percent power, and you want to go up to 30 percent.

DR. SAHA: Oh, okay. Now there, actually, again, if you -- I mean, if I can wait for one or two slides.

MEMBER ARMIJO: Okay, I'll wait.

DR. SAHA: This will be clearer. Things will be clearer. Can we go to the next slide? Okay. So this is a schematic. Again, this is from DCD, in the DCD 10.1-1, I just took a part of it. The high pressure feedwater heater part. Here you see this is basically the feed pump, the normal feedwater flow line is going like this, and there are two trains, heater number 5, 6, and 7. And the 7, as I said before, the steam comes from the main steam line. And there are valves here and here. It is not necessarily that one wants to increase the feedwater temperature all the time. It's kind of an option.

And, also, so feedwater temperature can increase when we allow main steam line to come to the 7 heater. Also, you can see there is a bypass line here, and this valve is, of course, normally closed. But if somebody wants to, the operator or the utility wants to reduce the feedwater temperature, they can open this bypass valve, so some feedwater will go unheated, and some other will go heated. And the mixture, temperature here, final feedwater temperature will be lower than the normal. So this is the way we can go high, as well as low in the feedwater temperature. Question?

MEMBER BANERJEE: The flow eventually is calibrated for temperature changes?

DR. SAHA: Are you going into --

mEMBER BANERJEE: The measurement of the --

DR. SAHA: Feedwater flow?

MEMBER BANERJEE: Yes.

MR. MARQUINO: Yes, they are.

MEMBER BANERJEE: You calibrate them over this?

MR. MARQUINO: Yes. We compensate for

temperature density variations in the heat balance, and the feedwater flow measurement. VICE CHAIRMAN ABDEL-KHALIK: So at full power, there is no lead steam going to feedwater heater number 7?

DR. SAHA: At the normal condition --

VICE CHAIRMAN ABDEL-KHALIK: Operation, full power.

DR. SAHA: In the normal operation, feedwater -- yes, okay. In normal operation, there is no steam going into this feedwater heater. There may be just a crack open valve or orifice just to keep these heaters warm.

DR. WHITE: But that would be to reduce your efficiency, presumably, because you're just circulating stuff around that's doing nothing.

DR. SAHA: No. This -- just a little steam will come, and the drain goes to this open heater number 4.

MEMBER BANERJEE: Doing this, does it affect your cycle efficiency?

CHAIRMAN CORRADINI: Not much.

DR. SAHA: No, no, no. Actually, the BOP side, the balance of plant side, is designed such that we have maximum thermal efficiency at operating point of 100 percent power and 420 degrees.

MEMBER BANERJEE: Yes. I'm asking when you do this --

MR. WALLIS: So when you maneuver, you reduce it.

DR. SAHA: Yes, we reduce a little bit of efficiency.

MEMBER SIEBER: Well, that happens in a normal configuration, too.

MEMBER BANERJEE: Yes.

MEMBER SIEBER: Once you start to throttle, the valves on the turbine lose some efficiency. But I think you have to go the whole way on this once you increase feedwater temperature. That reduces the core power output, which reduces the steam pressure, and since this is basically a constant pressure device, you have to change the governor valves to get the pressure back up. And so there's more things that happen than just changing the feedwater control.

DR. SAHA: That's right. Okay. Now, I would like to explain this, take some time and explain this figure, because it shows the similarity and the difference between what we are all familiar with for the forced circulation boiling water reactors. This is the forced circulation side, and this is the natural circulation, the ESBWR side. And here I have got two maps, one is power flow map, this way. And another is power feedwater temperature map this way.

MR. WALLIS: It would help if you put the -- on the power flow map, you actually put different feedwater temperatures. That one over there on the right, upper right-hand --

DR. SAHA: Yes, what I'm saying --

MR. WALLIS: It would help if you put -- the upper right-hand one, which has one curve on it, that's for one feedwater temperature. That one on the right upper right.

DR. SAHA: Upper right?

MR. WALLIS: That's for one feedwater temperature.

DR. SAHA: This is for one feedwater, yes.

MR. WALLIS: It would help if you had curves of different feedwater temperature in that --

DR. SAHA: Good point. Good point. Okay. What I wanted to say is this, that even for operating reactors, we do have a natural circulation line that was shown this morning, and then because of this cold flow that we have this recirculation of the pump, we have this operating zone. So there are two ways to change reactor power; one is, of course, control rod, another is the core flow. And, originally, of course, GE had this map, and then basically we analyzed further, and we went to higher and higher power. And NRC and ACRS have reviewed all this thing.

MEMBER BANERJEE: Total plant you have no plants yet at.

DR. SAHA: Not yet at, but they are going towards higher power.

MEMBER BANERJEE: Right.

DR. SAHA: Okay. So more electricity generation. Okay. Now the lower figure, this column, first column, shows the power feedwater temperature, and this black line, solid line is the normal feedwater temperature versus power. Because as you increase power, of course, more extraction steam, so feedwater temperature also increases.

Okay. Now here is this green region, is the feedwater temperature reduction region, and in several BWRs, operating BWRs, towards the end of cycle to get to more power out of the core, feedwater temperature has been reduced, maybe by passing feedwater heater. And, again, GE and the utility worked together, and NRC and ACRS have reviewed it, and they have approved this, so we do have operational experience of this region also, feedwater temperature reduction area.

Okay. Now let me focus on the right-hand side. Here is the ESBWR, and, again, today many times it was mentioned. It is basically practically in line, and to answer Professor Wallis' question, yes, if we change the feedwater temperature, and it does move a little bit, but, again, we do not get a big region. It is a very, very narrow band, but your point is --

MR. WALLIS: But it changes the power a lot, because you're on that vertical path.

DR. SAHA: Yes. Because 85 percent, this point will come down somewhere here. But flow doesn't change that much.

VICE CHAIRMAN ABDEL-KHALIK: If we go to this lower right corner diagram --

DR. SAHA: Yes, this is what I'm coming to.

VICE CHAIRMAN ABDEL-KHALIK: At the 85 percent power, 486 degrees F, Fahrenheit, if we were to operate at this point, the natural circulation driving head through the core, the difference with the same chimney would be decreased. Correct?

DR. SAHA: Again?

VICE CHAIRMAN ABDEL-KHALIK: The driving

pressure difference --

DR. SAHA: Can I have a blow up, the next figure has the blow up.

VICE CHAIRMAN ABDEL-KHALIK: Right there.

DR. SAHA: Yes.

VICE CHAIRMAN ABDEL-KHALIK: Okay. DR. SAHA: So let me explain first, this is the normal power ascension line with no seven feedwater heater, or no steam to the seven feedwater heater. Six feedwater heaters are on line, and we are cooling rods, and we are going this way. And suppose we are here, and now we open the valve to the seven feedwater heater, no change in the control rod pattern, the power goes here.

VICE CHAIRMAN ABDEL-KHALIK: So let's look at this dropped power, you've cut power down by 15 percent.

DR. SAHA: Correct.

VICE CHAIRMAN ABDEL-KHALIK: How much do you cut the flow? How much of the flow decreased?

DR. SAHA: Recirc flow? Recirculation flow?

VICE CHAIRMAN ABDEL-KHALIK: Right. DR. SAHA: Very little, 2 or 3 percent.

VICE CHAIRMAN ABDEL-KHALIK: That's it?

DR. SAHA: Yes. There is a table, 4.1-1 in NEDO 33338.

MR. WALLIS: Because if you'd shown it on the other curve, it would be obvious --

mEMBER BANERJEE: It would have been obvious.

MR. WALLIS: You've shown it in the other picture, the curves are close together, and the flow doesn't change much, although the power changes a lot.

VICE CHAIRMAN ABDEL-KHALIK: So from a stability standpoint, the worst point is still hotter than normal full power operating point.

DR. SAHA: Yes. I mean, this is from stability point of view, this is worse than this. But then this morning my colleague has shown you that even for the worst, that regional oscillation, the decay ratio is well below that acceptance criteria of .8. Okay?

MR. WALLIS: So the only reason you want to do this is so that you can maneuver without moving the control rods so much.

DR. SAHA: Yes, this one. If I may explain, so this is the normal ascension line. Okay? This is where I have given this legend, that feedwater temperature change only, and so this region here, you can do both if you want. Okay? And this is typical. Again, this is not hard and fast, and these are naturally going through evolution. This is a typical start up path. It could be that you come up up to a point where you would like to say reduce power before you maneuver the control rods. So you increase feedwater temperature, you lower power, do your maneuvering. Again, you go to another point, and again you increase feedwater. You can come up to here with your kind of best control rod pattern.

MR. WALLIS: The fuel or something, why would you want to do that?

DR. SAHA: Yes. This is the operational flexibility, and also easy on the fuel. So then once you come here, then you just drop the temperature again, basically close the valve to the seven feedwater heater, and you come here.

VICE CHAIRMAN ABDEL-KHALIK: Normally, during start up at low power, don't you bypass the steam directly to the condenser?

DR. SAHA: Okay. Here what we're talking about, what you were saying, said this morning, we were talking about this type one oscillation, those are at very low power, maybe only up to 2 percent power. Here we are talking about all this thing we would like to do, if necessary, at higher power, like 60 percent power and above.

MR. WALLIS: The turbine is not running.

DR. SAHA: The turbine is running. It is generating electricity, yes. This is not a low power situation. Low power would be way back --

mEMBER BANERJEE: What is the limit at Point A? Is it fuel performance, or what limits you to A?

DR. SAHA: There is no limit on Point A. This is our normal --

mEMBER BANERJEE: Yes. I mean, why can't -- if you extrapolate the line from Point C to A, to the left-hand side.

DR. SAHA: Right.

MEMBER BANERJEE: And keep going up --

MR. WALLIS: You don't have a license to do that.

MEMBER BANERJEE: It's called what? No, I know.

PARTICIPANT: It's called an uprate, like A Prime up there.

MEMBER BANERJEE: So it's a single power -
-

DR. SAHA: Just like operating reactors do have --

mEMBER BANERJEE: It's the fuel, critical power.

DR. SAHA: -- rod blocks, so here we just show that, maybe 108 percent or something like that.

MEMBER BANERJEE: So A is limited by CPR.

MR. WALLIS: It's limited by your license at the moment.

CHAIRMAN CORRADINI: Limited by your license, and then if you want to argue that you can make the MCPR, you can go up there. First you have to build one before you go there.

MR. WALLIS: Why do you have to ask if you can do this? You can obviously do it. But you have to ask if you can do it, or you just do it?

CHAIRMAN CORRADINI: No, but there was --

MR. WALLIS: As long as you don't violate any rule.

CHAIRMAN CORRADINI: Yes.

DR. SAHA: The question, of course, are the safety - this is our -- and, as I said, this is also -- we can also lower the temperature, so this is now an operating domain.

CHAIRMAN CORRADINI: Somewhere in --

DR. SAHA: We did not have really an

operating domain.

CHAIRMAN CORRADINI: Somewhere in your DCDs you made references a few times, and then in the SER there are discussion about how this control was. In fact, I was trying to understand what -- so this is very helpful.

MS. CUBBAGE: No. This is new information that came in this topical, will be officially incorporated in DCD Rev 5.

CHAIRMAN CORRADINI: But I thought in Chapter 4 there was some reference to feedwater control.

MS. CUBBAGE: In our SE, we alluded to the fact that this had been submitted, but we haven't reviewed it yet.

CHAIRMAN CORRADINI: Okay.

MEMBER BLEY: The driving force for you to figure this out is easier to control, or the rods are easy enough to control. What was driving, why you really want this --

DR. SAHA: As I said, driving thing was to have another method of changing power.

MR. WALLIS: Why?

DR. SAHA: Why?

MR. WALLIS: What do you gain by doing it?

DR. SAHA: As I said, yes, it is easier on the fuel.

MR. WALLIS: It's easier on the fuel.

DR. SAHA: Easier on the fuel. Correct.

MEMBER ARMIJO: But you've got a very resistant fuel, so unless you were thinking of going to, let's say back to operational techniques to prevent, let's say PCI failures, and reducing the cost of your fuel, maybe it's cheaper to make it, what other benefit is there?

DR. SAHA: We want to go to the zero fuel failure as INPO's I think 2010 initiative, so that one of the driving thing now for this.

MEMBER BLEY: Your recommendations would be to use the feedwater control for minor changes and maneuvering things to your license, to your customers. Is that right?

DR. SAHA: Well --

mEMBER BLEY: Where they can.

DR. SAHA: Okay. At 100 percent power, if they want to make some changes, slight changes, that they can with the control rods. There's no problem.

MEMBER MAYNARD: I think there are some potential safety benefits to this, too, besides just being good for the fuel. It's good to have a way to make minor power changes without having to do rod repositioning.

DR. SAHA: Right.

MEMBER MAYNARD: Not only for the fuel, but also just for the core, any time you're positioning control rods, now you're starting to move flex around and things in there, and also, any time you're having to reposition control rods, I believe that this is less susceptible to human error than control rod repositioning is. I'm not sure without taking a better look at it, but I think there are some potential safety reasons, in addition to just easier on the fuel.

CHAIRMAN CORRADINI: It's not transparent.

MR. WALLIS: It's not transparent. You're controlling with two hands, instead of with one, so it may not be --

DR. SAHA: Let me clarify something. Oh, you want to say something?

MR. MOEN: I'm Steve Moen. I worked with the team that developed this. I think it was very well stated over here that one of the big drivers for this is to provide additional operating flexibility. It gives the operators an extra knob that they can turn to control the reactor.

The initial driver was to reduce the duty on fuel, given that fuel still has -- experiences duty failures on occasion. They're very, very low today, but we wanted to reduce the possibility of that to the absolute minimum. And what this does is it allows us to bring the power down far enough, we can get out of the region where we can have duty-related failures.

MR. MARQUINO: Steve, you may want to clarify that's related to pattern exchange.

MEMBER SIEBER: It's big control rod movements that give you PCI failures. This avoids this. On the other hand, a commercial nuclear power plant, when you start it up, at least I was in charge, started up from the first day after fueling, and you shut it down the day before you refuel the next time. This would be okay, if we had nothing but nuclear power plants, and some of the --

CHAIRMAN CORRADINI: I was going to say, the thing that --

MEMBER SIEBER: They're the cheapest thing out there, so they run them at 100 percent power all the time, except when you have to do rod swaps.

DR. SAHA: Right.

MEMBER MAYNARD: There are times when you have good stability issues, maybe totally unrelated to your plant, that you have to make a power reduction, so the plants have restrictions on that. You may have to come down to 90, 85 percent power, so --

MEMBER SIEBER: Or your transmission system operator.

MR. UPTON: This is Hugh Upton, GEH. One of the other considerations is that you have to do control rod pattern change-outs during the cycle, so this also allows you to do that without over-stressing the fuel.

MEMBER SIEBER: Yes, you're still going to put some stress on it. It's just not going to be as much. You're moving the power around in the core.

MEMBER BANERJEE: You can also go to the green region.

MR. WALLIS: Presumably, it's slightly more unstable when you have -- you bring down your boiling boundary?

DR. SAHA: Which one?

MR. WALLIS: Hotter feedwater is slightly more unstable.

DR. SAHA: No, it is not.

MR. WALLIS: No?

DR. SAHA: Because if you see the exuberant number versus sub-cooling number plain, you see we already operate below that mean.

MR. WALLIS: You're below the mean.

DR. SAHA: Yes, we are below the mean. So what happens --

CHAIRMAN CORRADINI: Even with a decrease in the feedwater temperature?

DR. SAHA: Normally, we are already below the mean. So what happens --

CHAIRMAN CORRADINI: If I want to stray into the green region, I get towards the mean.

DR. SAHA: I heard, you were asking in the red region, the hot region.

CHAIRMAN CORRADINI: He was talking about green region.

PARTICIPANT: Must pick up now the other feed heaters.

DR. SAHA: I didn't understand your question.

MR. WALLIS: I was talking about the effect on stability of going to Point C.

DR. SAHA: Yes, so that is the hot region.

MR. WALLIS: As opposed to A.

DR. SAHA: That's right. So he's talking about hot region, so hot region, what is happening, we are going below -- I mean, dropping the sub-cooling number.

MR. WALLIS: Okay. Less sub-cooling, which usually is bad.

DR. SAHA: You are already below the mean, so we are more stable.

MR. WALLIS: Okay.

DR. SAHA: When we go to the green region, the opposite happens. And we have analyzed that, and our, again, maximum decay ratio value is well within the acceptance criteria of .8.

VICE CHAIRMAN ABDEL-KHALIK: Now when you change control rod patterns, let's say you're starting at Point A, how would you go about doing that?

DR. SAHA: Okay. So what we do, we basically first, we increase the feedwater temperature, increase the feedwater temperature.

VICE CHAIRMAN ABDEL-KHALIK: Okay.

DR. SAHA: So we come down this way, right here, say around 85 percent power, and then we do whatever swapping we have to do. And then we go back up again.

VICE CHAIRMAN ABDEL-KHALIK: But what happens to power during that swap at Point C?

DR. SAHA: Well, here the power can, of course, change a little bit when we are doing the swapping. But once we go to the new pattern, new control rod pattern, then we go up again here, by throttling steam.

MR. WALLIS: So you think that having two controls is easier --

DR. SAHA: Well, again, we have talked naturally, regularly with our potential U.S. customers.

MR. WALLIS: Actually, your procedures to the operators might be more complicated.

DR. SAHA: Yes, let me answer that.

MEMBER SIEBER: That's true.

DR. SAHA: Let's me answer this. Yes, let me answer this. We have talked regularly with our potential U.S. customer, because they're a team from that. And they would like to have the ESBWR as a base load plant, so they would not like to use this feature until the time of control rod exchange, which is maybe once in a quarter. So they would like to operate right here, as I think --

MR. WALLIS: As the fuel ages, they have to move around a bit, don't they?

DR. SAHA: Yes.

MR. WALLIS: So they have to maneuver.

VICE CHAIRMAN ABDEL-KHALIK: If you did

not have that flexibility, how would you do control rod exchange?

DR. SAHA: Okay. That is -- see, again, if he wants to add to it --

mEMBER MAYNARD: You put rods in further than you need it, you swap them around, and then you pull them back out.

PARTICIPANT: Right. Before it cools off too much.

MR. MOEN: Steve Moen, GEH. With the fine motion control rods, it gives us another knob that we can move the control rods without impacting the fuel too much. And there are some additional things that are in the works to reduce the susceptibility of fuel to fuel duty concerns. And, originally, we were working with the SBWR at lower power levels, where we weren't even approaching these thresholds where fuel duty was a concern. But, fundamentally, control rod motion is how the power was originally going to be controlled. And, to a large extent, on day-to-day, week-to-week operation, once an envelope is established, I'll say the fuel duty envelope, the plants will be able to move rods within that envelope without impacting the fuel, or causing fuel duty failures.

CHAIRMAN CORRADINI: Other questions?

MEMBER ARMIJO: What about the green region, is that part of the domain that you're trying to create?

DR. SAHA: Yes. We are creating this entire domain so that, if necessary, we can even operate here. But then, again, as I said, from thermal efficiency point of view, A is definitely the point that the plant would like to operate.

MEMBER ARMIJO: Okay. So the green is not a more efficient regime.

DR. SAHA: No.

MEMBER BANERJEE: How much degradation is there to go to that Point E there?

CHAIRMAN CORRADINI: Degradation of what?

DR. SAHA: Degradation in what?

MEMBER BANERJEE: Efficiency.

DR. SAHA: Yes. I cannot answer that.

MEMBER BANERJEE: So what is your thermal efficiency at A?

DR. SAHA: At A, around --

mEMBER BANERJEE: Thirty-three percent?

DR. SAHA: -- 35 percent.

MEMBER BANERJEE: As high as 35?

DR. SAHA: You know, 4,500, say 15, 20

megawatt electric is what we are saying, but, again, that number can change depending on the site condition. So 15, 20 divided by 4,500 --

VICE CHAIRMAN ABDEL-KHALIK: Thirty-three is what I -- so to get from Point A to Point E, you cut down bleed steam to another heater.

DR. SAHA: No, we use the bypass. Can I go back to that earlier line? No, we don't cut down on all that. See, this line, there is no valves on these lines, extraction lines, except for this line, this is a special line. That has valve, but these do not have any valve, so what we do to cool down the feedwater temperature below normal, we, of course, close the valves here. And then we open this valve, which is a bypass valve. So this is the feedwater that is coming, so some of it will go unheated. And others will be heated by fifth and sixth heater.

VICE CHAIRMAN ABDEL-KHALIK: Oh, I see.

MR. WALLIS: So you're adding --

DR. SAHA: Here, the temperature will be lower than --

CHAIRMAN CORRADINI: Bypass valve has always been there? That's always been there in the design?

DR. SAHA: Yes. What I understand, it was always there.

CHAIRMAN CORRADINI: I has an analyzed accident path in case I have a feedwater cooling event.

MEMBER ARMIJO: That was the question I wanted to ask. If you're operating at Point C on your domain, does that make a loss of feedwater heater transient more severe on the --

DR. SAHA: I don't think so. We analyzed those.

MEMBER ARMIJO: You have a bigger delta T.

DR. SAHA: When?

MR. MARQUINO: We did not change the requirement that the BOP design doesn't impose more than a 100 degree F delta T in the event of a failure.

MEMBER ARMIJO: Okay.

MR. MARQUINO: And we have analyzed the loss of feedwater heater. Now the delta CPR is a little bit worse at Point C with that same delta, but we can accommodate it by adjusting the CPR operating limit.

MEMBER BANERJEE: Come again?

MR. MARQUINO: If we have a higher delta, we set a higher operating limit, and we avoid transition boiling in that case, as well.

CHAIRMAN CORRADINI: Other questions? Thank you.

DR. SAHA: Okay. My pleasure.

CHAIRMAN CORRADINI: So can I get comments from the members about the two chapters today, because I want to kind of summarize some stuff tonight. And then we are going to look at accident analysis in Chapter 15 and 21 tomorrow. Can I go around the table, starting with Jack? Any issues that you want me to make sure I don't forget?

MEMBER SIEBER: I didn't see either in my -- doing my homework or reading today, any issues that would gravely interfere with the progress issuing and approving the DCD. There are a number of details that need cleaning up, and I'm sure that the staff will make sure that happens. The questions I had have been answered.

CHAIRMAN CORRADINI: Tom.

MR. KRESS: Well, I agree with Jack. I thought the staff was asking the right questions in the SER and that's a good job. As far as particular issues, personally, I hope the business of whether we need isolation valves or not on the PCCS is resolved to the way that we don't need them. I think that increases the risk putting those on there. I don't know how you do that, because I can see staff's problem with complying with the regulations.

I'm still not quite content with the business of potential injection of nitrogen. I suspect it's no longer a design basis, but it probably ought to be part of the PRA, maybe. I, also, was surprised at the amount of non-condensables we're dealing with. I'm not sure yet why that's the case, and I think we need to learn a little more about that. And I also liked Sanjoy's question about whether there's some coupling between the chimney and the core that might induce either oscillations, or even fatigue issues, thermal fatigues, so that's another one. And Said's question about what sort of power gradients you might get across a given chimney, I think we need to know what that is, and see if it has any problems. And I'm not sure I know enough about the detect and suppress for regional oscillations, whether we've got enough of the things that we can pick up regional operations, to detect them and suppress them, so I'd like to hear just a little more about what that system is. So, basically, that's my issues.

CHAIRMAN CORRADINI: Otto.

MEMBER MAYNARD: I definitely agree with Tom on the isolation valves. I think that's important to get resolved, and get resolved correctly. There are mechanisms that even if it requires a waiver, or exemption to the rules or regs, anyway, that would be interesting to find out what the final outcome of that is.

I think the staff is asking the right questions. A number of the things that are of interest to me are things that are not resolved yet, but the staff is pursuing those, and I think that's good.

There's a couple of things that, like the vacuum breaker. There's not a lot of margin there as far as on the size of the lift, but still, even if it's three times more than what the acceptance criteria is, you still have 40 hours or so before you come close to exceeding something, so even though you may not meet the 72 hours, there's still a lot of time there, so I think probably all that can be balanced out.

The debris and tube fouling I think is still an important issue. And I think there's two stages that we're going to address. I think, first of all, the design has to be to minimize and keep it out of there. I think when it comes to the COL stage, I think that's going to be probably the key time to work with the licensee on exactly how -- what are they going to do to make sure that the design criteria is met. And that, also, what inspections. I still think that over time some, I don't know, dust or whatever may build up in the tube. There needs to be some type of inspection to make sure that the heat exchangers will still do their job. That's probably more at the COL stage, than at this stage, but I do think that's an important issue, too.

CHAIRMAN CORRADINI: Said.

VICE CHAIRMAN ABDEL-KHALIK: I guess I'm concerned about the large number of open items. So specific comments about Chapter 4 would be, I'd like to see the analysis of this maximum heat up rate during start up. I'd like to see the details of the detect and suppress stability system. And if it is a defense-in-depth feature, I'd like to know what the operability requirements will be. I'd like to see the details of the new full-scale GE 14E test results are. And how those results sort of either support, or refute the applicability of the JEXL correlation. I'd like to see the details in support or otherwise, in support of that one dimensionality of the flow within the chimney cells given the large radial power gradients in a super cell. I'd like to see the test data on the flow induced vibrations, what the critical locations are in the GE 14E bundle versus the GE 14. I mean, there are some unsupported cantilevered length for the parked length rod, which is a little longer than what you have in the GE 14 bundle, and does that change the location of -- the critical location from a flow induced vibration standpoint.

For Chapter 6, I really would like to see the details of the containment response calculations. Some of the results just are counterintuitive. And, particularly, the effect of the vent fans. And the results with regard to the rate of the radiolytic decomposition, how much gas is being produced by radiolytic decomposition? The pressurizing containment in the event of discharge of the accumulator gas, this is something new, but if you do a calculation, just the gas in those two accumulators would increase the containment, the drywell pressure by 11 PSI. And that's a significant change.

MS. CUBBAGE: I don't know if it came across in the presentation, but there are -- the shutoff valves are safety-related and automatically actuated. GE can confirm that.

MR. MARQUINO: Right.

MR. KRESS: That would make it a PRA

issue.

MS. CUBBAGE: Yes.

VICE CHAIRMAN ABDEL-KHALIK: So I guess the point to be made is, there are a lot of detail things that perhaps would be much more appropriate if we generate a list of those detailed calculations, and ask the thermal hydraulic subcommittee to just look at that list of items, and see the details of the calculations, rather than present them sort of in a big picture presentation like we're seeing chapter-by-chapter. Thank you.

CHAIRMAN CORRADINI: Bill.

MEMBER SHACK: I'll say if all these questions are answered, I won't have any left. But I think I would keep in perspective, one of the things that I do like is that when you do these accidents, you have so much margin under many of these accidents. And as we go through all the unknowns here and the details that we have left out, I don't think you want to lose the picture that this actually is sort of an interesting looking reactor, with ample margins in many ways.

MEMBER ARMIJO: Yes. I think when you don't have to talk about peak clad temperature during a LOCA, that's a nice --

MEMBER SHACK: How to apply Appendix K.

MEMBER ARMIJO: That's a significant accomplishment, I think. Well, I don't want to. I think they're doing the right thing. In the case of the -- just on flow induced vibration experiments, I think they're good to do. My expectation with a shorter bundle, very low, much lower flow rates, that there probably won't be a problem, but they could find some surprises, and so doing the test is a good idea.

I'd like to learn more, hear more about this issue of uniform strain versus ultimate strain. To me, it's strange that we would be looking for a uniform strain, applying that to a pellet clad mechanical interaction problem, when really ultimate strain adequately handles that, but I'll wait to see some more on that.

I was happy to see finally that I understand that GE does recommend hydrogen water chemistry for the ESBWR, and that the design certification will permit it without any amendment, so that -- and the U.S. utilities who are the ESBWR are going to use it. I don't believe that just material selection, and materials fabrication controls alone will protect these materials from IASEC, and even from IGSEC. Even though they are better materials, I think the belt and suspender with a good environment, and good materials, and good fabrication could potentially make these a 60-year plant life materials. So I think that's a good thing.

Control rod drive design, several improvements have been made in the mechanical design of the control rod drive. GEH is proposing to get the control rod drop accident analysis removed. I think there should be some sort of encouragement for improving system designs so that -- but if you still stick them with the analysis requirements, then there's no incentive to improve the design, so I think -- I'm hoping that the staff looks at that carefully, and doesn't say yes, you improved the design, but we're still going to make you do the same old stuff. And I think that's all I have.

CHAIRMAN CORRADINI: Dennis.

MEMBER BLEY: Well, most of the things I was concerned with have been mentioned, but I personally -- and a couple of these things can wait until the PRA, perhaps. But these things that can't possibly happen are things that worry me a little. And like the CRDMs, I want to understand those a little better, and see what the PRA has to say about it. The debris issue, kind of the same thing, but it sounds like the staff is on track with chasing that.

I guess, I think I want to look at the GDC 56, and just the issue on the primary containment, and maybe that's something we want to comment on ourselves, it's important to understand real well. And the other thing that can't possibly fail, that I want to know more about, is these vacuum breakers. And I think seeing the test report will help. In addition, I want to see how it's handled in the PRA later. It's probably fine for now, but at least when we get to the PRA, I need to see what can't possibly fail means. That's all.

MEMBER BANERJEE: I think that most of the issues that are important have been mentioned. I think, though, that what Said brought up was to make a list of certain issues, which I think we'd like to see more details about at a thermal hydraulic subcommittee meeting. It would be useful, so we might want to get together at some point and make a trial list, and propose it, and see --

CHAIRMAN CORRADINI: Just to interject, I think -- I was talking to Amy at a break. My thought is that we could use this subcommittee, but essentially stay with it so the full subcommittee can hear about it, but get a meeting specifically on these issues, because I think that if you add them up, there'll be a few of these that all kind of come within this construct of containment response, et cetera.

MEMBER BANERJEE: Yes. The details, particularly with regard to containment behavior, that's a key thing here. And the coupling with --

CHAIRMAN CORRADINI: The core.

MEMBER BANERJEE: -- long-term cooling.

CHAIRMAN CORRADINI: Yes.

MEMBER BANERJEE: That needs to be explored. And then there are side issues, like what happens to debris, where does it go, does it foul, what happens to the non-condensables. And that's also related to what happens with these vacuum breakers, what margins you have, do you have these fans, do you really need them. So we need to see some details here. This is very much an overview. CHAIRMAN CORRADINI: Professor Wallis.

MR. WALLIS: Well, it's pretty well been said. I'd like to reiterate what Tom said. I think the staff did a very good job of asking these hundreds of questions. And most of the questions are the kind of questions that I think we would have asked.

Really, until we get the answers to some of these questions, how does the GE 14E fuel behave when you do these critical power tests, and what happens to the high void fractions, and so on, we get those answers, then we'll know better where we are. So there's a lot that we're waiting for.

I agree that we should look at certain things in more detail, actually look at the basic analysis, maybe go back to a few topical reports. We don't all need to do that, but one or two of us might want to do that. Generally, we seem to be in good shape. I'd really like to see some TRACE runs. That hasn't been mentioned yet, but keeping promise that TRACE is going to look at some of these key issues, and I'd like to see how well they can do.

The thing that I felt most uncomfortable about was the way the non-condensables get handled, particularly after 72 hours. And I would hope that it's a good enough reactor, you don't have to switch on a lot of fans, and move around a huge amount of gas in order to make it work after 72 hours. I don't quite understand why that's necessary. That's the issue that bothered me the most, was about this sudden appearance of a lot of non-condensables, which I thought had been sequestered in places where they didn't do any harm. I need to look at that some more. But, generally, I think the staff has done a very good job, and we need to see how GE responds to these open items.

MEMBER BLEY: One last thing I forgot to mention is, and maybe this is just something I need to understand. I want to understand why the recombiner issue is such a burden. What is it? I know we were part of it, from what you said, but really understand what all of the burden is, and why taking credit for that is -- looks hard to do.

CHAIRMAN CORRADINI: I think Mike is not here, so we have --

MS. CUBBAGE: He's right behind you.

CHAIRMAN CORRADINI: Can you give us some thought?

MR. SNODDERLY: No. I thought, I just was going --

(Laughter.)

MR. SNODDERLY: I think what can help us in our review is -- because I think what we're asking the Committee for right now is that the open items that we've identified are correct. And if there's something that we missed, let us know so that we can determine if we need to, or how to proceed.

Now, how do we address GE has performed their analyses, and they've explained how they calculated those analyses. And then we showed that we've done confirmatory analyses, that show that the design pressure is correct. I think that there -- we're trying to address uncertainties, and we've seen one place where there's uncertainty, is that there could be a build-up of non-condensables in the PCCS. There's a test program that shows that those non-condensables would probably burp through, but there's a chance that they could build up, and so we addressed that by saying provide a mitigative feature, or something that could do that. And they've done that with this drywell gas mixing system. And I think that it shows -- it provides greater margin. It has a system that I can analyze better, and understand better than a PARS system, that has, I believe, more uncertainty, and provides greater margin. So I'm a little -- I believe -- I don't want to let this opportunity slip away while we're all here with the people from GE, the Committee, so I want to really make sure -- do we have a good enough understanding of the non-condensables to make a regulatory decision? I think so. And I think --

CHAIRMAN CORRADINI: You're asking us

today?

MR. SNODDERLY: Well, I'm trying to determine where we go from here. To come back and to say we have to have a better understanding of where the non-condensables are, I think we've conservatively bounded it. Right? The worst case is that the non-condensables end up in the PCCS and affect its performance.

MR. WALLIS: And you say you blow them out with a fan? Is that the idea?

MR. SNODDERLY: Yes. And that --

mS. CUBBAGE: Recognize that the Committee ---- we haven't seen those results yet. GE hasn't provided them yet. We'll provide those results to you as soon as they come in, and we'll talk about them when we come back with the final SER, unless there's some --

CHAIRMAN CORRADINI: So let me talk -- suggest a path forward, because I think in some sense we covered a lot more of what I thought we'd be ending up doing in 15 today because it's all related to containment performance relative to ECCS, because we didn't have core uncovery as one of the issues. But a suggestion, I'll just go off with Said's point and connect it with Sanjoy's, maybe the members want to give me a list of things that apparently are details, but then will drive a common theme. And we try to get another day on what I'll call containment response, and if I were to pick one topic that I definitely want to start with, is that curve. That curve gets me a little bit crazy.

MR. SNODDERLY: Which curve, Mike?

CHAIRMAN CORRADINI: I get very unsettled when I turn on a fan at 72 hours to make things good by 20 percent.

MS. CUBBAGE: I mean, the alternative is you don't turn on the fan, and then the results were questionable, and that's why the staff had questions.

CHAIRMAN CORRADINI: I understand that, but I mean, just thinking out of the box, I'd rather vent out of the wetwell through a HEPA filter than turn on fans.

MEMBER BANERJEE: We're not doing a brainstorm here.

CHAIRMAN CORRADINI: I understand.

MEMBER BANERJEE: Right now we really --

CHAIRMAN CORRADINI: But my point is, what I would rather do is get together on a subcommittee with a set of issues, and at least start off with, to me, containment response as a starting point. But I think there's other issues that you guys have brought up relative to --

mEMBER BANERJEE: Stability needs to be looked at.

CHAIRMAN CORRADINI: Well, I wrote it down in terms of core chimney coupling, thermal hydraulic coupling. But to get a series of these, and I'd like to show them to the staff.

MS. CUBBAGE: Right.

CHAIRMAN CORRADINI: And see which ones are at a point where you feel you can come back and give us more detail, and which ones you're still analyzing, waiting for GEH response.

MS. CUBBAGE: Absolutely. And I think --

CHAIRMAN CORRADINI: And then bundle them, and then come back and have a subcommittee on that.

MR. WALLIS: I'd like to see the staff do some independent analysis of these non-condensables so that you really feel comfortable with that.

MR. SNODDERLY: And I think we can answer that question now. We are. It's conservative.

MR. WALLIS: Happy with this four fan, and six fan, and this mysterious huge amount you have to pump around. That's okay?

MR. SNODDERLY: Yes, because the analyses

- the concern, Graham, the concern is the sensitivity to the bypass leakage. That's what's unique here in this design, and the absence of wetwell sprays. So now bypass leakage is very important, and I think -- and what we tried to communicate to you today, is that the confirmatory analyses show that that's where the focus should be. And the non-condensable gases are conservatively bounded, conservatively modeled in the containment analysis, and the concern is their effect on possibly degrading PCCS performance.

MR. WALLIS: You see these plants as having to check their bypass leakage all the time with some instrumentation and stuff to be sure that they don't have more than a square centimeter?

MR. SNODDERLY: No more than what's done now, which would be an as-found, and as-left during the refueling outage.

MEMBER BANERJEE: So if the PCCS doesn't work, there's other problems that occur, in terms of getting water down to the GDCS system, long-term cooling. It's all coupled. This is a very coupled system, so you've got not just one thing to fix by blowing -- if you can blow the non-condensables and make sure the water goes back where it has to go, that's fine. But we really need to take a close look at this. I think what has happened is we've seen all these results. Some people have done MELCOR, some people have done TRACG, some people have done something else. It all has to be put together and brought to some order in our minds.

MR. SHUAIBI: Mike, if you don't mind, let me suggest, I think the suggestion was that the Committee was going to get together and come up with a list of things that you're interested in seeing. And maybe we could work through your staff, Gary Hammer, and see what the best way to deal with those items are. If it's getting you reports, we can do that. If it's having another meeting, then that's what needs to happen, and we can work on that.

CHAIRMAN CORRADINI: I think that might be the most effective way, because some things you are still analyzing, GEH is still doing calculations on. Other things may be wrapped up in a way that with four or five issues that seem disparate, all fit together in some calculation with an audit calculation that we could look at and kind of -- so it might occur in a month, it might occur in two months. We're going to have wait until other things you get, and look at.

MS. CUBBAGE: Right. And I can just tell you from -- we can talk schedule later, but from a timing perspective, I think it would be a challenge to come back before the end of March, just in light of where the status of different issues and different work load is.

CHAIRMAN CORRADINI: Thank you.

MEMBER MAYNARD: Something I think we need to keep in mind here, because one of the things that seemed to be confusing is the curve that shows then at 72 hours, all of a sudden we do something. And, again, that's for regulatory purposes, and for the analysis. In reality, that's not what's going to be going on. They're not going to be setting there for 72 hours. I think we need to keep that in mind. We may want somebody -- what we really expect to be going on.

MEMBER BLEY: What's really going to happen, analyze that.

MEMBER MAYNARD: I think we're getting a little confused, and from a regulatory standpoint they have to demonstrate that they can sit there basically hands-off doing nothing for 72 hours. And if you do that, yes, then at the end of 72 hours when you start doing something, you have more of a need to do it than if you've been doing it all along.

MEMBER BLEY: I think two things. I don't think any -- at least I didn't hear anybody on this Committee say they really understood those curves of what was happening in 72 hours, so that's one thing. The other is something you just said, Mike, which kind of -- I'm probably wrong on this, but I have to ask the question. I would be more comfortable analyzing the fan system and the recombiners, but chemical engineers I've worked with probably would say just the opposite. Do we have chemical engineers here looking at that, or are we nukes, and EEs and MEs?

MEMBER BANERJEE: I'm a chemical engineer.

MEMBER BLEY: And you're not the one who said you couldn't analyze the recombiners, or have as much confidence --

MR. SNODDERLY: And I think, Dennis, that's the last point I'll make, that part of what -- another challenge that we were looking at is, something else isn't typical. We don't have a safety-related active mixing system for the drywell. Okay? So when you take that away, and then you say well, we're going to look at four to six PARS, and say that that's going to solve our non-condensable gas problem, then it brings in something like chemical engineering kind of problems about poisons, reliability, mixing, and so the problem comes, what's the worst -- if I can't say for exactly where these non-condensables are going to go, because I have a one node model. I'm trying to bound this thing. What's the worst thing that can happen? Well, I have a bounding amount of non-condensables, and they end up in the PCCS. So I'm going to say that if that happens, I can solve that problem. That's why I think we're where we are today.

MR. KRESS: You think that's the simplest, most direct.

MR. SNODDERLY: That's where -- making a decision that I have to make --

MR. KRESS: You still have to say that even if you had --

MR. SNODDERLY: Yes. Right. Because otherwise they're going to come back, and have to justify the mixing, and the absence of an --

MR. WALLIS: The whole design basis of the PCCS is that the non-condensables don't end up in it. It's been designed so they don't, so I'm still concerned about --

MR. SNODDERLY: Well, if they don't, then Steve is there, and it's removing heat.

MEMBER BANERJEE: All the experiments show that they're clear, that there is a lot of evidence which shows they're clear. So in a way, if that can be pretty certain, then -- and we have to look at that in a little bit more detail, I think. You may have satisfied yourself, Mike, that there is sufficient uncertainty that you want a backup system there.

MR. SNODDERLY: We haven't satisfied you, and we need to do that. And as Mohammed said, let's work out what GE can do to explain their analyses, and what we can do to explain our confirmatory analyses.

VICE CHAIRMAN ABDEL-KHALIK: Just a point of information, Mr. Chairman. Has GE transmitted the results of their full-scale GE 14E testing to you?

MS. CUBBAGE: They have not. I heard earlier end of --

VICE CHAIRMAN ABDEL-KHALIK: What is the time line for that?

MS. CUBBAGE: -- March was probably a best case.

MR. MOEN: Yes, end of March time frame. Expect about the end of March.

CHAIRMAN CORRADINI: And the same for the flow induced vibration test?

MR. MOEN: I'm not sure what the schedule is for that. Steve Moen, GEH. I'm not sure what the schedule is for the FIV testing. We're still working that out with the staff, and, of course, internally.

MS. CUBBAGE: I don't think you're working --- you may be waiting to inform us, but the schedule is what you can deliver. Right?

CHAIRMAN CORRADINI: Okay.

MS. CUBBAGE: We're waiting for it.

CHAIRMAN CORRADINI: Any other comments by the members? So at least one action I hear is that I'm going to get from all of you individual comments, such as Said I saw already has a list. And I'll accumulate them, and with Gary work with Amy to see if that's a way to start thinking how to bundle it to, if you have -- if it's appropriate, and there's a point where you want to come back, how we can do it to be most efficient.

MS. CUBBAGE: Right. Because I think we need to get through the rest of the chapters with the SER with open items. Then we're going to be coming with the final at the end. There will be a window in-between where we can try to get some of these issues in, so they don't just all get saved up to the end when there's no time to resolve them.

MEMBER BANERJEE: My impression, though, from Mike's talk, Mike here, Mike's exposition on the mic - where is Mike? Is that he would like some sort of clarity on this relatively soon. Is that what --

MR. SNODDERLY: I didn't hear that.

MS. CUBBAGE: No. I think we've come to an understanding that you need to hear more, so that you get the same understanding level that the staff has with the issue. And, also, we all need to see these additional results that GEH is going to provide.

CHAIRMAN CORRADINI: Okay. Any other comments? Well, it's past our normal -- so thank you. We're recessed.

(Whereupon, the proceedings went off the record at 7:14 p.m.)

CERTIFICATE

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

Name of Proceeding: Advisory Committee on Reactor Safeguards

Docket Number: n/a

Location: Rockville, MD

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

Eric Hendrixson
Official Reporter
Neal R. Gross & Co., Inc.

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review

Chapter 21 of the Safety Evaluation Report
Testing and Computer Code Evaluation

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21

Review Team for Chapter 21:

- Project Manager
  - Shawn Williams
- Lead and Supporting Reviewers
  - Ralph R. Landry
  - Veronica Wilson
  - Edward Throm
  - Shanlai Lu
  - Muhammad Razzaque
  - James Gilmer
  - Weidong Wang
  - Ben Parks
  - Peter Yarsky
  - Jose March-Leuba, Consultant – ORNL
  - Jay Spore – Consultant - ISL
  - Andre Drozd
  - Syed Haider
  - Allen Notafrancesco
  - Jack Tills - Consultant

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21

RAI Status Summary

- Original RAIs: 111
- RAIs Resolved: 77
- Open Items: 34

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 21

Introduction Presented by
Ralph R. Landry
Senior Level Advisor
NRO/DSRA

January 17, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21

Outline of Presentation

- Applicable Regulations
- LOCA Open Items– W. Wang
- Transient Open Items – J. Gilmer
- Discussion Committee questions

  – Stability: Presented in Chapter 4
  – ATWS: Presented in Chapter 15

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21

Summary of TRACG Review Activities

- Testing and Scaling accepted 2004
  - Summarized in Chapter 21 SER
- LOCA Applicability accepted 2004
  - 20 confirmatory items to be resolved at the certification stage
  - Addendum SER with Open Items provided to ACRS
- Stability Applicability accepted 2006
  - 7 confirmatory items to be resolved at the certification stage
  - Addendum SER with Open Items provided to ACRS
- ATWS Applicability under review
  - SER with open items provided to ACRS
- Transients (AOO/IE) Applicability under review
  - SER with open items provided to ACRS

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

Summary of Regulations and Other Review Guidance

- 10 CFR 50.34/50.46
- SRP 6.3, "Emergency Core Cooling System"
- SRP Section 15.6.5 "Loss-of-coolant Accidents Resulting From Spectrum Of Postulated Piping Breaks within the Reactor Coolant Pressure Boundary"
- SRP Section 15.0.2 "Review of Transient and Accident Analysis Method"

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

- TRACG applicability to ESBWR LOCA
  - GEH submitted LTR NEDC-33083P "TRACG Application for ESBWR" in 2002.
  - Staff reviewed and accepted the TRACG code for analyzing ESBWR LOCA with 20 confirmatory items to be resolved at the certification stage
  - GEH submitted documents to address these confirmatory items and staff produced "Addendum with Open Items to the Safety Evaluation of NEDC-33083P-A"

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

Confirmatory Items

- Item #1 – Phenomena Identification and Ranking Table (PIRT) for Long-Term Core Cooling
  - High elevation breaks MSLB and FWLB ranks:
    - GDCS capacity relative to RPV volume
    - PCCS capacity relative to decay heat
  - Low elevation breaks GDLB and BDLB ranks
    - Lower drywell volume versus elevation
    - Break flow and pressure drop through DPVs
    - Others are similar to MSLB and FWLB
  - Staff Evaluation
    - Long-term LOCA PIRT did not identify unreviewed phenomena
    - Staff accepts the PIRT

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

Confirmatory Items

- Item #4 - Update TRACG Model Description
  - GE submitted a list of the changes from TRACG02 to TRACG04
  - The following models improved the accuracy ESBWR LOCA analysis:
    - Entrainment model
    - Flow regime map
    - Fuel rod thermal conductivity
      - RAI 6.3-54 requests GEH to justify use of this model

Confirmatory Items

- Item #4 (continued) - Update TRACG Model Description
  - Staff concurs that following updated models have no impact on ESBWR LOCAs are:
    - 3-D neutron kinetics model
    - Quench front model
    - Hot rod model
    - Minimum film boiling temperature
    - Cladding perforation and oxidation models
    - Enhanced pump homologous curves
    - Improved Boron model

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

Confirmatory Items

- Item #12 - Address Power Transient Resulting from MSIV Closure
  - GEH stated that there is no significant power transient because of MSIV closure since the control rods are always inserted before the MSIVs close for all breaks.
  - Staff agrees with the GEH assessment and concurs that this is not an issue for the ESBWR LOCA.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

Confirmatory Items

- Item #20 - Provide a list of changes to the ESBWR design since the review of NEDC-33083P-A
  - Changes affecting TRACG applicability
    - Core power: changed from 4000MW to 4500MW
      - RAI 21.6-75: confirm the applicability range of the GEH interfacial shear models.
    - ICS is now part of ECCS
      - Supplemental RAI 21.6-55: Staff requested additional information regarding the modeling of the IC, such as TRACG nodalization clarification and justification that the modeling of the IC heat removal capacity in the LOCA event is conservative

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

Confirmatory Items

- Item #20 (continued) Provide a list of changes to the ESBWR design since the review of NEDC-33083P-A
  - Staff concurs that the following changes do not affect the TRACG applicability
    - Core shroud size and core lattice
    - Number of bundles and control rod drives
    - GDCS pool and airspace location
    - PCCS units and capacity changed – diameter/pitch same as the tested
    - Pressure relief system - critical flow model is independent as the number of valves
    - FW control – assumed to be tripped in the beginning of the LOCA
    - Turbine bypass capacity
    - PCCS drain tanks removed – SBWR design and was accepted in the past

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

Confirmatory Items

- Item #10 The assumption of the loss of feedwater flow used by GEH is not conservative. (RAI 21.6-103)
- Item #11 Feedwater Heater Modeling
  - GEH added detailed modeling of the feedwater system currently under staff evaluation.
- Item #18 Uncertainty Analysis
  - (Discussed in Chapter 6.3)

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (LOCA)

Discussion/Committee Questions

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 21.6 (AOO's/IE's)

Presented by
NRO/DSRA/SRSB

January 17, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (AOO/IE)

Outline of Presentation

- Overview of TRACG Application to AOOs/IEs and regulatory requirements
- Open Items associated with the DCD review
- Review findings associated with the supporting topical reports

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (AOO/IE)

Summary of Regulations and other Review Guidance

- SRP Section 15.0.2 (Review of Transient Accident and Analysis Methods)
- Regulatory Guide 1.203 (Transient and Accident Analysis Methods)
- NUREG/CR-5249 (CSAU for LOCA)

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (AOO/IE)

TRACG Application for AOO/IE

- Described in NEDE-33083P, Section 4, and in RAI responses
- CSAU-Based Technical Evaluation (14 steps)
- Staff Independent Calculations
  - TRACE/PARCS code package

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (AOO/IE)

Open Items

- Isolation Condenser Modeling
  (RAI 21.6-55)
- PIRT Ranking of Parameters
  (RAI 21.6-64)
- Lower Plenum Cold Water Mixing

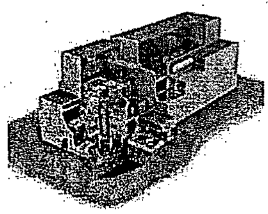
ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 21.6 (AOO/IE)

Discussion/Committee Questions

ESBWR - Overview
DCD Chapter 4 - Reactor

Advisory Committee on Reactor Safeguards

Gerald Deaver
Russ Fawcett
Noyem Jahingir
Stephan Moen
Pradip Saha
John Sorensen
Jun Yang
January 16-17, 2008
GE Hitachi Nuclear Energy



Presentation Content

- Section 4.1 – Summary Description
- Section 4.2 – Fuel System Design
- Section 4.3 – Nuclear Design
- Section 4.4 – Thermal & Hydraulic Design
- Section 4.5 – Reactor Materials
- Section 4.6 – Functional Design of Reactivity Control System
- Summary

Section 4.1 – Summary Description

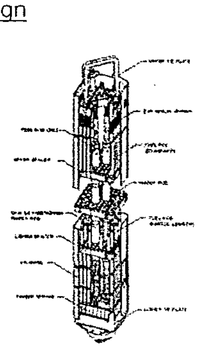
- Section 4.1 provides an overview description of the ESBWR reactor and provides a road map to the content of Chapter 4

Section 4.2 – Fuel System Design

- Section 4.2 Provides:
  - > Fuel Assembly and Control Rod Design Bases
  - > Fuel Assembly and Control Rod Description
  - > Fuel Assembly Design Evaluations
    - GSTRM analyses based on "worst case" or statistically bounding limits
    - Analysis operating conditions cover normal operation and postulated Anticipated Operational Occurrences (AOO)
  - > Control Rod Design Evaluations Demonstrate
    - Design meets stress, strain and cumulative fatigue criteria
    - Capability of insertion during all modes of plant operation
    - Mechanical compatibility with core and reactor internals
- The ESBWR Fuel System and Control Rod designs are similar to those utilized in currently operating BWRs with improvements based on BWR fleet operating experience

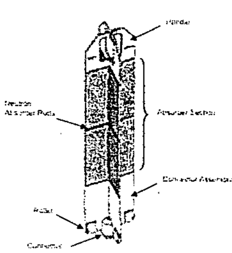
Section 4.2 – Fuel System Design

- Design Derived from GE14
  - > Proven Components
    - Exposures to 68000 MWD/MT
  - > Proven materials
  - > Fuel Design Basis and Testing Applies to ESBWR
- Differences
  - > Length reduced for dp
    - Increased fuel rod plenum
  - > PLR length reduced
  - > Spacer positions slightly altered



Section 4.2 – Fuel System Design

- The ESBWR Marathon control rod design is a derivative of the approved BWR/2 - /6 Marathon design
- Mechanical design margins are increased by design modification to accommodate B_4C swelling



Section 4.3 - Nuclear Design

- Section 4.3 Provides a description of:
  - > Nuclear Design Bases
    - – Reactivity basis prevents uncontrolled positive reactivity excursion
    - – Overpower bases for control of power distribution
  - > Nuclear Design Analytical Methods
    - – Steady-State Nuclear Methods
    - – Reactivity Coefficient Methods
    - – Stability Methods
  - > Nuclear Design Evaluation
    - – Negative reactivity feedback
    - – Control requirements
    - – Criticality during refueling
    - – Power distribution
    - – Stability

Section 4.3 - Nuclear Design

4500 MWth Rated Thermal Power

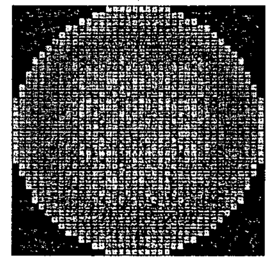
1132 Bundles
- > KKM 240 Bundles
- > ABWR 872 Bundles

269 Control Blades

FMCRDs (Fine Motion Control Rod Drives)
- > Fast Scram (good transient response)
- > Redundant Insertion
- > Reduced Fuel Duty (small notch size)

Moderate Power Density (54.3 KW/L)

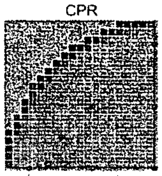
N-Lattice (symmetric water gap)
- > Same as ABWR
- > Improvement in CSDM



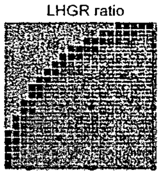
Section 4.3 - Nuclear Design

- Power shapes consistent with fleet experience
- Standard control rod patterns

CPR



LHGR ratio



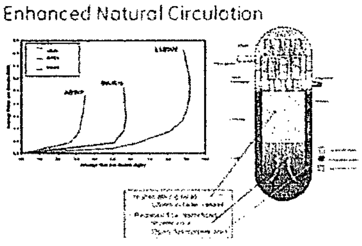
Section 4.4 - Thermal and Hydraulic Design

- Section 4.4 Provides Description of:
  - > Design Description
    - – Natural Circulation reactor coolant system configuration
    - – Power operating map (FW temperature control)
  - > Reactor Core Thermal & Hydraulic Design Bases
    - – Assure adequate margin to specified acceptable fuel design limits during normal operation and AOO
  - > Reactor Core Thermal & Hydraulic Design Methods & Evaluations
    - – Critical Power
    - – Core Thermal-Hydraulics
- The ESBWR design is similar to operating BWRs except that recirculation pumps and associated piping are eliminated

Section 4.4 - Thermal and Hydraulic Design

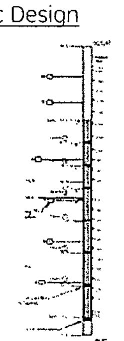
Natural Circulation in ESBWR vs. BWR

Enhanced Natural Circulation



Section 4.4 - Thermal and Hydraulic Design

- As part of DCD review, a conservative set of GEXL14 correlation statistics was developed for GE14E fuel
- Full scale Critical Power and Pressure Drop test of GE14E was completed in November
- GEXL14 correlation statistics are confirmed conservative for GE14E



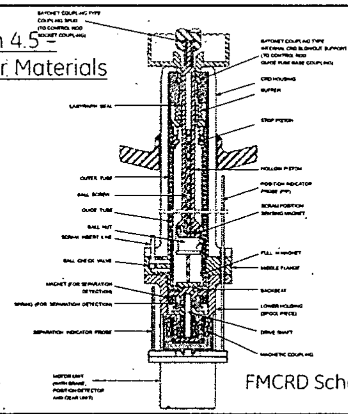
Test Assembly Schematic

Section 4.5 – Reactor Materials

Summary of Control Rod Drive Materials:

- For Fine Motion Control Rod Drives the materials are the same as ABWR which has not had any operational issues
- The following changes are being made to the FMCRD:
  - Induction motors are being used in place of stepper motors
  - Sealless design to minimize leakage and maintenance

Section 4.5 – Reactor Materials



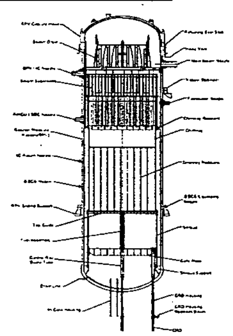
FMCRD Schematic

Section 4.5 – Reactor Materials

Summary of Reactor Internals Materials:

- All components are low carbon (0.02% Max) stainless steel except for the following which are Modified Nickel Alloy 600 per ASME Code Case N-580-1:
  - Shroud Support
  - Control Rod Drive Penetration Stub Tube
  - Chimney Head bolts (partial)
  - In-core Guide Tube Restraints (partial)
  - Guide Rods (partial)
- Castings are used for Orifice Fuel Support, Feedwater End Brackets, and Steam Separator Swillers
- XM-19 is used for bolting
- X-750 is limited to Chimney Bolt Retainer Springs

Section 4.5 – Reactor Materials



Section 4.6 – Functional Design of Reactivity Control System

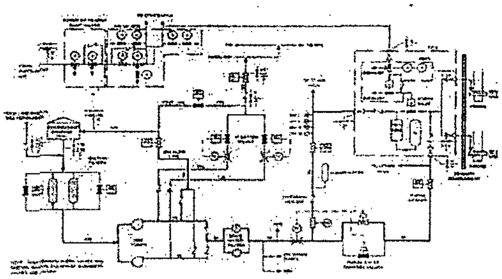
Control Rod Drive System

- Same as traditional BWR systems except it now includes the supply of non-safety high pressure makeup water
- Three major elements:
  - Fine Motion Control Rod Drives (269)
  - Hydraulic Control Units (135)
  - Control Rod Drive Hydraulic subsystem

Section 4.6 – Functional Design of Reactivity Control System

- FMCRDs provides electric motor driven positioning for normal rod movement, and hydraulically powered rod insertion during abnormal conditions
- HCUs provide hydraulic power for SCRAM
- CRDHS provides demineralized water that is regulated and distributed to the HCUs and FMCRD purge flow

Section 4.6 – Functional Design of Reactivity Control System



Control Rod Drive System

Summary

- Chapter 4 Provides Description of the ESBWR Reactor, Including Design Bases, Design Features, Design Evaluation Methodology, Materials, and Performance Analyses.
- GEH is Working With the NRC Staff To Address Remaining Open Items

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter **4**

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4

Outline of Presentation

- Brief the Subcommittee on the staff's ongoing review of the ESBWR DCD application:
  - 4.2 "Fuel System Design"
  - 4.6 "Functional Design of Fine Motion Control Rod Drive System"
  - 4.3 "Nuclear Design"
  - 4.4 "Thermal Hydraulic Design"
  - 4D & 21.6 "Stability"
- Answer the Committee's questions

* 4.5 "Reactor Materials" Will not be part of today's presentation but technical reviewers are available to answer questions if required.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4

Review Team for Chapter 4

- Lead PM
  - Bruce Bavol
  - Amy Cubbage
- Lead Technical Reviewers
  - Paul Clifford
  - George Thomas
  - Dr. Peter Yarsky
  - James Gilmer
  - Dr. Weidong Wang
  - Dr. Jose March-Leuba, ORNL
  - Robert Davis
  - Nihar Ray

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4

Summary of Regulations and other Review Guidance

- GDCs: 10, 11, 12, 13, 20, 25, 26, 27, 28

Guidance From:

- SRP Section 4.2
- SRP Section 4.3
- SRP Section 4.4
- SRP Section 4.6

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4

RAI Status Summary

- Original number of RAI's - 184
- Number of RAI's resolved - 150
- Number of Open Items - 34

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter **4.2**
Fuel System Design

Presented by
Paul Clifford
NRR/DSS

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Fuel System Design

ESBWR Fuel Design Criteria:

- Fuel assembly and fuel rod design requirements consistent with currently operating fuel designs.
- Control blade design requirements consistent with currently operating blade designs.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Fuel System Design

Open Items with Fuel Design Criteria:

- Allowance for limited fuel centerline melting during Anticipated Operational Occurrences (AOOs).
- Fuel cladding strain capability.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Fuel System Design

GE14E Fuel Assembly Design:

- Ongoing review of NEDC-33240P "GE14E Fuel Assembly Mechanical Design Report" and NEDC-33242P "GE14 for ESBWR Fuel Rod Thermal-Mechanical Design Report".
  - FRAPCON-3 used to perform independent calculations to validate GE14E fuel rod design.
  - Audit of supporting GEH engineering calculations.
- Significant operating experience with nearly identical GE14 design.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Fuel System Design

Open items with GE14E Fuel Assembly

- Awaiting flow-induced vibration test results.
- Fuel rod corrosion limits required.
- GSTRM Part 21 evaluation.
- Revision expected for each topical report.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Fuel System Design

ESBWR Marathon Control Blade Design:

- Ongoing review of NEDE-33243P "ESBWR Marathon Control Rod Nuclear Design Report" and NEDE-33244P "ESBWR Marathon Control Rod Mechanical Design Report".
  - Audit of supporting GEH engineering calculations.
- Significant operating experience with nearly identical Marathon design.

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ESBWR Design Certification Review
Fuel System Design

Open Items with Control Blade Design:

- B_4C swelling rate in question.
- Irradiated stainless steel properties in question.
- Operating experience identified potential design flaws.
- GEH has re-designed the ESBWR control blade design. Revision 01 for each topical report recently received.

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ESBWR Design Certification Review
Fuel System Design

Summary:

- Multiple issues which have necessitated revisions to the ESBWR DCD and supporting topical reports.

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Fuel System Design

Discussion/Committee Questions

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Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Fine Motion Control Rod Drive System (FMCRD) Design
Chapter 4.6

Presented by
George Thomas
NRO/DSRA/SRSB

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
FMCRD System Design

- FMCRD Design is similar to the ABWR Design approved in 1997
- Operating experience – In Japan, ABWRs have demonstrated the ability to build and operate the FMCRD system meeting the requirements of the safety analyses.
- Failure Modes and Effects Analysis (FMEA) performed for the ABWR is applied to the ESBWR

DCD Open Items for FMRD System Design Section

- No issues with hardware
- Performance characteristics of the control rod drive system are explicitly credited in the Chapter 15 safety analyses. (RAIs 4.6-27 and 4.6-28)
- Control Rod Drop Accident analysis is an open item in Chapter 15 (RAI 4.6-23)

ACRS Subcommittee Presentation
ESBWR Design Certification Review
FMCRD System Design

<u>Discussion/Committee Questions</u>

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter **4.3**

Presented by
Dr. Peter Yarsky
NRO/DNRL/NGE1 and NRR/DSS/SNPB

January 16, 2008

ACRS Subcommittee Presentation ESBWR Design Certification Review Chapter 4.3

<u>SER Technical Topics of Interest</u>

- NEDC-33179P "Gamma Thermometer System for LPRM Calibration and Power Shape Monitoring"
- NEDC-33239P "GE14 for ESBWR Nuclear Design Report"
- NEDC-33326P "GE14E for ESBWR Initial Core Nuclear Design Report"
- NEDO-33338 "ESBWR Feedwater Temperature Operating Domain Transient and Accident Analysis"

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4.3

Significant Open Items

- In-core instrumentation (GDC 13)
  - Automated Fixed In-core Probes (AFIPs) to replace the Traversing In-core Probe (TIP) system in operating BWRs
- Neutronic Methods (GDC 10)
  - Applicability of historically determined methods uncertainties to the ESBWR

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ESBWR Design Certification Review
Chapter 4.3

Significant Open Items

- Plan for resolution:
  - Audit core monitoring software and methods
  - Apply appropriate conservatism where required to resolve methods related issues

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4.3

Initial Core

- Previously identified Chapter 4.3 COL Action Items are being addressed through initial core design topical reports (NEDC-33326P)
- Staff intends to resolve several of these items through RAIs for the new submittals

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4.3

Significant Design Changes and New Submittals

- Feedwater Temperature / Power Operating Domain (NEDO-33338P)
- Initial Core Nuclear Design (NEDC-33326P)

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ESBWR Design Certification Review
Chapter 4.3

Discussion/Committee Questions

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UNITED STATES NUCLEAR REGULATORY COMMISSION

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter **4.4 (Core Thermal and Hydraulic Design)**

Presented by
James Gilmer
NRO/DSRA/SRSB

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4.4: Methods

- Core Thermal and Hydraulic Design Methods
  - Proposed fuel is GE14E, a shortened version of the GE14 fuel currently used in the Operating Fleet
  - Core flow, pressure drop, and heat transfer analyses utilize TRACG methods
  - An OLMCPR penalty has been proposed to account for uncertainties (e.g. total core flow measurement, bundle power uncertainty)
  - Critical Power Correlation (GEXL14) based on approved method applied to Operating Fleet GE14 fuel
  - GEXL14 Correlation uncertainty based on ATLAS facility and STERN Laboratory test data of GE14 fuel for the full range of ESBWR conditions
  - GE14E specific tests conducted

Significant Review Activities

- Critical Power Correlation, Uncertainty, and OLMCPR Development Topical Report (NEDC-33237P)
- Initial Core Transients Topical Report (NEDO-33337P)
- Feedwater Temperature Operating Domain Topical Report (NEDO-33338P)

Current Open Items

- Critical Power testing for GE14E fuel
- High Void Fraction data
- CPR confirmatory studies with COBRAG
- Critical Power Uncertainty evaluation
- Determination of R-factor specific to GE14E fuel

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4.4: Methods

Summary:

- Staff finds the thermal-hydraulic methods described in DCD Rev. 3 acceptable for the ESBWR design
- GEXL Correlation uncertainty must be re-evaluated using the new GE14E test data.

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4.4

Discussion/Committee Questions

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter **4.D – Stability, and**
Chapter **21.6 - TRACG Analysis Methods for ESBWR Stability**

Presented by
Dr. Weidong Wang
Dr. Jose March-Leuba, ORNL
NRO/DNRL/NGE1 and NRO/DSRA/SRSB

January, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

Summary of Regulations and other Review Guidance

- GDC 12 – Oscillations are either not possible or readily detected and suppressed
- GDC 10 – If oscillations develop, the Reactor Protection System prevents SAFDL violations
- Guidance from
  - SRP 15.9 "BWR Stability"
  - SRP 15.0.2 "Review of Transient and Accident Analysis Methods"

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

SER Technical Topics of Interest

- The review of ESBWR stability has covered three general areas
  - Core stability
    - Channel, core-wide, and regional oscillations
  - Chimney stability
    - Density oscillations
  - Startup stability
    - Low pressure startup with nuclear heat
- All areas covered in the staff SER and presented to ACRS in 2006 during the TRACG review

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

SER Technical Topics of Interest (Previously Issued)

- TRACG methods are documented in NEDE-33083PA, "TRACG Application for ESBWR," dated March 2005, which includes:
  - Large- and small-break LOCA
  - Containment analysis
  - AOO's
  - Stability (NEDE-33083PA Supplement 1)
  - ATWS (NEDE-33083PA Supplement 2)

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

TRACG SER Technical Topics of Interest (cont)

- TRACG use was previously approved for ESBWR stability analysis with confirmatory items to be resolved at the certification stage.
  - Channel, core-wide, and regional decay ratio (DR) for steady-state operation
- TRACG not approved to calculate DRs during transients, but can be used for:
  - Demonstration of stability after AOOs
  - Demonstration of stability during startup, and determination of maximum startup heat up rate

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

TRACG SER Technical Topics of Interest (cont)

- TRACG SER main stability conclusions:
  - TRACG is capable of predicting oscillatory behavior in reactor power and flow for ESBWR.
  - TRACG is capable of tracking a density wave.
  - TRACG's numerics will permit an oscillation to occur, and they will not cause it to occur.
  - TRACG stability procedure can calculate a decay ratio for steady state conditions
  - TRACG is able to predict oscillations during the startup trajectory for the early startup phases

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

TRACG SER Technical Topics of Interest (cont)

- TRACG SER Conclusions are based on
  - Review of TRACG physical models
  - Numerical-damping evaluation
    - Fine nodalization, including chimney
  - TRACG qualification, including
    - Natural circulation benchmarks (Dodewaard, CRIEPI-SIRIUS, PANDA)
    - Benchmarks of operating reactor stability events (Peach Bottom, Leibstadt, Forsmark, ...)
  - Confirmatory calculations
    - TRACG by the Staff, LAPUR

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

Design Certification Topics of Interest

- TRACG results indicate that
  - ESBWR design is stable at nominal conditions
  - Regional instability mode is dominant
    - Decay ratio ~0.4 (CSAU)
    - Within acceptance criteria DR < 0.8
  - Chimney has small effect on stability.
    - No chimney flow oscillations predicted
  - Startup instabilities not expected at nominal heat up rate of 50 MW/hr

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

SER Technical Topics of Interest (cont)

- GDC 12 is satisfied because instabilities are highly unlikely in ESBWR
  - Future ESBWR core loadings will guarantee GDC 12 compliance by calculation
- ESBWR provides defense in depth to comply with GDC 12 and 10 with a Detect and Suppress stability solution
  - DCD Rev 4 specifies the use of DSS/CD

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

Significant Open Items

- TRACG input data issues
  - Physics data generation (cross section)
  - Dynamic gap conductance model
- Fuel-specific issues
  - GE14E for ESBWR (Chapter 4.2)
  - CPR (GEXL) correlation (Chapter 4.4)
- ATWS-Stability analysis not complete. RAIs issued
- Startup – constant Xenon assumption questioned

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 4-D & 21.6 Stability

Discussion/Committee Questions

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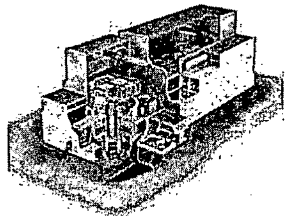
GEH Nuclear Energy

Chapter 4
GEH ESBWR Stability Evaluation



January 16, 2008

Dr. Jun Yang

HITACHI

Licensing Requirements

- General Design Criterion 10 (Reactor Design) requires that:
  "..specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences."
- General Design Criterion 12 (Suppression of Reactor Power Oscillations) requires that:
  "power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed."

ESBWR Stability Licensing Basis

- Based on TRACG stability analysis results, a high degree of confidence is established that oscillations will not occur by imposing conservative design criteria on the channel, core wide and regional decay ratios under all conditions of normal operation and anticipated transients.
- Further, the ESBWR will implement a Detect and Suppress Solution as a defense-in-depth system.

Types of Stability Analyses for ESBWR

- Coupled neutronic-thermal-hydraulic instabilities
  - Density-wave induced (Type 2)
    - Single-channel mode
    - In-phase Core-wide mode
    - Out-of-phase Regional mode
  - Condensation/Flashing induced (Type 1)
    - Flow oscillation during plant startup
- Xenon Transients

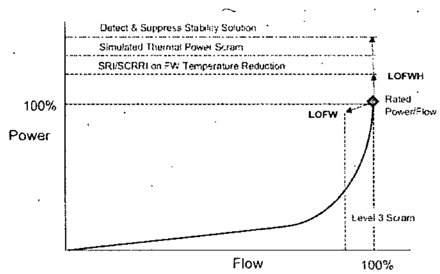
Limiting DR Results under Rated Condition

	Core-wide DR	Hot Channel DR	Regional DR
Acceptance Criteria	**0.8**	**0.8**	**0.8**
Equilibrium Core	0.41	0.25	0.53
Initial Core	0.28	0.16	0.43

- Additional analysis was conducted at small exposure increments through the cycle in order to make sure that the worst exposure level in terms of Stability is captured. It is determined that the limiting exposure is at the Peak Hot Excess (PHE) cycle point for both equilibrium core and initial core.

Preliminary Information under GEH Verification

Limiting Conditions for AOO Stability



LOFWH (Loss-of Feedwater Heating)
LOFW (Loss-of Feedwater Flow)

DR Results for Limiting AOOs

	Regional DR
Acceptance Criteria	**0.8**
Equilibrium Core, LOFWH, (100% Power, 420F FW Temp)	0.66
Equilibrium Core, LOFW, (100% Power, 420F FW Temp)	0.58

- As the feedwater temperature drops during LOFWH, power increases gradually. SRI/SCRRI (Select Rod Insert/Selected Control Rod Run-In) is initiated automatically upon the detection of FW temperature reduction of 30°F or higher during AOOs and limits the power increase. Therefore, the stability during AOOs is assured by SRI/SCRRI and the scram protection.
- Adequate margin is maintained to the stability design criteria during AOOs.

ESBWR Plant Startup Stability Summary

- TRACG calculates small flow oscillations when voiding begins in the separators
  - During this phase,
    - Core flow is single phase
    - No oscillations in neutron flux
    - Large thermal margins (CPR >20)
  - Stable void fraction established in separators and chimney
- Smooth ascension to rated pressure and power
- Startup flow oscillations pose no threat to any thermal limits

Conclusion

- TRACG04 is approved by NRC for licensing analysis of ESBWR stability margins during normal operation and anticipated transients
- Based on TRACG analysis, it is demonstrated that ESBWR meets the stability design criteria and compliance with GDC 10 and 12 is assured.

21.6 NEDE-33083P, SUPPLEMENT 1 SER Confirmatory Items

1, 2 & 3. Physics Parameters, Fuel design, Critical Power Correlation

- No change from Fuel Design & Physics uncertainty parameters from SER,
- Stability results are insensitive to CPR correlation

4. Stability during Anticipated Transient without Scram

GEH provided documentation that ESBWR is stable (No limit cycle oscillations) during ATWS

21.6 NEDE-33083P, SUPPLEMENT 1 SER Confirmatory Items (cont'd)

5. **Detect & Suppress Function – Defense in Depth**
   ESBWR employs an LPRM based function which assures clad damage is avoided. Additional design detail on the DSS function is being provided.

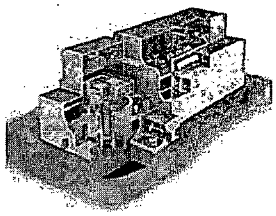
6. **Startup Stability**
   GEH provided documentation that ESBWR is stable during startup. Additional evaluations are in progress for power levels above the TS heat-up rates, and with peaking which conservatively bounds Xe transients.

7. **Gap Conductance**
   GEH is employing the approved GESTR gap conductance model, and the PRIME pellet conductance model, which produces a conductance similar results to the GESTR pellet conductance.

ESBWR - Overview
DCD Chapter 6
Engineered Safety Features

Advisory Committee on Reactor Safeguards

Jerry Deaver
Brian Frew
Chester Cheung
January 16-17, 2008



GE Hitachi Nuclear Energy

Presentation Content

- Section 6.1 – Engineered Safety Features Materials
- Section 6.6 - Preservice and Inservice Inspection and Testing of Class 2 and 3 Components and Piping
- Section 6.2 - Containment Systems
- Section 6.3 - Emergency Core Cooling Systems
- Summary

Section 6.1 – Engineered Safety Features Materials

- Section 6.1 Provides Description Of:
  - > Material Selection to Ensure That Material Interactions Do Not Occur That Can Potentially Impair Operation of Engineered Safety Features
  - > Material Selection (Metallic and Organic) to Withstand the Environmental Conditions Encountered During Normal Operation and Postulated Accidents
- The ESBWR Incorporates Materials Similar to Those Utilized in Past BWR Designs With Improvements Based on BWR Fleet Operating Experience

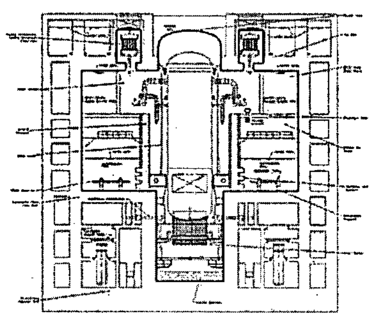
Section 6.6 – Preservice and Inservice Inspection and Testing of Class 2 and 3 Components and Piping

- Section 6.6 Provides Description Of:
  - > Class 2 and 3 System Boundaries
  - > Accessibility Requirements To Facilitate Preservice and Inservice Inspection and Testing
  - > Examination Categories and Methods
  - > Inspection Intervals
  - > Evaluation of Examination Results
  - > System Pressure Tests
  - > Augmented Inservice Inspections
  - > Code Exemptions and Code Cases
  - > Plant Specific Program Information
  - > COL Information

Section 6.2 – Containment Systems

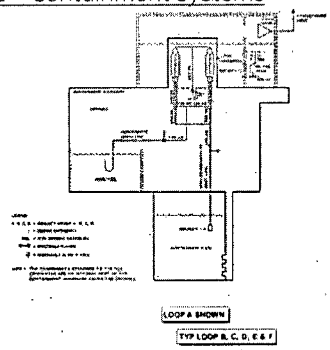
- Section 6.2 Provides Description Of:
  - > Containment Systems Functional Design Features
    - – Pressure Suppression Containment System, Including Drywell (DW), Wetwell (WW), Passive Containment Cooling System (PCCS), Containment Isolation, and Supporting Systems
  - > Containment Systems Performance Analyses
    - – Containment Pressure and Temperature Nominal and Bounding Analyses
    - – Negative Pressure Evaluation
- The ESBWR Incorporates Pressure Suppression Containment System Similar to Those Utilized in Past BWR Designs With Passive Cooling and Improvements Based on BWR Fleet Operating Experience

Section 6.2 – Containment Systems



Containment System

Section 6.2 – Containment Systems



Passive Containment Cooling System

Section 6.2 – Containment Performance Analyses

- Evaluation Model
  - > TRACG code application for ESBWR containment performance had been reviewed and accepted by ACRS (2/2004)
  - > Additional studies were performed to address the SER confirmatory items, design changes and nodalization changes
- Containment Systems Performance Analyses
  - > Containment Pressure and Temperature for Nominal and Bounding Analyses
  - > Negative Pressure Evaluation
- Representative spectrum of guillotine breaks
  - > Feedwater Line (FWL), GDCS Line (GDL), Bottom Drain Line (BDL)
  - > Main Steam line (MSL)

Section 6.2 – Cont. Performance Analyses (continued)

- Conservative Models used to maximize the long-term containment pressure
  - > All non-condensable gases purged to wetwell (WW)
  - > No mixing allowed in suppression pool
  - > No mixing allowed in WW gas space
- Drywell to Wetwell bypass leakage area assumed
  - > Design basis: 1 cm^2 ($A/\sqrt{k}$)
  - > Leakage rate to be assured by drywell to wetwell bypass leakage test
- MSL break produced maximum DW pressure (0-72 hrs)
  - > Nominal calculation: Max. DW Press.=354.8 kPa **(18.9% margin)**
  - > Bounding calculation: Max DW Press.=384.6 kPa **(9.3 % margin)**

Section 6.2 – Cont. Performance Analyses (continued)

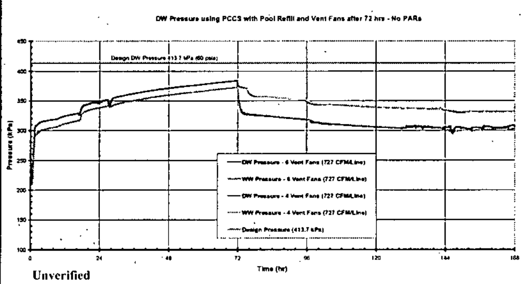
- Systems credited in performance analyses

Time after break	0 - 3 (days)	3 + (days)
Systems credited	PCCS; ADS; GDCS; IC (drain line inventory) SLCS (liquid inventory)	IC/PCC pool makeup; *Passive Autocatalytic Recombiners (PARS); Drywell gas recirculation fans; FAPCS/RWCU (Defense-In-Depth)*
Containment responses	DW pressure reaches max. at 72 hrs. (DCD Sect. 6.2 results)	Rapid reduction and continued control of DW pressure, well below design value

•Drywell gas recirculation fans take suction from PCC vent line, and discharge the non-condensable gases to GDCS gas space.

Section 6.2 – Cont. Performance Analyses (continued)

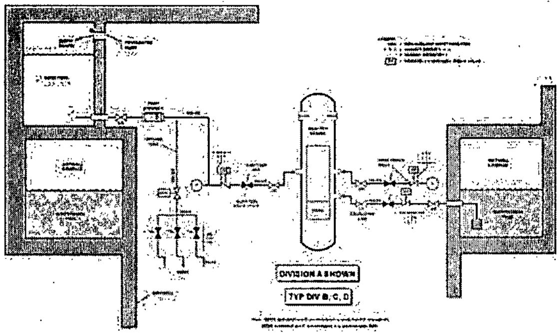
•Main Steam Line break, bounding calculations
- IC/PCC pool refilling at 72 hrs
- Drywell gas recirculation fans initiated at 72 hrs



Section 6.3 – Emergency Core Cooling Systems

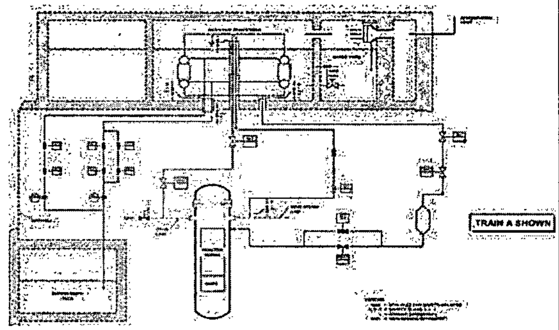
- Section 6.3 Provides Description Of:
  - > Emergency Core Cooling Systems Functional Design Features
    - Passive Gravity-Driven Cooling System Injection
    - Passive Isolation Condenser System Injection
    - Passive Standby Liquid Control System Injection
    - Automatic Depressurization System Using Depressurization Valves
  - > Emergency Core Cooling Systems Performance Analyses
    - Reactor Pressure Vessel Level Analyses Verify No Core Uncovery
    - Short-Term and Long-Term Core Cooling Analyses
- The ESBWR Incorporates Passive Emergency Core Cooling Systems Considering BWR Fleet Operating Experience Providing Significant Core Cooling Capability

Section 6.3 – Emergency Core Cooling Systems



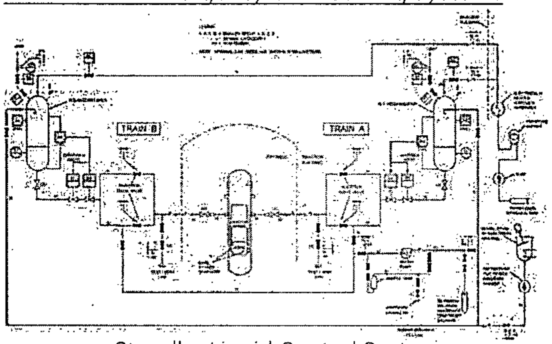
Gravity-Driven Cooling System

Section 6.3 – Emergency Core Cooling Systems



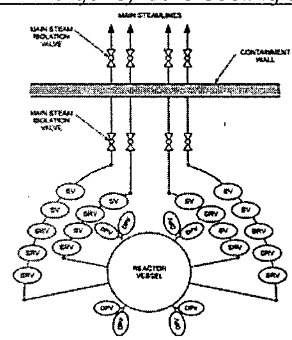
Isolation Condenser System

Section 6.3 – Emergency Core Cooling Systems



Standby Liquid Control System

Section 6.3 – Emergency Core Cooling Systems



Automatic Depressurization System

Section 6.3 – ECCS Performance Analyses

- Evaluation Model
  - > TRACG code: application for ESBWR ECCS performance had been reviewed and accepted by ACRS (2/2004)
  - > Additional studies were performed to address the SER confirmatory items, design and nodalization changes
- ECCS Performance Analyses
  - > Same TRACG nodalization as that used for containment analyses
  - > Short-Term (0-2000 sec.) and Long-Term Core Cooling Analyses
  - > Reactor Pressure Vessel Level Analyses Verify No Core Uncovery and No Fuel Heatup

Section 6.3 – ECCS Performance Analyses (continued)

- Short-term (0-2000 sec) analyses
  - > Nominal calculations
    - – Break spectrum: all 9 RPV penetrations analyzed with 3 single failures
      - Main Steam Line, Feedwater Line, GDCS Injection Line, and Bottom Drain Line (DCD Section 6.3)
      - DPV stub tube, SDC suction line, IC return line, GDCS equalization line (RAI 6.3-46)
      - SLCS injection line (RAI 6.3-65)
    - – Minimum chimney static head = 8.90 m, or **1.5 m** measured from the Top of Active Fuel (TAF)
    - – Chimney static head increases shortly after GDCS injection
    - – Limiting break locations (Main Steam Line and GDCS Injection Line) selected for bounding calculations
  - > Bounding calculations
    - – Limiting case: GDCS Injection Line break with 1 injection valve failure
    - – Minimum chimney static head = 8.61 m, or greater than **1 m** measured from the Top of Active Fuel (TAF)

Section 6.3 – ECCS Performance Analyses (continued)

- Long-term (0-72 hrs) analyses
  - > Containment performance analyses performed for DCD 6.2 demonstrate chimney static head at greater than 8.5 m (1 m above TAF) for a period of 72 hrs
- Beyond 72 hrs evaluation (response to RAI 6.3-79)
  - > GDCS line and bottom drain line breaks evaluated (break elevation less than 13 m)
  - > Other breaks evaluated (break elevation greater than 13 m)
  - > RPV level remains at greater than 8.5 m (1 m above TAF) for a period of 30 days
- All long-term analyses demonstrate RPV level remains at least 1 m above TAF

Summary

- Chapter 6 Provides Description of ESBWR Engineered Safety Features, Including Materials, Inspection and Testing Requirements, Design Features, and Performance Analyses
- GEH Is Working With the NRC Staff To Address Remaining Open Items

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review

Chapter 6
Engineered Safety Features

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6

Review Team for Chapter 6:

- Project Manager
  - Shawn Williams
- Lead Technical Reviewers
  - 6.1.1: Robert Davis
  - 6.1.2: Yamir Diaz-Castillo
  - 6.2.1, 6.2.1.1.C, 6.2.1.2, 6.2.1.3: Hanry Wagage
  - 6.2.2: Andrzej Drozd
  - 6.2.3: Edwin Forrest
  - 6.2.4, 6.2.5, 6.2.6: Raj Goel
  - 6.2.7: Nihar Ray
  - 6.3: George Thomas, Weidong Wang, Veronica Wilson
  - 6.4: Edwin Forrest
  - 6.5: Jay Lee
  - 6.6: Robert Davis

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6

Outline of Presentation

- RAI Status
- Significant Open Issues SER 6.1/6.6
- Significant Open Issues SER 6.2
- Significant Open Issues SER 6.3
- Discussion/Committee Questions

*Chapter 6.4 was discussed at the November 15, 2007, ACRS SC Meeting
*Chapter 6.5 will be discussed with Chapter 15.4 on January 17, 2008

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6

RAI Status Summary

- Original RAIs: 306
- RAIs resolved: 215
- Open Items: 91

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Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 6.1, "Engineered Safety Feature Materials"
Chapter 6.6, "Preservice and Inservice Inspection and Testing of Class 2 and 3 components and Piping"

Presented by
NRO/DE/CIB2

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6 – SER Section 6.1.1

<u>Engineered Safety Feature (ESF) Materials</u>

- ESF materials were found to comply with the requirements of ASME Code, Section III
- Fabrication of ESF components comply with the requirements of ASME Section III
- Materials and processing of stainless steels conform with the guidance in NUREG-0313, Rev. 2 and RG 1.44
- Cleaning and cleanliness controls conform with the guidance of RG 1.37

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6 – SER Section 6.1.1

Open Items

- Isolation condenser material specifications, fabrication and processing of Alloy 600 tubing
- PCCS heat exchanger material specifications, fabrication and processing of 304L tubing

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6 – SER Section 6.6

Preservice and Inservice Inspection of ASME Code Class 2 and 3 Components

- With the exception of Open Items, PSI and ISI of Class 2 and 3 systems were found to comply with the requirements of 10 CFR 50.55a and ASME Code, Section XI
- Development of the preservice inspection (PSI) and inservice inspection (ISI) programs is the responsibility of the COL Holder
- All items within the Class 2 and 3 boundaries are designed to provide access for the examinations required by IWC-2500 and IWD-2500

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6 – SER Section 6.6

Augmented Examinations

- Augmented ISI to protect against postulated piping failure between the containment isolation valves will be performed as described in SRP Section 6.6

- Augmented inspections as described in GL 89-08, to detect and monitor potential wall thinning of high-energy piping by erosion/corrosion will implemented. Inspections will include all susceptible ASME Code Class 1, 2, 3, and non-code class piping

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6 – SER Section 6.6

Open Items

- ISI of austenitic and dissimilar metal welds and proposed use of radiography

- Inspection of IC and PCCS heat exchangers

COL Action Items

- The COL applicant will provide a description of the PSI/ISI programs for Class 2 and 3 components and piping. The COL applicant will also provide a milestone for full program implementation.

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6 – SER Section 6.1 and 6.6

Discussion/Committee Questions

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Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 6.2

Presented by
NRO/DSRA/SBCV

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
SER Section 6.2 Containment Systems

SER Section		Reviewer
6.2.1	Containment Functional Design	Hanry Wagage
6.2.2	Passive Containment Cooling System	Andrzej Drozd
6.2.4	Containment Isolation System	Raj Goel
6.2.5	Combustible Gas Control in Containment	Raj Goel

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Section 6.2.1 Containment Functional Design and
Section 6.2.2 Passive Containment Cooling System

Design Features

- Drywell and wetwell
- Drywell to wetwell flow paths: vertical/horizontal vents, PCCS vents, SRV discharge lines, and vacuum breakers.

Significant Open Items

- Containment subcompartment analysis (RAI 6.2-23)
- Containment debris protection for ECCS strainers (RAI 6.2-6)
- Amount of unqualified coatings inside containment (RAI 6.1-16)
- Meeting GDC 50–Containment design basis (RAI 6.2-140)
- Drywell to wetwell bypass leakage (RAI 6.2-145)
- Meeting GDC 38–Containment heat removal (RAI 6.2-139)

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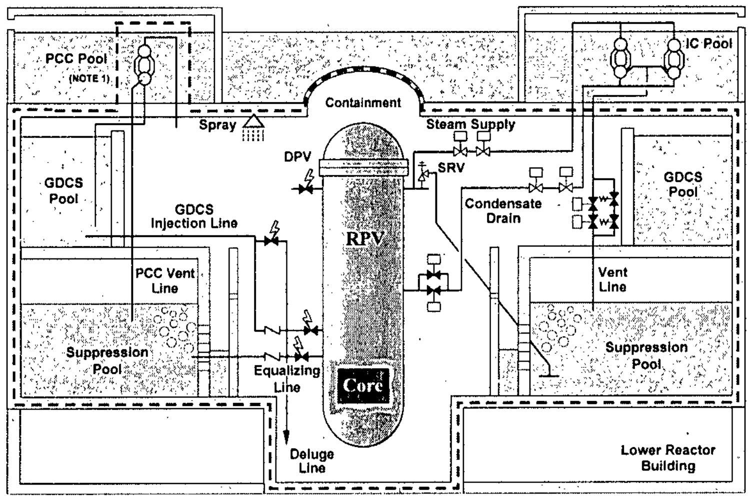

Figure 1. A schematic of ESBWR containment (DCD Figure 6.2-15)

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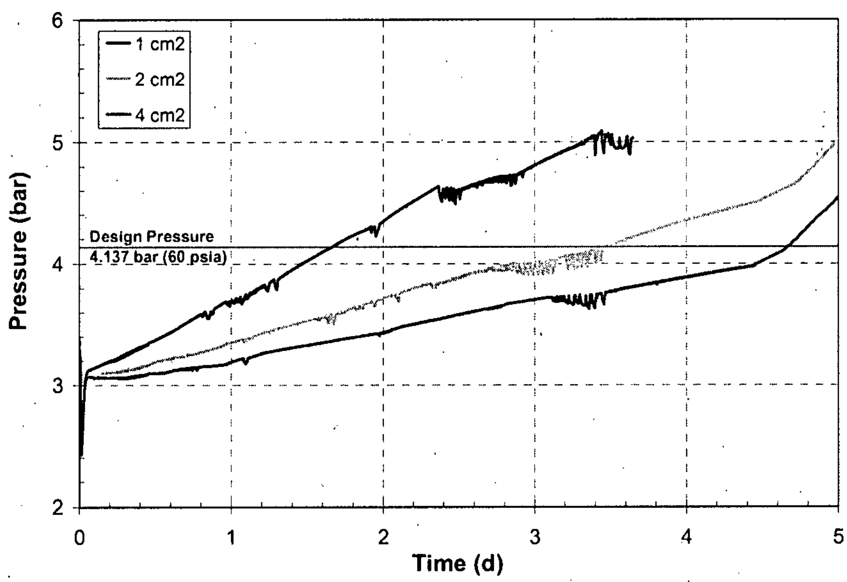

Figure 2. MELCOR predicted ESBWR drywell pressure: sensitivity to bypass leakage w/o PCC pool refill

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Section 6.2.1 Containment Functional Design

Table 1. Drywell to Wetwell Bypass Leakage (A/√K) for Different BWRs

Type	Wetwell Free Gas Space Volume (ft^3)	Design Leakage		Surveillance Test Leakage Acceptance Criteria		Comment
		Value (cm^2 (A/√K))	Reference	Value (cm^2 (A/√K))	Reference	
Mark I (Dresden 2)	112,800	167	SR 3.6.1.1.2	3.3	SR 3.6.1.1.2	Test criterion is 2% of the design value.
Mark II (Susquehanna 1)	148,590	49.7	FSAR Table 6.2-25	4.97	SR 3.6.1.1.2	Test criterion is 10% of the design value.
Mark III (Grand Gulf 1)	1,400,000	836	UFSAR Section 6.2.1.1.5.7	83.6	SR 3.6.5.1.1	Test criterion is 10% of the design value.
ABWR	210,500	5	DCD Section 6.2.1.1.5.3	5	DCD Section 6.2.1.1.5.7	The bypass leakage w/ sprays is 50 cm^2 (A/√K) (DCD Section 6.2.1.1.5.4).
ESBWR	191,800	1	DCD Section 6.2.1.1.5.1	2	DCD Section 6.2.1.1.5.4.3	Proposed test criterion is 200% of the assumed design value.

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Section 6.2.1 Containment Functional Design

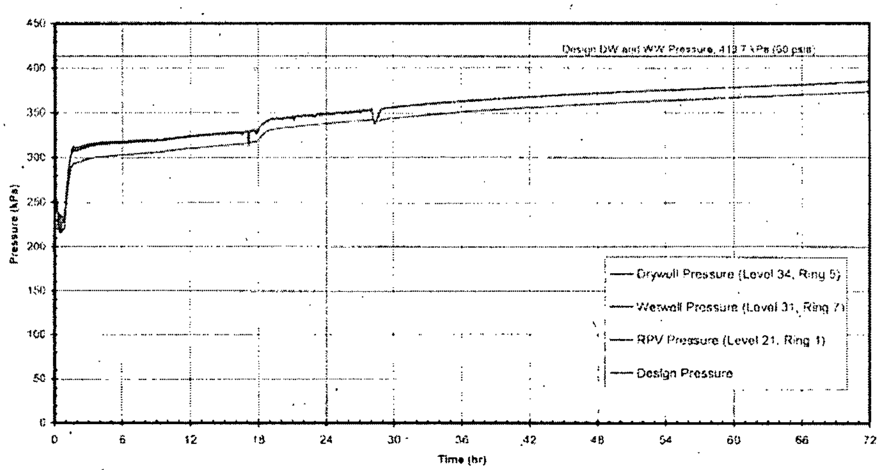

Figure 3. Main steam line break (bounding case) containment pressures (DCD Figure 6.2-14a1)

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Section 6.2.4 Containment Isolation System

Design Features
- Permits the normal or post-accident passage of fluids through the containment boundary, while protecting against release of fission products to the environment

Significant Open Items
- Need to justify not including PCCS isolation valves as required by GDC 56 (RG 1.141, ANS-56.2/ANSI N271-1976) (RAI 6.2-102)

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Section 6.2.5 Combustible Gas Control in Containment

Design Features
- Containment inerting system
- Flammability control system (PARs) (DCD Rev. 4)
- Containment atmosphere monitoring
- Containment structural integrity
- Post-accident radiolytic oxygen generation

Significant Open Items
- Need to add oxygen concentration verification to Technical Specifications (presently in availability controls manual) (RAI 16.2-110)

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6 – SER Section 6.2

Discussion/Committee Questions

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Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter **6.3**

Presented by
NRO/SRSB

January 16, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Outline of Presentation

- Applicable Regulations
- SER Technical Topics of Interest
- Significant Open Items
- Discussion / Committee Questions

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Summary of Regulations and Other Review Guidance

- GDCs 35, 36, 37
- 10 CFR 50.46 and Appendix K to 10 CFR 50
- SRP Section 6.3, "Emergency Core Cooling System"
- SRP Section 15.6.5 "Loss-of-Coolant Accidents resulting from Spectrum of Postulated Piping Breaks Within the reactor Coolant Pressure Boundary"
- SRP Section 15.0.2 "Review of Transient and Accident Analysis Method"

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

ECCS

- Automatic Depressurization System (SRVs and DPVs)
- Safety Relief Valves (SRV)
  - (Discussed at previous ACRS Meeting)
- Isolation Condenser System (ICS)
  - (Discussed at previous ACRS Meeting)
- Standby Liquid Control System (SLCS)
  - (Discussed at previous ACRS Meeting)
- Gravity Driven Cooling System (GDCS)

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

DPV

- Depressurization Valve (DPV)
  - Squib actuated valves were tested
  - The test report is under staff review

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

GDCS

- Check valve design was changed from biased open to normally open
- Check valve design is an open item (RAI 6.3-78)
- GDCS Open items (ITAAC related):
  - As-built nozzle throat length should be verified against TRACG input (RAI 14.3-307)
  - Flow loss coefficient needs to be verified by test against TRACG input. (RAI 14.3-189)

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Staff verified all RPV penetrations and accepts GEH's 8 break locations with evaluation of limiting single failures:

(1) Main Steam Line (MSL)
(2) Gravity Driven Cooling System Line (GDL)
(3) Bottom Drain Line (BDL)
(4) Feed Water Line (FWL)
(5) Isolation Condenser System Return (ICR)
(6) Depressurization Valve (DPV)
(7) Equalizing Line (EQL)
(8) Shut Down Cooling Line (SDC)

Open Item (RAI 6.3-65):
Staff requested GEH to perform SLC line break

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Single Failure Selection

- 10 CFR 50.46 requires ECCS function accomplished with a single failure
- Staff found that GE has considered all of the credible single failures in their analyses of design bases LOCA events
  - Staff evaluated failures with GDCS valve, ADS, SLCS, ICS, vacuum breaker, bottom drain line isolation, CRD hydraulic control unit
  - 1 GDCS valve, 1 SRV, or 1 DPV single failure was selected for LOCA analysis
- Single failure open items:
  - When vacuum breaker fails to close, an isolation valve will be used. (RAI 6.3-63)
  - GDCS check valve failure consequences (RAI 6.3-78)

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Evaluation Model Parameters and Assumptions

- Bounding calculation used rated power +2%
  - Consistent with SRP 15.6.5
- Maximum linear heat generation rate
  - Consistent with the design limits report
- Axial power shapes
  - Since no core uncovery, less important
- Initial stored energy
  - RAI 6.3-54 asks GEH to justify using fuel thermal conductivity model
- Control rod insertion
  - Factored into the decay heat curve

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Summary of ECCS-LOCA Analyses

- All calculations show that core remains covered with water
  - 1.447m above top of active fuel
- Main steam line break and gravity driven line break are most limiting
  - lowest minimum chimney water level
  - bounding conditions are applied to these two cases
- Open item (RAI 6.4-46)
  - explain why isolation condenser return (ICR) line break is not listed as the most limiting

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Minimum Chimney Static Head Level above Vessel Zero per Active Single Failure			
Parameter Break Size, m^2 (ft^2)	1DPV m (ft)	1GDCS INJ m (ft)	1SRV m (ft)
Nominal Condition			
EQL 0.002026(0.02181)	9.47 (31.08)	9.26 (30.36)	9.37 (30.75)
DPV 0.08320 (0.8956)	8.97 (29.42)	9.21 (30.20)	9.22 (30.25)
SDC 0.06558 (0.7059)	9.52 (31.22)	9.16 (30.05)	9.47 (31.06)
ICR* 0.01824 (0.1963)	9.34 (30.65)	9.00 (29.54)	9.24 (30.32)
MSL 0.09832 (1.058)	8.90 (29.20)	9.15 (30.02)	9.00 (29.53)
FWL 0.07420 (0.7986)	9.34 (30.64)	9.48 (31.10)	9.48 (31.10)
GDL 0.004561 (0.04910)	9.34 (30.64)	9.08 (29.77)	9.24 (30.31)
BDL 0.004052 (0.04361)	9.46 (31.02)	9.30 (30.52)	9.45 (31.00)
Bounding Condition			
MSL 0.09832 (1.058)	9.31 (30.54)	9.37 (30.74)	9.49 (31.14)
GDL 0.004561 (0.04910)	8.94 (29.34)	8.61 (28.25)	8.81 (28.89)

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Significant Open Items

- RAI 6.3-81 requests that GEH demonstrate how the LOCA analyses comply with 10 CFR 50.46(a)(1) (i) or (ii).
  - 10CFR 50.46(a)(1)(i) states in part that "Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated".
  - 50.46(a)(1)(ii) states: "Alternatively, an ECCS evaluation model may be developed in conformance with the required and acceptable features of appendix K ECCS Evaluation Models."
- Long-term cooling calculations showed that the core remains covered up to 12 hours. Staff is requesting GEH to show the results up to 72 hours. (RAI 6.3-64)

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Significant Open Items

- In RAI 6.3-46 response, GE performed sensitivity study of GDLB. Staff requested clarification for why break sizes smaller than 20% are not limiting for GDLB Break
- For GDLB, staff asked why 80% size break is the most limiting using nominal conditions but 100% size break is the most limiting case using bounding conditions
- Supplemental RAI 6.3-65, staff requested GEH to evaluate SLCS line break long term results with the worst single failure

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Conclusions

- The analyses show that the core is covered in all LOCA cases
- Preliminary staff confirmatory analyses confirmed that GEH analyses are valid
- Major open items remain

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ACRS Subcommittee Presentation
ESBWR Design Certification Review
Chapter 6.3 Emergency Core Cooling Systems

Discussion/Committee Questions

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