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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARD

(ACRS)

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SUBCOMMITTEE ON ESBWR

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OPEN SESSION

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WEDNESDAY

OCTOBER 21, 2009

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ROCKVILLE, MARYLAND

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

SUBCOMMITTEE MEMBERS PRESENT:

MICHAEL CORRADINI, Chairman

SAID ABDEL-KHALIK, Member

J. SAM ARMIJO, Member

SANJOY BANERJEE, Member

WILLIAM J. SHACK, Member

CONSULTANTS TO THE SUBCOMMITTEE:

THOMAS S. KRESS

GRAHAM B. WALLIS

NRC STAFF PRESENT:

CHRISTOPHER BROWN, Cognizant Staff Engineer

KATHY D. WEAVER, Cognizant Staff Engineer

AMY CUBBAGE

BRUCE BAVOL

TOM SCARBROUGH

GEORGE THOMAS

JOE DONOGHUE

ALSO PRESENT:

JESUS DIAZ-QUIROZ

WAYNE MARQUINO

RICK WACHOWIAK

JERRY DEAVER

MD ALAMGIR (via telephone)

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

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

8:45 a.m.

CHAIR CORRADINI: (presiding) Okay. Let's come into session.

I will not read the whole thing. Let's just come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards, the ESBWR Subcommittee. We are in our second day of meetings.

My name is Mike Corradini, Chair of the Subcommittee.

We think we have the current members in attendance. We know we have Said Abdel-Khalik, Sam Armijo, Bill Shack, maybe Sanjoy Banerjee, and our consultants Tom Kress and Graham Wallis.

I will just remind everybody the purpose of the meeting is to review resolution of certain issues related to reactor systems, mechanical systems, and INC for the ESBWR design certification.

We are in the middle of hearing presentations and holding discussions with representatives of the staff and GEH regarding these matters.

Christopher Brown and Kathy Weaver of the

ACRS staff are the Designated Federal Officials for this meeting.

Let me just remind everybody the rules of participation have been published in The Federal Register. A transcript is being kept and will be made available, as stated in the Register.

It is requested that speakers first identify themselves and speak with sufficient clarity and volume so they can be readily heard.

Please turn off your cell phones or put them in the vibrate mode.

We have not received any requests from members of the public to make oral statements.

Just, again, to remind everybody, probably the most important thing, we are going to start off in open session, then we are going to go into break, and we will go into closed session and throw out all the observers that aren't staff or GEH, and primarily because this information is protected as proprietary by GEH pursuant to 5 USC or security-related information.

Should I turn to Amy? Do you want to kick us off, Amy, about what we are planning to hear today?

MS. CUBBAGE: Great. This Amy Cubbage on the staff, the Project Manager on the ESBWR.

You are going to hear about a variety of topics today, mostly related to the reactor systems area. You are going to hear from GE Hitachi and also staff from NRO, NRR, and our Office of Research, who have been providing outstanding support during this review.

I am just going to run through the agenda very quickly to give you some background on why we are going to be discussing these topics.

The first two issues, open issues, regarding non-condensable gas in the GDCS line and the design of GDCS check valves were issues that were identified by the ACRS as topics of interest during the SER with open items discussions. So we wanted to brief the Committee on the RAIs that resulted and the resolution of those issues.

The next item, TRACE confirmatory calculations on anticipated operational occurrences. That was an item that we were not prepared to discuss when we met about a year and a half ago. Those calculations are available now for presentation.

The next topic, on the initial core design, that is a topical report review that we have completed our safety evaluation report, and it was provided to the Committee.

The next item, CPR correlation applicability. That item was partially briefed during the SER with open items phase, but additional information came in about the time of that meeting, providing additional information where GE did testing on the GE14E fuel, and we will hear about that today.

Feedwater temperature operating domain, when we last met on that topic, GE had just recently or was about to submit that topical report. They gave you a preview. At this time, the staff has completed its review and there are no open items. So we are going to discuss our review of that topical report.

And lastly, stability and chimney open items. Those were issues that were of ACRS interest at the SER with open items phase. We are going to discuss the resolution of those issues.

There are no open issues remaining for any other topics that we are going to discuss today.

So, with that, I would like to turn it over to -- Wayne, who is starting?

CHAIR CORRADINI: Is Wayne going to start?

MR. MARQUINO: I am going to start.

CHAIR CORRADINI: So, just to remind the members, there's a little bit of a difference. In the agenda it shows that we are going to talk about non-condensable gases and then check valve. As I understand it, GEH is going to discuss both first, and then we will turn to the staff to have that discussion.

So, Jesus, do you want to start it off, please?

MR. DIAZ-QUIROZ: Sure. Good morning.

My name is Jesus Diaz-Quiroz. I am with GEH.

This morning I will be covering the topic of non-condensable gases in the GDCS line and, thereafter, the check valve itself and its branch lines.

Final items pertaining to this particular topic, GEH has responded to RAI 21.6-12, which was on the presentation agenda here. I will be covering GDCS operation during LOCA, GDCS injection, line integration, in-service testing of GDCS injection lines, sources of non-condensable gases in those lines and, actually, the calculations for GDCS flow. I will summarize at the end there.

Just looking at how the GDCS operates, of course, a LOCA would ensue. Eventually, level 1 is reached. After level is reached, there is a confirmed level 1, where ADS and GDCS/SLC timers are started.

Fifty seconds later, DPV actuation occurs. So, at that point, the reactor pressure vessel begins to depressurize. About a hundred seconds later, you have that GDCS squib valves are actuated.

Of course, at this time, the reactor pressure vessel is higher than the GDCS injection pressure. So then you have a reverse flow in the line, in each branch line. The GDCS check valves close. Then, thereafter, pressure --

CONSULTANT WALLIS: I take it they were open before?

MR. DIAZ-QUIROZ: Yes, they were open before, right.

CONSULTANT WALLIS: Do they dangle or something? Do they dangle? Gravity holds them open?

MR. DIAZ-QUIROZ: No. No, these particular valves won't dangle. They are not swing-type check valves.

CONSULTANT WALLIS: Okay.

MR. DIAZ-QUIROZ: That's not what we are looking at.

MR. WACHOWIAK: We will cover that in about 40 minutes.

CONSULTANT WALLIS: Okay.

MR. DIAZ-QUIROZ: Okay.

CHAIR CORRADINI: Thank you. Go ahead.

MR. DIAZ-QUIROZ: All right. So, as the reactor pressure continues to depressurize, the pressure in the vessel drops below the injection pressure, and then the check valves open, and then, at that point, of course, GDCS flow begins. It gradually increases to its maximum. Of course, it's tank draining. The rate of flow will drop off as the level drops.

During this time, of course, you have that reactor pressure vessel communicates with the drywell because of the DPVs being open. They are permanently open. Once they are open, they cannot be closed. Depending on where the break is at, if it is above the waterline, of course, that as well will communicate with the drywell.

At the same time, the GDCS pool airspace communicates with that same volume, the drywell volume, because there's a gap between the GDCS pool wall, the top of the pool wall, and the top of the drywell slope. So we have this communication that occurs for the same volume.

Just shown here, a 3D depiction of one GDCS injection line. If you look at the left side slide there, you see --

CONSULTANT WALLIS: So these are connected, but the DPVs are open. There is still a pressure drop across the DPVs?

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: It is pressurizing the RPV side?

MR. DIAZ-QUIROZ: Right. The DPVs are open. So what ends up happening is, of course, you are dumping into the drywell; you are pressurizing the drywell. So the GDCS pool itself communicates with the --

CONSULTANT WALLIS: But you do provide a resistance to the draining of the tank, but it's small?

MR. DIAZ-QUIROZ: Right. Right. And that is why the vessel continues to depressurize. At some point, the injection pressure exceeds the reactor pressure.

So, again, looking at the left side, you have one GDCS injection line only shown here. You see where you have the 5.9 meter. You see the GDCS pool inlet there on the left side.

MEMBER SHACK: Can you use the mouse?

MR. DIAZ-QUIROZ: I'm sorry?

MEMBER SHACK: Use the mouse?

MR. DIAZ-QUIROZ: Okay. All right. Thank you. I will just point to the GDCS pool inlet.

That is where that inlet is in the pool itself, and then you have that 5.9 meters. Above that is the minimum water level for the pool. Then that line runs down, and that's an NH nominal line. It runs down, branches off in this case here, and then you go from 8- to 6-inch reducers for each branch line. Then you have a check valve, here shown in vertical orientation.

Then the next valve, the next valve there, the squib valve and then the maintenance. Then, of course, it rises up, and then turns around to go back into the vessel through the nozzle.

CHAIR CORRADINI: You guys once gave us an isometric. Just a quick reminder, there's about 6 meters from the minimum water level to the first quasi-horizontal run. Then the H, the height from there down to the branch is what, another 10 meters?

MR. DIAZ-QUIROZ: Yes. What happens is, from the top of that inlet to the nozzle itself, if you go down to the side elevations here on the slides --

CHAIR CORRADINI: Oh, okay, never mind. If it's there already --

MR. DIAZ-QUIROZ: Okay. All right. Well, we'll discuss it.

CHAIR CORRADINI: That's fine. Thank you.

CONSULTANT WALLIS: We will get to the system in the next couple of slides?

MR. DIAZ-QUIROZ: Right.

So there you have pretty much what you call, some people would call the U-shape, but you have the highest point being the nozzle on one end, downstream, the squib valve, which is normally closed. Then you have the pool inlet, which is the highest point upstream of the squib valve.

MEMBER BANERJEE: But the check valve, of course, only works if you've got flow going from the GDCS to the vessel.

MR. DIAZ-QUIROZ: The check valve, right, it is normally in an open position.

MEMBER BANERJEE: It's normally in an open position?

MR. DIAZ-QUIROZ: Right, right. So, when it closes, when you have the RPV pressure is greater than the injection level pressure, that is when you have that quick impulse to close. That protects the upstream --

MEMBER BANERJEE: So it prevents backflow?

MR. DIAZ-QUIROZ: Yes, it does.

MEMBER BANERJEE: But it is normally open?

MR. DIAZ-QUIROZ: Normally open, yes. That is the requirement.

MEMBER BANERJEE: It closes if there was a flow backward?

MR. DIAZ-QUIROZ: Yes.

CHAIR CORRADINI: Any pressurization.

MR. DIAZ-QUIROZ: Any pressurization, right, flow, right.

CHAIR CORRADINI: You may not have been in the room. They are going to get the check valve design in the next set of presentations, the next set.

MEMBER BANERJEE: But it impacts this presentation.

CHAIR CORRADINI: Correct.

MR. DIAZ-QUIROZ: Right.

CHAIR CORRADINI: But I will limit your questions about geometry.

MEMBER BANERJEE: But not about flow?

CHAIR CORRADINI: No.

MR. DIAZ-QUIROZ: Okay. Again, the two highest points being, downstream of the squib valve, the nozzles; upstream of the squib valve, the pool inlet side.

MR. WACHOWIAK: And the lowest point --

MR. DIAZ-QUIROZ: The lowest point being the GDCS squib valve, which is normally closed, and, of course, you have sloping up toward each of those high points away from that squib valve.

MEMBER BANERJEE: That block valve is normally closed, right?

MR. DIAZ-QUIROZ: That block valve, no, is not normally closed, although there are maintenance valves that will be used to flush the lines and do repairs on those valves, on the squib valves and the check valves.

MEMBER BANERJEE: The block valve is normally open?

MR. DIAZ-QUIROZ: Our block valves are normally open, and these lines are locked open during standby mode, of course. Otherwise, there's no way to actuate them. So they are normally open.

Again, I will just quickly go through the piping here.

MEMBER ABDEL-KHALIK: Is there an indication in the control room of the status of that block valve?

MR. DIAZ-QUIROZ: Yes. Every one of those valves on that line has status indication, in addition to the squib valve and the check valve itself.

Just to quickly go over the GDCS injection line, the piping, there's four 8-inch injection lines. Each of those, the 8-inch lines are about 18 meters long, which then drop. So you have this run of 8-inch, then it drops down, branches off into two 6-inch branch lines. Then, of course, I just went over the components in those branch lines. Check valve, squib valve, lowest point, maintenance valve, and then it rises up again to go to the nozzle.

Then, sloping of those horizontal lines, of course, as I mentioned, it is toward each of the high points, away from the squib valve. So you have venting to either side.

MEMBER BANERJEE: Can you go back to the figure and show the sloping?

MR. DIAZ-QUIROZ: Yes.

CHAIR CORRADINI: I don't think it shows it, Sanjoy, the way you want it. We an isometric in our package.

MEMBER BANERJEE: I have the isometric, but it is still not clear to me how it slopes.

MR. DIAZ-QUIROZ: Right, just go ahead to that slide.

So, here, of course, since this is a

depiction, a 3D depiction, it is difficult to show sloping, but the triangles here show the way. There's the squib valve. Sloping is away from the squib valve. So it is up. Of course, the vertical run, and then, since this is downstream of the squib valve, you have sloping up toward the nozzle.

Then, if you go back again to the squib valve, away from the squib valve, upstream, sloping up toward that vertical run, the check valves then; of course, vertical run, sloping up toward the main injection line, 8-inch line. Then it is vertical, sloped up toward -- vertical, and then this long run, of course, is sloped up toward the pool itself.

MEMBER BANERJEE: Is there an indication whether the check valve is open or closed?

MR. DIAZ-QUIROZ: Yes, there is. There's a position indication that is required for that check valve to show open or closed.

CHAIR CORRADINI: And even though we are getting into your next presentation, have you guys yet determined the detail as to at what point it says open versus percent open? Do you know what I am asking?

MR. DIAZ-QUIROZ: Right.

CHAIR CORRADINI: Is that still in design.

MR. DIAZ-QUIROZ: Well, it depends on the flow coefficient that we are going to use, but, really, we are looking at -- we have talked to several vendors, and one valve candidate is a nozzle-type check valve where the disc itself would actually fully seat. So that would be full open.

CHAIR CORRADINI: Okay. All right. Thank you.

MR. DIAZ-QUIROZ: So, in-service testing of the --

MEMBER BANERJEE: So, in summary, everything is open except the squib valve?

MR. DIAZ-QUIROZ: Right. There is only one valve that is closed, right. You're right. The squib valve, of course, which you might call a hermetically-sealed valve, which is a cap that is basically sheared by the squibs themselves, the booster charge.

CHAIR CORRADINI: Okay, thank you.

MEMBER BANERJEE: Are there any vents in the line?

MR. DIAZ-QUIROZ: Vents? No. No, there are no vents in the line. The configuration itself provides the venting.

MR. MARQUINO: It depends on how you want to look at it. I would say there are two high-point vents in the line that are always open.

MR. DIAZ-QUIROZ: Right.

MR. MARQUINO: One is the pipe connection to the GDCS pool, and the other is the pipe connection to the vessel.

MR. DIAZ-QUIROZ: So, within the line itself, the high points do not exist other than what you see. Because, due to the sloping, you do get the high points at the nozzle end and the pool --

MEMBER BANERJEE: What is the slope?

MR. DIAZ-QUIROZ: The slope? Well, I mean, you are looking at anywhere from one-third, 100 millimeters to 300 millimeters, or so.

Of course, there is an ITAAC --

MEMBER BANERJEE: What is the angle, roughly?

MR. DIAZ-QUIROZ: The angle? Sorry, I don't have that quickly.

MEMBER BANERJEE: Give me the height over the length.

MR. DIAZ-QUIROZ: Right. The height being 100 millimeters over 300 millimeters, so one over three.

CHAIR CORRADINI: Twenty-five degrees.

MR. DIAZ-QUIROZ: Right. So, at that

point, that's something --

MEMBER BANERJEE: That is a pretty big slope here.

MR. DIAZ-QUIROZ: Right, it is a big slope.

MEMBER BANERJEE: A hundred millimeters over 300?

CHAIR CORRADINI: Is it a quarter inch over --

CONSULTANT WALLIS: That doesn't sound right.

MR. DIAZ-QUIROZ: Four inches over 12 inches. So the same number. It is a large number and, of course --

MEMBER BANERJEE: It is like that.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: It doesn't show that in the figure. I don't think that is correct.

MR. DIAZ-QUIROZ: No. No, it doesn't. The figure doesn't show it.

There is an ITAAC requirement that the lines --

CHAIR CORRADINI: So 19.5 degrees.

MR. DIAZ-QUIROZ: Okay. All right.

CHAIR CORRADINI: Approximately.

MR. DIAZ-QUIROZ: That is something that has been discussed, the isometric. The final routing has not been done. There is an ITAAC for this final routing to self-vent. So that sloping will have to be revisited at that time as well.

MEMBER BANERJEE: So the squib valve is like that.

MR. DIAZ-QUIROZ: Well, if you want to make sure that the squib valve operates correctly, you don't want to make a "V" shape like you said.

MEMBER BANERJEE: Right. Let's say around the squib valve, how is it sloped?

MR. DIAZ-QUIROZ: I threw out a number, is basically what I did. The final sloping will be dictated by the final routing and how much room is left between the annulus and the reactor pressure vessel, and how much is required for thermal expansion.

So the ITAAC that I mentioned will require self-venting. But, yes, if a lesser slope can be done, well, then that is what we will be using.

MEMBER BANERJEE: Let's go to that figure there.

MR. DIAZ-QUIROZ: This one?

MEMBER BANERJEE: Yes. The one that

you --

MR. DIAZ-QUIROZ: Okay.

MEMBER BANERJEE: Between the squib valve and the elbow, what is the length there?

MR. DIAZ-QUIROZ: The squib valve and this elbow?

MEMBER BANERJEE: Yes.

MR. DIAZ-QUIROZ: The rough length here? You're looking at about a meter between the squib valve and that elbow, and on the other side of it, it is about 1.2 meters.

MEMBER BANERJEE: Okay. And the difference in the elevation between the squib valve and the elbow is how much?

MR. DIAZ-QUIROZ: It is about here to here.

MEMBER BANERJEE: The difference in elevation between the elbow and --

CHAIR CORRADINI: Well, if it is 3-to-1, if they can actually realize 3-to-1, you could just do it.

MEMBER BANERJEE: So that would be 30 centimeters?

CHAIR CORRADINI: Yes, yes.

MEMBER BANERJEE: And 30 centimeters on

the other side? So the squib valve is in a "V"?

MR. DIAZ-QUIROZ: It could be. It could be in a V-shape, but, of course, that is extreme. Again, if the lesser slope can self-vent, as the ITAAC requires --

MEMBER BANERJEE: How do you determine what can self-vent or not? Are you going to do some experiments?

MR. DIAZ-QUIROZ: Experiments? Well, I mean, do you have --

MEMBER BANERJEE: What is the difference between 30 and 15 or between 15 and 10 and between 10 and 5?

CONSULTANT WALLIS: Or zero. Zero self-vents pretty well.

MEMBER BANERJEE: Zero?

MR. DIAZ-QUIROZ: Right. This is just to assure that's --

MR. MARQUINO: This is not different from other process plants. So we have applied line slope requirements on other BWRs and will apply similar line slope requirements in --

CONSULTANT WALLIS: This slope requirement seems absolutely extreme.

MR. DIAZ-QUIROZ: Right, it is extreme.

That would be the maximum.

CONSULTANT WALLIS: If it is so big, you should really show it on the figure, because it is misleading to show it --

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: It's such an extreme slope.

MR. DIAZ-QUIROZ: True.

MEMBER BANERJEE: Then we have a different set of problems. The squib valve is down in the trough. Then, depending on what happens, you've got a trough there, which is sort of a crude place to trap gas if it gets in there.

CHAIR CORRADINI: Again? I'm sorry?

MEMBER BANERJEE: Well, it is always nice to have -- if you have a flow and you get some gas by some means in a trough, it gets trapped in the trough.

CHAIR CORRADINI: Right.

CONSULTANT WALLIS: That gets trapped in the trough.

MEMBER BANERJEE: Yes. It is like a little loop seal.

Anyway, carry on.

At least we've got an idea roughly. That is an extreme slope.

MR. DIAZ-QUIROZ: Right.

MEMBER BANERJEE: I thought it was like 1 degree or so.

MR. DIAZ-QUIROZ: Right, right. It's an extreme slope, and that would be in the extreme case.

CONSULTANT WALLIS: Apart from that, the only way you can non-condensables stuck in this thing is for the upper block valve to be closed, so they don't vent to the pool.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: That's the only way. That's the only thing you have to consider, it seems to me. If someone did some maintenance and left that block valve closed, the squib valve pops, and the operator says, "Gee whiz, I've got no flow. Ah, the block valve was closed." It's just like TMI when they opened.

MR. DIAZ-QUIROZ: Right.

MEMBER BANERJEE: And then what happens?

CONSULTANT WALLIS: Then it goes, "Ump, ump, ump, ump," and the various things happen.

MR. MARQUINO: Okay, but the block valve is inside containment. It is not accessible in a LOCA. That is why we have procedural requirements to make sure the block valves are open, to make the

ECCS --

CONSULTANT WALLIS: But I'm just saying, the only way you could get non-condensables in there is for this happen.

MR. MARQUINO: Yes, we agree. Okay.

CHAIR CORRADINI: So just one other clarification, since I have stuff written down, but I don't have it with me. So I need one of the eight -- is it one of the eight lines or two of the eights to provide the appropriate flow for makeup?

MR. DIAZ-QUIROZ: Well, if you track -- two sensitivities have been conducted to show that, once some of the flow, if you really lined that up, it would be, of course, one line, one branch line.

CHAIR CORRADINI: But I just want to make sure, from a success criteria approach, what is the minimum that I need to --

MR. MARQUINO: We have slides on that.

CHAIR CORRADINI: Later?

MR. MARQUINO: Later, from a success criteria approach.

CHAIR CORRADINI: But just remind me, what's the answer right now?

MR. MARQUINO: Well, in licensing basis space, we assume one valve fails as part of the single-failure criteria. Actually, we only need one-seventh of the flow to make up for decay heat at the time the system injects. So we feel we have a robust design here.

CHAIR CORRADINI: No, I'm not trying to judge. I just wanted to remember the number. So it is one-seventh?

MR. MARQUINO: Yes.

CHAIR CORRADINI: Okay. Thank you.

MR. MARQUINO: Right.

MEMBER BANERJEE: You have how many GDCS lines which get split in two?

MR. DIAZ-QUIROZ: There's a total of four that get split into two. So you have the total of eight branch lines, so eight nozzles.

CONSULTANT WALLIS: From three pools?

MR. DIAZ-QUIROZ: From three pools, right. So there are two lines share one of the larger pools, yes.

MEMBER BANERJEE: And the block valve is located after the split or before the split?

MR. DIAZ-QUIROZ: There is a block valve after the split. There is a block valve here, not shown, upstream of the check valve.

MR. WACHOWIAK: It is shown.

MR. DIAZ-QUIROZ: It's shown? Okay.

MEMBER BANERJEE: Ah, okay, so there is a valve before --

MR. DIAZ-QUIROZ: Right, right. For isolation, maintenance.

MR. WACHOWIAK: In the PRA, we looked at the inadvertent closure of these valves, not inadvertent closure, but remaining closed following an outage, and identified that it is requiring the indication in the control room, and also something that is required to be addressed by the HFE program as an insight for the plants. So it is important that these valves are open.

MEMBER BANERJEE: And there is a position indicator, actually?

MR. DIAZ-QUIROZ: Right, if they are blocked.

MR. WACHOWIAK: At this point in time, it's specified as position indication. When the HFE program goes through all of the machinations that they have to go through, we will decide whether a stem indication is sufficient or some other indication may be needed on top of that. But that is a part of the HFE program where we decide, the Human Factors Engineering Program.

MR. DIAZ-QUIROZ: Next slide.

In-service testing program is required by technical specifications. There you have that, during every refueling outage, you would flush lines and you would test the check valve itself for open and closed.

CHAIR CORRADINI: And then, just since I guess I want to get to the checking part of this, so when you do the flushing, once again, from the venting standpoint, the way Wayne described it, you are essentially going to then use, if you were to do maintenance on this line and reopen the line, you would expect to essentially then have the venting through backup, through the GDCS pool?

MR. DIAZ-QUIROZ: Right. That would occur, and, in addition, you would have flushing. Of course, the connections are at the low point. Flush --

CHAIR CORRADINI: Right.

MR. DIAZ-QUIROZ: So any gas would rise, you're right, to the high points that would exist, which is the pool and the nozzles. The flushing, of course, to assure that nothing is in the lines themselves as well.

CHAIR CORRADINI: Thank you.

MEMBER ABDEL-KHALIK: Now the squibs would not be fired?

MR. DIAZ-QUIROZ: No, the squibs have a different testing criteria where every refueling outage, a certain percentage of them are pulled out, and they are fired, of course, offline. Then, based on that, of course, you develop an experience, and then maybe change that percentage.

CONSULTANT WALLIS: Now the squibs are fired by an explosion, which makes gas.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: And if something went wrong with the squib valve, you could get gas from the explosion injection. It seems very far-fetched, but that is a source of gas.

MR. DIAZ-QUIROZ: Right, it could be a source of -- what happens is you have a piston; you would have a piston that would, the gas expansion would propel that to shear the cab.

MR. MARQUINO: The explosive chamber is separated from the primary system.

CONSULTANT WALLIS: There is no path to it.

MR. MARQUINO: There's no path to it. If a path opened up, you would have, basically, a second LOCA with water draining out of that point. So that is not --

CONSULTANT WALLIS: But assuming that the thing is sealed and the explosion happens, and for some reason there's a leak into the --

CHAIR CORRADINI: But I think his point is, Graham, though, there are two separate systems. To have what you want, you would create a LOCA. I think that is what Wayne's --

MR. MARQUINO: It is a bad thing to happen, but it is not --

CONSULTANT WALLIS: It wouldn't create a LOCA. It wouldn't create a LOCA because it still enclosed in the piston. It is just it leaks into the valve.

MR. DIAZ-QUIROZ: The pressure requirements, the class requirements, the boundary --

CONSULTANT WALLIS: We would have to look at the details of the valve.

MEMBER BANERJEE: But maybe when you show us the valve details, you can show us a sketch of this.

MR. DIAZ-QUIROZ: Right. Well, here I won't be covering the squib valve, but I could probably --

CHAIR CORRADINI: Well, let's just hold it until we get to the check valve.

MR. DIAZ-QUIROZ: Okay.

CHAIR CORRADINI: But I think we want to clarify that because we went through that in one January. I don't know which January. I thought we were satisfied that they were separated such that, the way you described it, at least at the time in my mind, there was no chance of essentially passage through, unless you then have reverse passage of water back out.

Let's hold that until the check valve discussion. Okay?

MEMBER ABDEL-KHALIK: So what kind of debris, or whatever, you would expect to clear during this flushing?

MR. DIAZ-QUIROZ: Well, it's to assure flushing -- water will be in the line for a period of two years. So you would want to at least cycle the water. Of course, you wouldn't expect any debris because in the pools themselves, they sit, the well itself sits about 6 meters above the diaphragm floor. There's plates that cover up, there's slosh guards that cover up that gap. So you wouldn't expect debris.

CONSULTANT WALLIS: The debris would come from some maintenance mistake.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: Someone left something there.

MR. DIAZ-QUIROZ: Right.

MR. MARQUINO: So the flushing is primarily to make sure that the line is full. It is part of starting up after maintenance on this line to make sure that it is full of liquid.

MR. DIAZ-QUIROZ: Right. Part of that cycle of water.

MEMBER ARMIJO: You never flow water through that whole line as long as you've got that squib valve there.

MR. DIAZ-QUIROZ: Right. So the upstream -- downstream of the squib valve itself, you have another test connection that you would flush that side, that segment of it. So you flush both sides.

CONSULTANT WALLIS: So there are other ways that stuff can come in, through these other connections?

MR. DIAZ-QUIROZ: Well, the connections themselves, if the line is -- you could possibly pump water in there, but you will have to test the check valve itself. I will discuss that later. That will require pumping water into it.

MEMBER BANERJEE: Are there sort of little stand pipes with valves for flushing?

MR. DIAZ-QUIROZ: If you are looking for a high point, the high point wouldn't exist because you would have to either put it on the side or on the bottom of the pipe.

MR. MARQUINO: But the low point --

MR. DIAZ-QUIROZ: But the low point is still the squib valve.

MR. MARQUINO: The low point drains, I imagine, will be conventional drain points. I am not even sure if they are temporarily connected to the drain system or permanently connected to the drain system.

MR. DIAZ-QUIROZ: They are not permanently connected, no.

MEMBER ABDEL-KHALIK: Now here upstream and downstream refers to --

MR. DIAZ-QUIROZ: The squib valve.

MEMBER ABDEL-KHALIK: Upstream is the --

MR. DIAZ-QUIROZ: Right, right.

MEMBER ABDEL-KHALIK: -- is the tank?

MR. DIAZ-QUIROZ: Is the tank, right, the tank.

MEMBER ABDEL-KHALIK: Downstream is the vessel?

MR. DIAZ-QUIROZ: The vessel, the nozzle, right, right.

MEMBER BANERJEE: So you have two stand pipes of some sort facing downwards, let's say --

MR. DIAZ-QUIROZ: Okay.

MEMBER BANERJEE: -- which have their own little valves on them.

MR. DIAZ-QUIROZ: Right.

MEMBER BANERJEE: These, let's say, are facing downwards, which are used for flushing.

MR. DIAZ-QUIROZ: Right.

MEMBER BANERJEE: That is not shown in the figure.

MR. DIAZ-QUIROZ: No, it's not. That detail is not shown in the figure, you're right.

MEMBER BANERJEE: Are there any other details we should know about, other than these --

MR. DIAZ-QUIROZ: Well, the final routing, of course, is not completed. So, I mean, there's plenty of detail to be had.

CHAIR CORRADINI: So I don't want to hold you up. Did you have another question?

MEMBER BANERJEE: Yes, I do.

CHAIR CORRADINI: Keep going.

MEMBER BANERJEE: Now, in existing BWR lines, has there been gas found during normal operation?

MR. DIAZ-QUIROZ: Well, there is operating experience that has shown in some lines, the hydrogen has been mentioned, I believe.

MEMBER BANERJEE: Right.

MR. DIAZ-QUIROZ: Right. And that was due to sloping, inappropriate sloping on the high points where you had venting at high points, yes.

MEMBER BANERJEE: However, there was gas generation?

MR. MARQUINO: So one example, specific example of that, is somehow after operating our plants for 30 years, if there was an event that occurred where during shutdown non-condensable gas that was in solution in the instrument lines came out of solution and lowered the liquid content in the instrument line, and gave a false water level indication, so you will see we get into that in one of the subsequent slides. That would only expose the high-pressure and potentially high-temperature portion of the line, which is just the very last segment.

Between the bioshield and the vessel, you could have a high temperature and pressure. So that little length might have dissolved gas that could come out.

MEMBER BANERJEE: I am just trying to think back because this is a generic issue, as you know, that we are facing.

MR. DIAZ-QUIROZ: Right.

MEMBER BANERJEE: So I would like to know how many BWRs have had experience with gas being in the safety injection lines historically. Is it just one? Is it ten? Is it -- how many?

MR. DIAZ-QUIROZ: I don't know that.

MEMBER BANERJEE: And how many times has it been found and where? Because, I mean, this is an issue which is facing us in the operating reactors right now.

CHAIR CORRADINI: But your connection here is, I mean, if I might just rephrase, you want to make sure that they have taken lessons learned from those operational experiences, right?

MEMBER BANERJEE: Right, lessons --

CHAIR CORRADINI: I don't know if they will be able to answer all those questions that you are asking.

MEMBER BANERJEE: Lessons learned, I don't know if it has progressed to that stage yet. I think it is still an open issue, right?

MR. MARQUINO: Well, maybe the staff could comment on that because I can't remember whether the operating plant experience that triggered this was a BWR, a PWR, or both, but we could do some research on that and get back to you.

MEMBER BANERJEE: Okay. Yes.

MEMBER SHACK: But in an operating plant, he can't reroute the pipe.

MEMBER BANERJEE: No.

MEMBER SHACK: He's got some options here that he doesn't have in an operating plant.

MEMBER BANERJEE: Well, it is a question of whether the experience from the operating plants -- because it is very hard to detect, and it is hard to prevent as well.

So, if I remember, there was a lot of discussion on problems associated with detection of these sort of gas inclusions. So we need to understand what the operating plant experience has been, whether sloping has actually gotten rid of things --

MR. DEAVER: Can I make a comment on that?

MEMBER BANERJEE: Yes.

MR. DEAVER: This is Jerry Deaver with GEH.

A comparable system in operating plants is the core spray line. In the core spray line geometry, where it comes in the vessel, we have piping inside the vessel, and they have a quarter-inch vent line right at the top of the header. So that is the venting path in BWRs.

I have never heard of a problem in operating BWRs in this system because of that vent line or that vent hole that is in the piping. So it is self-venting, too.

MEMBER BANERJEE: So, if there is gas in the safety injection lines, where does it arise in the BWRs? Where?

CHAIR CORRADINI: In the operating plants?

MEMBER BANERJEE: Yes.

CHAIR CORRADINI: I guess let's take that as an action item. I thought Wayne's answer to you about this was the only place, at least in the current design, that they are concerned about this is, once you get out of the squib, through the shield, into the vessel, and that run a pipe where they could, essentially, generate some hydrogen. And they are going to consider that in the subsequent discussion.

MR. WACHOWIAK: And we have a few slides here that discuss our search for sources of non-condensable gas.

CHAIR CORRADINI: So I guess I take it that the staff has got to get back to you about some of the operating experience when they come up.

Graham, did you have a question?

CONSULTANT WALLIS: Yes, I have a point that occurs to me here.

The GDCS water is cold.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: And the water down near the squib valve region there is probably pretty warm. It has been sitting there kind of close to the vessel.

MR. DIAZ-QUIROZ: It has been sitting there. You have thermal conduction.

CONSULTANT WALLIS: So, over a period of time, there is kind of occurring natural circulation in the 8-inch pipe with cold water flowing down --

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: -- and warm water flowing up. And over a long period of time, because there's dissolved gas in the cold water, there will be some gas emitted from that cold water, but it will bubble all the way up to the block valves. So there is something going on there. It's not as if nothing is happening.

MR. DIAZ-QUIROZ: Right. Right. It's not that nothing is happening, but, as you said, it will bubble up, and you have this kind of warming --

CONSULTANT WALLIS: Probably there is some thermal cycling rather than with any kind of gas.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: So that's just something that you might consider. There is some natural circulation up and down in that 8-inch pipe all the time.

MR. DIAZ-QUIROZ: Right. Right. It's not insulated, but exposed to the reactor --

CHAIR CORRADINI: I am sorry, Said, go ahead.

MEMBER ABDEL-KHALIK: I was going to talk about the in-service testing. Is there also a startup test to go along with that would assure that the lines are filled on day one?

MR. DIAZ-QUIROZ: On day one, well, there is flow testing required for the lines themselves. And, yes, the procedure, you will have to be able to fill them. So the valve will be in place. You will use the drain points to drain, make sure they are filled properly.

MEMBER ABDEL-KHALIK: So there is a section in the startup testing program that deals with this?

MR. WACHOWIAK: And to deal with the non-condensable gases, there is an ITAAC that is going to be required. We are going to need to demonstrate that these lines do self-vent.

MEMBER ABDEL-KHALIK: Okay.

MR. WACHOWIAK: So we will write a procedure that -- I don't know what it is right now, but we will write a procedure that demonstrates that the gas that gets into these lines will vent to the different high points.

CONSULTANT WALLIS: You seem to be making an awful lot of fuss about a trivial problem. I mean gas does --

CHAIR CORRADINI: Could I get that in writing?

(Laughter.)

CONSULTANT WALLIS: Well, I mean we haven't got to the meat of this thing yet. We're talking about whether stuff, gas slides up a slope. I mean it is absurd to spend much time on that.

CHAIR CORRADINI: Just so we have that, I will roll back that discussion.

(Laughter.)

MR. DIAZ-QUIROZ: Sources of non-condensable gases, as mentioned just now, you have dissolved gas on both segments of the line toward the GDCS pool, toward the nozzle. One is at a lower pressure, basically, under the gravity head from the pool down to the point of the GDCS injection valve. Then the other is at reactor pressure during normal operating pressure. These are standby modes for the GDCS line.

There is a small segment. So we will have, depending on the final sloping of that branch line that leads into the nozzle, where the nozzle itself is a flow restrictor which is 3 inches -- you go from 6 inches to 3 inches -- where the sloping, you will have this little pocket that will occur where you could possibly accumulate some gases.

So, depending on the final sloping, again, depending on the severity of the sloping, but you could have just a possible little pocket there of gas that could occur during standby mode.

MEMBER BANERJEE: The GDCS pool is how far below the intake or the --

MR. DIAZ-QUIROZ: The intake itself?

MEMBER BANERJEE: Yes.

MR. DIAZ-QUIROZ: So you are looking at 5.9 meters. So you're looking at, roughly, about 5.8 meters from the minimum to the intake. So you have some volume that will remain in the tanks when they drain.

MR. MARQUINO: It is on slide six.

MR. DIAZ-QUIROZ: Well, here, we don't show the pool. So the relation, you know, the pool floor to that intake, but it will be above the floor about a meter or so.

So you have this driving head of 5.9 meters. It will drain down to where it will eventually, of course --

MEMBER BANERJEE: And that is the minimum level?

MR. DIAZ-QUIROZ: That is the minimum level, right. Right. So you look at the maximum level being about 6.1, 6 nominal.

MEMBER BANERJEE: So, even if the GDCS pool reaches saturation, you still have 5.9 meters of head?

MR. DIAZ-QUIROZ: Right, from the pool itself, and then the line routing down towards the bottom squib valve, the nozzle, basically; there's difference in height.

CONSULTANT WALLIS: Now I don't understand this presentation. You spent all that time on stuff which is not important.

What really matters is the worst case and how does TRACG handle it, and what does it predict? I don't see any TRACG outputs here. Tell us what you predict for the worst case.

MEMBER BANERJEE: Well, they are trying to reassure us that this won't happen.

CONSULTANT WALLIS: The only thing that matters is the worst case and show that it works.

MR. MARQUINO: We will get there.

CONSULTANT WALLIS: Can you get to that?

MR. DIAZ-QUIROZ: Okay. All right. I will go ahead and move on.

So, first, during LOCA, the GDCS injection valve opens, and then you have the high pressure segment, of course, depressurizes and any possible dissolved gas will eventually come out because of that.

Steam entering, might enter. The primary route for steam, of course, is through the break, if it is above the waterline, and also the DPV line. So any gas, of course, will be carried out mostly through there. You might have steam entering that line. It might carry some gas, but, of course, then, when flow starts, you will quench the steam, if there is steam in there.

Then, again, radiolytic gas is produced inside the vessel, and, of course, will exit out through the steam itself, through the break or the DPVs.

This is just a quick statement on --

MR. MARQUINO: So, if you will bear with us for a minute?

CONSULTANT WALLIS: oh, I have a question here about steam entering quenched by GDCS. I read your report, and you said that the GDCS flow was two or three times enough to quench the steam. How do you know how much steam is entering there? Steam loves to enter and condense. How did you know how much steam was entering?

MR. MARQUINO: Dr. Alamgir did that evaluation. He can answer that on the bridge line, if you would like.

We have provided an RAI response, 21.6112, on that.

CONSULTANT WALLIS: The extreme assumption is it just brings the water up to saturation, and that gives you the steam flow. Then you look at the counter-current flow, presumably, and see if that can be maintained. Is that what he did?

MR. MARQUINO: Well, the only potential there is you saw there's a horizontal length of piping --

CONSULTANT WALLIS: Yes.

MR. MARQUINO: -- to the vessel. So, because the water level in some breaks drops below the nozzle, that length of piping can drain out, and we can have the liquid flowing in that pipe. So we could get steam along the top of the pipe.

Now, in my simple understanding of that, the volume of steam that would enter it is the volume of steam in the top of the pipe.

CONSULTANT WALLIS: No, the steam would come at MACC1, if it wanted to get to the water. It is not a trivial thing when you put subcooled water in contact with steam.

MR. MARQUINO: Right.

CONSULTANT WALLIS: I'm not sure how you understand how much steam rushes in that pipe --

CHAIR CORRADINI: Let's go to the bridge line. Let's just, before we discuss it, is the gentleman that you just mentioned on the bridge line?

MR. MARQUINO: Yes. Is the bridge line open?

(Speaker on bridge line attempts to speak.)

CHAIR CORRADINI: You are going to have to speak a bit louder, please.

MR. ALAMGIR: This is MD Alamgir from GEH. Can you hear me?

CHAIR CORRADINI: Yes.

MR. ALAMGIR: Okay. What is the question, please?

CONSULTANT WALLIS: How do you know the rate -- in your report and on this slide here, No. 9, it says that the steam entering is quenched by the GDCS flow. This is if the injection line is exposed to steam at the RPV.

I just don't know how you know how much steam is entering.

MR. ALAMGIR: We have .1612 where the TRACG calculation shows that, given the large -- the GDCS flow, it quenches everything --

CONSULTANT WALLIS: How do you know the steam flow rate?

MR. ALAMGIR: That calculation shows

whatever is approaching the cold front, it condenses right outside the venturi and the exit of the GDCS pipe into that.

CONSULTANT WALLIS: How do you know how much steam has to be condensed?

CHAIR CORRADINI: I think Dr. Wallis is asking you, did you do hand calculations so you are confident in the TRACG calculation?

MR. ALAMGIR: Yes, we did.

CONSULTANT WALLIS: How does TRACG know how much steam is condensed? If steam sees cold water, it rushes towards it, doesn't it?

MR. ALAMGIR: We know that there is also a big hole up there, DPV.

CONSULTANT WALLIS: Well, I think you need to explain this in writing, so that I can understand it.

CHAIR CORRADINI: It's in the RAI, though, Graham, I think.

CONSULTANT WALLIS: I read it. I just said in the RAI it asserts that the steam is quenched by the GDCS, but it doesn't explain how they calculate that. It just asserts it.

MEMBER BANERJEE: I guess if you wanted to do a bounding calculation, to answer Graham, you would say simply that the steam enters at the velocity of sound.

CONSULTANT WALLIS: But, then, that's far too much --

MEMBER BANERJEE: It is 300 meters per second.

CONSULTANT WALLIS: That's far too much steam.

MEMBER BANERJEE: And that sort of condenses --

MEMBER SHACK: Isn't it their TRACG calculation with the counter-current flow flag turned on?

CONSULTANT WALLIS: It probably it, and it says it knows how to calculate --

MEMBER BANERJEE: It doesn't know how to calculate flooding in horizontal pipes.

CONSULTANT WALLIS: How about this condensation at MACC1?

MEMBER BANERJEE: It's impossible. It's not possible that TRACG does that.

CONSULTANT WALLIS: I think it does.

MR. ALAMGIR: It is at the MACC1 velocity in the GDCS line with that situation. That is my personal --

CONSULTANT WALLIS: MACC1 is a limiting case?

MEMBER BANERJEE: Yes, that is what I am saying. If you use MACC1, then you've got it.

CONSULTANT WALLIS: I very much doubt it.

CHAIR CORRADINI: Wait a minute. Let's just roll back. Before we beat him up by long distance, so can you explain to us -- you said two things that I want to get clear.

One is you said you did the TRACG calculation which indicated that whatever was flowing in was condensed. Then you said you did a check calculation. Can you explain the check calculation you did?

MR. ALAMGIR: Yes. The check calculation is based on the aspect ratio. The venturi is 3 inches, and the DPV is very large compared to that.

One hand calculation approximation that I made is that, if the steam has flowed proportional to the areas, this is the amount of steam that would flow. Then I took that steam and then compared it with the subcooling available at the GDCS line. It is overwhelmingly large. It is able to condense everything.

CONSULTANT WALLIS: But you need to know

the velocity, not just the area. If it has MACC1, it is going to have a tremendous flow rate, isn't it?

MR. ALAMGIR: I must say that I did not consider MACC1 because, to me, it seems incredible.

CONSULTANT WALLIS: Well, I think there is an experiment that you cite where the water actually flushes the steam out, and condensation occurs outside the pipe. Isn't this on --

MR. ALAMGIR: The experiment is Slovenian. It shows in almost similar conditions that the cold water condenses the steam and pushes out the front out of the pipe in 8 seconds.

CONSULTANT WALLIS: The assertion that the steam entering is quenched I think is not supportable. But if you can show that the water pushes the steam out, so that steam doesn't enter at all, that makes sense.

MR. ALAMGIR: Well, Professor Wallis, the test in Slovenia, and the pictures are in the RAI response, the plots, temperature profiles about the pipe; show that the cold water is able to condense the steam and push it out.

MEMBER BANERJEE: But what was the diameter of the pipe?

MR. ALAMGIR: For?

CHAIR CORRADINI: In the experiment.

MR. ALAMGIR: Which pipe? The test?

MEMBER BANERJEE: Yes, in the Slovenian experiment.

MR. ALAMGIR: Well, it is about the size of -- about 4, 8, I think about 4 inches, but I will check and come back to you.

MEMBER BANERJEE: And what is the size --

CHAIR CORRADINI: Say it again? Let's just slow down. What did you say?

Are you on speaker phone at GEH? Hello.

All right. So hang on a second.

What's the problem? He's on speaker phone.

Our transcriber, our recorder, can't hear you. If you can just pick up the phone, if that is possible, so he can hear what you are saying?

MR. ALAMGIR: I am not in a room where I can pick up the phone.

CHAIR CORRADINI: Okay, fine.

MR. ALAMGIR: The diameter is 73 millimeters. I just looked at the paper for the test.

MEMBER BANERJEE: And what is the GDCS line?

CHAIR CORRADINI: Just so we're clear, 73 millimeters is 3 inches. So it is essentially the same size.

MR. ALAMGIR: The same size as the venturi, yes.

MR. MARQUINO: Can I ask a clarifying question here? You are asking whether our code can calculate the flow rate of steam into the line. The significance of that is how fast the line would equilibrate with steam and liquid in it.

The volume of the line we are talking about is a horizontal length that is, just eyeballing this isometric, it is about 3 meters long.

CONSULTANT WALLIS: I don't know what you mean. If you have cold water flowing along the pipe, then you condense all the steam that flows in, that would bring it up to saturation, unless there is some limiting condition.

MR. MARQUINO: Okay. The water is going to go to saturation eventually. It is either going to go to saturation inside --

CONSULTANT WALLIS: Not down there.

MR. MARQUINO: -- the RPV -- well, if the water goes into the RPV, it is going to condense steam --

CONSULTANT WALLIS: In the RPV.

MR. MARQUINO: -- and go to saturation.

CONSULTANT WALLIS: Sure. Right. Absolutely.

MR. MARQUINO: If the steam enters the pipe, the water is going to go to saturation in the pipe.

CONSULTANT WALLIS: But does the steam keep going and condense further up the pipe?

MR. MARQUINO: Because the steam can't go in this vertical section here.

CONSULTANT WALLIS: It can go up the first part, though.

MR. MARQUINO: Right.

CONSULTANT WALLIS: I mean if it is horizontal, which it isn't.

MR. MARQUINO: So this section of pipe is important in addressing your questions about --

CONSULTANT WALLIS: So you've probably got the right answer. I am just saying that the assertion that the steam entering is quenched and you've got two or three times the amount of water to condense the steam is not a supportable statement. You have other arguments which are probably good. I am just saying I don't like that argument because I don't think you can support.

MEMBER BANERJEE: Well, I think the issue really is, imagine that steam enters that line. So now you've got counter-current flow in a horizontal length. So the steam is on top. The water is flowing this way; the steam is going that way. Right? And the steam is condensing on the water surface.

So, at some length, the steam will stop flowing because it will all condense. What you've got is the water flowing. However, the water outflow now has an area which is significantly less than the diameter of the pipe. That is the concern.

So that the steam might be going in through whatever open area there is in this counter-current flow. The water is coming out, and condensation is occurring until all the steam condenses.

However, the water flow is impeded because it is flowing through a smaller area. I mean, if you really look at the boundary condition there, it is whatever is the height for the critical flow out of that pipe.

If you had an open pipe, and say you had counter-current flow of steam and water, you would get more flow of the water simply because of the fact that you've got less area.

Now what you are saying --

MR. ALAMGIR: Mr. Banerjee, I agree with you, and the fact that the test in the high pressure steam water, which is cited in the RAI response, it indicates that there is no horizontal stratification, and it is a flood of water pushing out the cold --

CONSULTANT WALLIS: If the Froude number is big enough, that is what happens.

MR. ALAMGIR: So that is experimental evidence.

CONSULTANT WALLIS: I will buy the experimental evidence. I also will buy the argument that, because the slope is so big -- it is not a horizontal pipe; it is sloping upward to the RPV -- the steam isn't going to flow down there. I buy those arguments. I just don't buy the statement that the steam is quenched.

CHAIR CORRADINI: Okay. So, just to summarize, I think we have beaten this one, at least I judge we have beaten this one to death.

I have forgotten the name of the gentleman on the line.

I think Dr. Wallis' point is he is not quibbling with the conclusion; he is quibbling with the explanation.

CONSULTANT WALLIS: The rationale, right.

CHAIR CORRADINI: Yes, the rationale. So I think that's got to be cleared up.

CONSULTANT WALLIS: I am not quibbling with it, either. I am asserting it. It is not a quibble.

(Laughter.)

MR. ALAMGIR: Thank you, Dr. Wallis. We have a slight different point of view, but I respect your point of view.

MEMBER BANERJEE: I haven't finished with you, though.

(Laughter.)

CHAIR CORRADINI: So you got rid of one person. You still have one to deal with, Dr. Banerjee.

MEMBER BANERJEE: Right. Now I think that these experiments that you are citing, if they were at high pressure and at a high enough Froude number, they would drive out the steam, so the steam could not enter. So the condensation -- the pipe would essentially run full.

CONSULTANT WALLIS: Right.

MEMBER BANERJEE: There's no room for counter-current flow. But is this true of all conditions that you expect after the GDCS line is uncovered? I mean, do these experiments assure you that, under all the conditions that would occur, that you will not get steam entering that line?

Now I am actually willing to buy Graham Wallis' point that the line slopes upwards; therefore, it makes it more difficult to enter. But, if it was truly a horizontal line, I think you would have a problem.

But can you answer the range of conditions covered by the experiment compared to what you might guess --

CONSULTANT WALLIS: I think they are going to tell us, when we get to the end of this very long day, they are going to tell us that the Froude number is probably 2 or 3, or something useful like that.

MEMBER BANERJEE: Well, if you told us that now, that the gravity wave velocity is going to be much less than the full velocity, so you can't get a counter-current gravity wave going back, then I would buy that argument, but that you can do by hand.

CONSULTANT WALLIS: We haven't see that argument yet.

MEMBER BANERJEE: Right. And I wouldn't believe TRACG because TRACG doesn't calculate gravity waves, as far as I know. Does it?

CONSULTANT WALLIS: By the way, I think we agree there is no problem if they slope the pipe up.

CHAIR CORRADINI: Okay. Then you two have convinced each other. All right. So let's move on.

Thank you, and stay on the line, though.

MR. ALAMGIR: Thank you.

MR. MARQUINO: Thanks.

Can we go to slide 12? I would like to do 11 and 12 in reverse order.

Slide 12 describes another alternate calculation that we did on elbow CCFL effects in the GDCS line. So here we postulated that, despite what Professor Wallis says, we assume the line is completely full of non-condensable gas, and then we calculated how long it would take that non-condensable gas to bubble out of the line into the GDCS pool.

CHAIR CORRADINI: So, Wayne, just to say it again, what part of the line was full of non-condensable gas?

MR. MARQUINO: The whole line.

CHAIR CORRADINI: From the squib up?

MR. MARQUINO: No. From the vessel nozzle all the way back to the pool --

CONSULTANT WALLIS: That's not the worst

case.

MR. MARQUINO: We hypothetically said that the whole line is full of gas, and we calculated how long it would take that mass of gas to bubble back into the pool.

CONSULTANT WALLIS: Seventy seconds. Now TRACG calculates something like that. Because if you're ever going to show us the TRACG predictions, I noticed in the --

CHAIR CORRADINI: You can't criticize them. They are trying to do the hand calculations first.

CONSULTANT WALLIS: The RAI was the same thing, that you have this gas escaping up into the GDCS pool before the squib valve even blew.

MR. MARQUINO: Right, right.

CONSULTANT WALLIS: That's not the worst case. The worst case is, if they leave that block valve closed and then the squib valve pops; when the squib valve pops, that's what you have got to consider.

MR. MARQUINO: Yes, that's true.

CONSULTANT WALLIS: If you could get to that worst case and you could show us that that one impedes the flow, that is all we need to do.

MEMBER BANERJEE: And that you can do by hand.

MR. MARQUINO: Yes, but here we are shortcutting this because, if we did the TRACG, more TRACG cases, the question is, can TRACG do this?

CONSULTANT WALLIS: Okay.

MR. MARQUINO: So we are trying to --

CONSULTANT WALLIS: I think TRACG does have a flooding correlation. Doesn't TRACG have a flooding correlation?

MR. MARQUINO: I think it does, but --

MEMBER BANERJEE: Let him get to it, please. He is going to tell us.

MR. MARQUINO: So to --

CONSULTANT WALLIS: So you think you are going to escape by citing Banerjee and Wallis on page 12.

(Laughter.)

CHAIR CORRADINI: That was his plan. Let him try to do it.

(Laughter.)

MEMBER BANERJEE: We could always retract our correlation.

MR. MARQUINO: So, if there are problems with these references, please let us know about it.

(Laughter.)

We used the Wallis CCFL correlation. Dr. Alamgir used that. And Dr. Shiralkar was involved in this calculation also.

We used the Banerjee test data of elbows.

CONSULTANT WALLIS: Well, why do you do this? Because it is got all the time in the world to come out before you even try to blow -- it has got years to come out of there. It has been sitting there with an open top for years.

MR. MARQUINO: We agree.

CONSULTANT WALLIS: Why do you worry about 70 seconds?

(Laughter.)

MR. MARQUINO: We agree.

CONSULTANT WALLIS: Then why do you do it? It is irrelevant.

MR. MARQUINO: Maybe we didn't understand what the concern was. Because we were summoned here to discuss non-condensable gas in the GDCS line.

MEMBER BANERJEE: Assuming it was there. Yes.

MR. MARQUINO: We talked to the staff, and we said, well, we submitted this RAI response that addressed this point.

CONSULTANT WALLIS: How is it sitting there all that time without coming out?

MR. MARQUINO: And the staff said, well, you submitted a TRACG calculation, but now show us your qualification of TRACG for non-condensable gas in the GDCS line. At that point, we said, well, we don't have to use TRACG; we can do a direct calculation of this. That is what we have provided here.

CONSULTANT WALLIS: Well, I would accept this. You take 70 seconds. If you have gas in that line and the block valve is open on top, it takes about 70 seconds -- TRACG predicts something similar, because I looked at the result -- to get the gas out. This can happen anytime before any accident or anything. So there is no gas in there unless the block valve is closed on top.

CHAIR CORRADINI: But, Graham, if I could just interject?

So let's say you're right, and the block valve is closed. They see it is closed and they open it. Isn't it the same 70 seconds?

CONSULTANT WALLIS: Yes, but after the squib valve opens.

MEMBER BANERJEE: Oh, now you've got flow.

MS. CUBBAGE: The block valves are going

to be --

CONSULTANT WALLIS: It's not with the squib valve open. This is happening before the squib valve is open.

CHAIR CORRADINI: Yes, but I am asking a different question. I am saying that, if I postulate --

CONSULTANT WALLIS: It is not the same thing. You blow the squib valve, and then you open the block valve. Then the water comes down and prevents the things going out.

MEMBER BANERJEE: Yes, that is the issue.

MS. CUBBAGE: Excuse me. Excuse me.

How many block valves are we postulating are closed?

CONSULTANT WALLIS: The only thing that matters here is if the block valve on top near the tank is closed.

MS. CUBBAGE: No, how many?

CONSULTANT WALLIS: Then they can trap gas.

MS. CUBBAGE: But there's four lines coming from --

CHAIR CORRADINI: All four block valves are closed?

CONSULTANT WALLIS: One of the lines --

MS. CUBBAGE: Well, then it doesn't matter.

CONSULTANT WALLIS: Well, why are you raising the issue then if it doesn't matter?

(Laughter.)

CHAIR CORRADINI: I think I want to let Wayne continue, right, to do the calculation. Then let's walk through it. Because in January of '07, actually, we got all over GEH about the sloping of the lines and the confidence we had in non-condensable gases blocking flow that would block core cooling. Okay?

So you proceed, and let's understand the hand calculation, then go to the TRACG calculation. Then we will come back and attack you.

MEMBER ABDEL-KHALIK: The concern at the time was that the check valve would not be normally open.

MEMBER BANERJEE: That was the concern.

CHAIR CORRADINI: That was one of the concerns. There was a range of concerns.

MEMBER ABDEL-KHALIK: And it is normally open now by design.

MR. DIAZ-QUIROZ: By design, yes.

MEMBER ABDEL-KHALIK: Yes.

MEMBER BANERJEE: Yes, I think that the concern was that gas could be trapped between the squib valve and the check valve. Let's be precise.

CONSULTANT WALLIS: That gas could be trapped in the line if the block valve -- maybe all the block valves are closed.

MEMBER BANERJEE: No, no, no.

CONSULTANT WALLIS: I don't know.

MEMBER BANERJEE: The concern that we specifically had was -- that's why I kept asking you, is the check valve open or not normally?

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: But we hadn't thought about the problem enough to know what was the worst case then.

MEMBER BANERJEE: There could be worse cases, but our concern at that time was gas trapped in that region.

Okay. So let's carry on.

MR. MARQUINO: Okay. Let's back up to slide 11.

This provides information on TRACG calculations where we apply a delay time to the start of injection, where we evaluated how long the injection could be delayed, and we evaluated how much the flow rate could be reduced.

So, given that it would take 70 seconds for the line to vent if it was completely full of gas, we can reduce the GDCS flow in TRACG to 1/7th of the value calculated in the licensing basis and still have enough flow to make up for boiloff in the core.

CONSULTANT WALLIS: So excuse me. This is the hand calculation where you actually have the gas in there when you blow the squib valve.

MR. MARQUINO: Uh-hum.

CONSULTANT WALLIS: Because the TRACG calculation I saw in the RAI, you actually had it bending out before you blew the squib valve.

MR. MARQUINO: This is a subsequent calculation.

CONSULTANT WALLIS: A different calculation.

MR. MARQUINO: It is a different calculation, yes.

CONSULTANT WALLIS: So this is more like the worst case? There's gas in there when you blow the squib valve. That's the worst case.

MR. MARQUINO: Yes.

CONSULTANT WALLIS: In the line, the top

line. Not in the lines of the RPV, but the line to the --

MR. MARQUINO: Actually, I will be more specific. The 1/7th value, that was simply determined by the decay heat at the time GDCS flow starts. The steam generation from that decay heat and the flow rate in the licensing basis calculation, and --

CONSULTANT WALLIS: That's from all tanks? That's from all tanks?

MR. MARQUINO: Yes.

CONSULTANT WALLIS: So all the lines have gas in them?

MR. MARQUINO: Yes. If you want to look at it that way, yes.

CONSULTANT WALLIS: So this is really a bad case.

MEMBER BANERJEE: Well, it is a bounding calculation.

CONSULTANT WALLIS: But then that means all the block valves have been closed.

CHAIR CORRADINI: Now I am getting confused.

Go through your thing, so I understand what you are doing, before we quiz you on it.

MR. MARQUINO: Okay. The 1/7th GDCS flow, there is no additional TRACG calculation involved in that. It is simply a matter of looking in the DCD at the time GDCS flow starts, what is decay heat at that time; what would be the steam generation based on that decay heat; what is the GDCS flow rate after it starts?

The steam generation of 1/7th of decay heat; therefore, if the GDCS flow were reduced forever by that amount, if it was only 1/7th of the flow predicted by TRACG, we would still be making up for steam generation because decay heat is only going to get lower from that point in time.

CHAIR CORRADINI: Okay. Keep on going.

MR. MARQUINO: The second sub-bullet is a TRACG calculation where we basically didn't turn on GDCS flow. We reduced it to a very small number, something like 1 percent, and then we looked for how long it will take the core to heat up. A delay of 400 seconds could be tolerated before the core would start heating out. So we could go out to 900 seconds after the LOCA before having any core heatup.

Four hundred seconds is greater than 70 seconds. So, even if the line was full of non-condensable gas that had to bubble out, we still would not have any core heatup.

MEMBER BANERJEE: Let me ask you about the hand calculation. That assumes that you are working along a flooding line which is somewhat less than for a vertical pipe because you have an elbow there, right? So it is some half of 2/5ths, or whatever.

So you have got a Jg-Jl relationship and you are calculating the liquid penetration and the gas penetration to get that 70 seconds clearing; you are doing that by hand, correct?

MR. MARQUINO: Yes.

MEMBER BANERJEE: So that would be the time for the Jg, or whatever you calculate, to clean this thing out?

CONSULTANT WALLIS: It seems long, doesn't it?

MEMBER BANERJEE: Well, they did it.

CHAIR CORRADINI: But can I ask --

MEMBER BANERJEE: At least that is understandable, what you have done.

CHAIR CORRADINI: Can I ask a clarification?

MEMBER BANERJEE: Yes.

CHAIR CORRADINI: You did that based on the initial flow rate? The Jg plus Jl with --

CONSULTANT WALLIS: They calculate the

flow rate from the displacement --

CHAIR CORRADINI: Let me ask him.

MR. MARQUINO: I want Dr. Alamgir or Dr. Shiralkar to answer.

The question is, what flow rate was used in the calculation of 70 seconds?

MEMBER BANERJEE: If you go back to the previous slide, the flooding correlation is there, right, if you just go back?

So there is a relationship between Jg and Jf?

MR. MARQUINO: Yes.

MEMBER BANERJEE: Which is that correlation?

CONSULTANT WALLIS: Which lets the stuff, then, back into the GDCS pool. The worst case is, if the flow rate coming out of the GDCS pool is just enough to hold the gas stationary.

MR. MARQUINO: Right.

MEMBER BANERJEE: So zero gas penetration, Jg equal to zero.

CONSULTANT WALLIS: That's possible, but it doesn't last very long.

MEMBER BANERJEE: So what is Jf?

CONSULTANT WALLIS: It doesn't last very

long because the RPV is depressurized.

MR. MARQUINO: Right.

CONSULTANT WALLIS: That is what saves you in all of this, is that the RPV is depressurizing rapidly, so things flush out.

MEMBER BANERJEE: No, but the question, Graham, is, what is Jf to make Jg zero then?

CONSULTANT WALLIS: Does that get achieved? Right.

MEMBER BANERJEE: Yes.

CONSULTANT WALLIS: Right.

MR. ALAMGIR: Dr. Shairalkar, are you online?

If not, I will answer this question on his behalf. He had done the calculation.

Can you hear me?

MR. MARQUINO: Yes.

MR. ALAMGIR: Okay. So what is the flooding correlation, one equation? The other equation is based on the fact that the liquid that is coming down has displaced equal volume of the gas, given that the squib valve is closed.

CONSULTANT WALLIS: So you are assuming no flow into the RPV?

CHAIR CORRADINI: Correct.

CONSULTANT WALLIS: Well, that's wrong because there is a pressure difference, and it could actually be flowing the other way.

MR. MARQUINO: Just let him explain what he did. It is conservative.

CONSULTANT WALLIS: No, it's not.

MEMBER BANERJEE: No, no, it's not. Let him explain. Go ahead.

MR. ALAMGIR: So the assumption made is the volume of the gas that is displaced is equal to the volume of the liquid that is coming down, and that provides another relationship between Jg* and Jl*, which is vary it as Jg equals anjl, and that is a solution for either Jg or Jl. From that, 70 seconds --

CONSULTANT WALLIS: Well, you should have read what I wrote in July. The worst case is, if the pressure of the whole line, the pressure drop in the whole line and the gravity head is just enough to get you a Jf down, which is just enough to hold the gas stationary.

MEMBER BANERJEE: Which is Jg* equal to zero.

CONSULTANT WALLIS: Then understand this situation will tend to persist.

MR. WACHOWIAK: Just enough to hold it stationary in an 8-inch line.

CONSULTANT WALLIS: Yes. That situation will persist forever, but it doesn't because the RPV pressure goes down.

MR. MARQUINO: But what they said was, if you have liquid coming in, you have to have gas exiting.

CONSULTANT WALLIS: No, you don't because liquid goes into the RPV.

MEMBER BANERJEE: You don't. If you look at the correlation, if Jf* is 1, roughly, then it will be zero gas penetration.

CONSULTANT WALLIS: It will hold the gas stationary.

MEMBER BANERJEE: There will be no gas.

MR. MARQUINO: Okay. We are looking at this as there is no flow going in at the vessel nozzle.

CONSULTANT WALLIS: That's not true.

MEMBER BANERJEE: No, that's not the --

CHAIR CORRADINI: I think we are learning things, but I don't think we are getting forward relative to what they have done.

CONSULTANT WALLIS: Well, we are getting

forward a great deal because what I am hoping these guys did was to look at the worst case, and that is the only thing they have to do, and I don't think they have got there yet. I'm surprised.

CHAIR CORRADINI: I thought they have approached the worst case in three different ways, and they have come up with a conclusion that --

CONSULTANT WALLIS: Well, this stuff about a seventh flow in 400 seconds, that is very useful, but the question is, how long does it take to get the gas out of there if the pipe is full of gas? And if it just so happens that the liquid flow is just right to hold that gas stationary, it is not going to go anywhere.

CHAIR CORRADINI: So can I ask a question, just since we are learning at this point for a few more minutes?

So that correlation up there is applicable to an 8-inch pipe?

MR. ALAMGIR: No, it is for a 37- to 40-plus-millimeter diameter.

CHAIR CORRADINI: Okay. So I would maintain, based on physics, that there's no way an 8-inch pipe can let gas below it not bubble up above it.

MEMBER BANERJEE: No, Mike, you're wrong.

They have done full-scale experiments in the elbow from a steam generator to a hot leg at Dresden.

CHAIR CORRADINI: Air/water?

MEMBER BANERJEE: No.

CONSULTANT WALLIS: Steam/water.

MEMBER BANERJEE: High pressure steam water down to air/water. That correlation there roughly holds, up to 14-inch pipes.

CONSULTANT WALLIS: But that is a bend. That is a bend. It is not a vertical pipe.

MEMBER BANERJEE: Yes, that is a bend. It is at the elbow.

So your point is not correct.

CHAIR CORRADINI: Well, then I will put it to the side.

MEMBER BANERJEE: But that correlation is pretty okay.

MR. ALAMGIR: I just want to make a passing comment that it is an experiment. Professor Banerjee, you know this one.

MEMBER BANERJEE: Yes.

MR. ALAMGIR: For about the same size as the GDCS nozzle --

MEMBER BANERJEE: Right.

MR. ALAMGIR: -- 200 millimeters. There

the correlation is limiting. In fact, your tests are the most limiting, which is good.

CONSULTANT WALLIS: I feel you should do it this way: if the pipe is full of gas, then if the liquid flow is just about right to hold the gas there, this doesn't persist for very long because the RPV pressure is dropping. As soon as that drops, it just flushes everything out of there. That is what you should be doing.

CHAIR CORRADINI: But, Graham, isn't that the 70 seconds versus the 400 seconds calculation?

CONSULTANT WALLIS: No. No. The 70 seconds is a bogus --

CHAIR CORRADINI: No, no, but they need to go -- the pressurization would take it to that point in less than 400 seconds. That was Wayne's original point.

CONSULTANT WALLIS: Seventy seconds is the time that, if you have the squib valve closed, so there's no flow, so that the volume or flow of gas out is the same as the volume flow of liquid down, that is the 70 seconds.

MEMBER BANERJEE: At zero.

CONSULTANT WALLIS: That is the 70 seconds.

MEMBER BANERJEE: Seventy seconds would clear it.

CONSULTANT WALLIS: That is the time it takes to get the stuff out if the squib valve is closed. As soon as you open the squib valve, the liquid can flow into the RPV and take the gas with it or it can hold the gas in place or it can let it come out.

MEMBER BANERJEE: Well, Graham, if you wanted to bound this, there are two different ways. I think they have answered the question about the steam counter-current flow, which is the first part, which is the condensation.

If we assume that the Slovenian experiments cover the range of conditions of interest, then they've got experimental evidence behind them, which is really good.

With this case, there are two bounding cases. One is zero liquid penetration, which is Jf zero, and they have shown that you clear the line in 70 seconds.

The other bounding case is Jg zero and you will get some Jf out of that, which will be Jf* of the order 1.

CHAIR CORRADINI: So may I ask a question at this point?

MEMBER BANERJEE: Yes.

CHAIR CORRADINI: So, if that is the case --

MEMBER BANERJEE: Yes.

CHAIR CORRADINI: -- I would maintain that flow rate is larger than 1/7th flow that they have just calculated.

MEMBER BANERJEE: Could be, but I don't know.

CHAIR CORRADINI: We can do the hand calculation.

MEMBER BANERJEE: I don't know. I don't know.

CHAIR CORRADINI: But wait. Just let's proceed.

So I still think, at least as I understood what Wayne was expressing, it is that that 1/7th flow is the most limiting case, given that that Jf* is greater than that.

MEMBER BANERJEE: Well, if it is, then that is fair enough.

CHAIR CORRADINI: Because, then, Graham's point is the water leaks through, the gas is magically held in place, and I still cool the core.

CONSULTANT WALLIS: Not magically; it's physically by clear mechanics.

(Laughter.)

CHAIR CORRADINI: At this point, since I am still personally not sure that correlation is applicable to an 8-inch pipe, it is held there and it leaks past and cools the core.

MEMBER BANERJEE: Well, what he is saying is that correlation is probably a limiting case, that they have evidence which suggests that --

CONSULTANT WALLIS: The gas is broken up into smaller bubbles and stuff.

MEMBER BANERJEE: Yes, but it is not a bad correlation to use.

CHAIR CORRADINI: Okay. But have I expressed it correctly, that the two extremes are, for this, Jg* is zero and Jf* is zero. With that, it still shows that we are essentially okay.

MEMBER BANERJEE: Then you're okay.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: Now what really saves you is that, because the RPV pressure is dropping so rapidly, the pressure drop driving the liquid flow increases rapidly, and that Jf gets so big that it just pushes the steam. Once the gas begins to go out, the hydrostatic head builds up more rapidly, and it comes out. So that is the answer really.

I mean, if the RPV pressure were not dropping the way it is -- I think it is dropping like a stone, unless you guys are wrong. That will sweep out the gas. That is the answer to it.

CHAIR CORRADINI: Right. It is designed to do that.

CONSULTANT WALLIS: All these pseudo-answers are not really very good.

MEMBER BANERJEE: But, Graham, what you are saying is right, but I think if they can show, even if the pressure is not rapidly dropping --

CONSULTANT WALLIS: Even if the gas stays there forever, they are still all right.

MEMBER BANERJEE: They still have enough flow.

CONSULTANT WALLIS: I guess they could do that.

MEMBER BANERJEE: Then they are home free, basically.

CONSULTANT WALLIS: I think they are home in all kinds of ways.

MR. ALAMGIR: Dr. Banerjee, I do not see a flooding occurring here due to hydraulic jump, just because there is no sustained source of non-condensable gas. There is just a pocket.

If you think of another condition where there is bubble-rise velocity, including the bubble-rise velocity, it is about the same order. So I do not see it as a scenario where it would be held down.

With due respect --

CONSULTANT WALLIS: If you have liquid flowing down a pipe, there is a certain velocity at which it will prevent gas flowing out, right?

MEMBER BANERJEE: Well, what he is saying is, what correlation should you use? But if you use the most conservative correlation and you are still getting more than 1/7th the flow, you know, the GDCS flow, then you are fine, aren't you? Or is that too conservative? Maybe you should answer that question.

MEMBER SHACK: Well, you can do an experiment. What happens, actually, if you have stagnant gas in a pipe, and you turn on the liquid, you tend to get a big slug flow bubble. Then the question is, is that stable?

I think you can solve the problem. I think I need to see the most recent RAI response because the one I saw doesn't go through any of this stuff. It is previous to all the arguments I heard.

MR. ALAMGIR: We should keep in mind that there are eight lines.

CHAIR CORRADINI: This was prepared specifically for this meeting.

CONSULTANT WALLIS: Then we need to see it in writing. I think you need to edit out the stuff which is not --

CHAIR CORRADINI: Wait. Let him talk, Graham.

CONSULTANT WALLIS: Okay.

MR. ALAMGIR: So then this is full of gas. So that is an extreme assumption.

CONSULTANT WALLIS: Even then, you're all right.

CHAIR CORRADINI: So let me just ask Wayne and your compadres down in North Carolina, what you prepared for this meeting, is this going to be formally sent to the NRC?

MR. MARQUINO: If the NRC requests that.

CHAIR CORRADINI: Okay.

MS. CUBBAGE: The NRC has not requested that.

CONSULTANT WALLIS: So you are resolving this without even getting an answer to the question, right?

MS. CUBBAGE: We will speak to our conclusions in a moment.

CONSULTANT WALLIS: Oh, you will? Okay.

CHAIR CORRADINI: Okay. So are you clear as to the questions raised by the Committee, Wayne?

MR. MARQUINO: Yes.

CHAIR CORRADINI: Okay. Is it Adrian? I'm sorry.

MR. MARQUINO: No. It's MD Alamgir.

CHAIR CORRADINI: Alamgir. Excuse me.

MD, do you understand the questions raised?

MR. ALAMGIR: I understand the question raised, that there could be a hypothetical situation where there is zero gas flow and liquid is coming down.

CHAIR CORRADINI: And just to drive the nail into the dead body -- hang on -- just to drive the nail into the dead body, the point made by Dr. Banerjee was that, if you took the correlation expressed, set Jg to zero, looked at the Jf you got, and showed that that flow is essentially larger than your 1/7th flow, which essentially gave you cooling, or made up exactly for decay heat, that would be the worst of the worst.

CONSULTANT WALLIS: My point, you've got to consider first the gas is very slowly moving up the pipe. It takes a long time to --

CHAIR CORRADINI: Can I at least get my point across before we --

CONSULTANT WALLIS: It is not the worst. It is not the worst.

CHAIR CORRADINI: Do you understand?

MR. ALAMGIR: Let me replay what you just said.

For Jg equals zero, calculate Jl, and show that as greater than 1/7th.

CHAIR CORRADINI: That was what Dr. Banerjee suggested as a worst case.

CONSULTANT WALLIS: No. What you do is put the gas in there, fill in the pipe, calculate Jf, because you've got a hydrostatic head; you've got friction. You know how much hydrostatic head you have lost. If you calculate this Jf, I think you will find it is big enough to sweep the gas out.

CHAIR CORRADINI: Okay.

CONSULTANT WALLIS: That is what you should do. Don't do some hypothetical thing.

MR. ALAMGIR: Now I know you do not believe in TRACG, but TRACG has mechanistic models which already show that it can do it.

CONSULTANT WALLIS: TRACG does it? I'm not sure TRACG --

CHAIR CORRADINI: We are not going to leave until we have a mission. Dr. Alamgir restated the question. If that is not the question, I would like to --

CONSULTANT WALLIS: Do it right. Just do it right and it will be okay.

CHAIR CORRADINI: Well, let's just clarify. Hold on.

CONSULTANT WALLIS: Don't ask me to solve the problem for you.

MS. CUBBAGE: Can I suggest that, after the staff's presentation, we could come to a conclusion and action items?

CHAIR CORRADINI: Yes. But to finish this part off, Dr. Banerjee suggested a procedure.

Dr. Alamgir, you understand that procedure?

MR. ALAMGIR: I understand as I stated a few minutes ago.

CHAIR CORRADINI: Right. Okay. Fine. Let's move on.

CONSULTANT WALLIS: Now wait a minute. If they are going to put in something which is still somewhat half-baked, I am not going to take it again.

CHAIR CORRADINI: But, Graham, at this point, I need them to move on.

CONSULTANT WALLIS: I know. It is a trivial problem. It is a homework problem. Just do it right. That's all they have to do. Don't do some half-baked thing which is not really a fully wrapped-up answer, and it is easy.

MEMBER BANERJEE: Well, let's do this, Mike.

CONSULTANT WALLIS: Just do it.

MEMBER BANERJEE: After the staff presentation, we will internally come to a position in discussion amongst us.

CHAIR CORRADINI: Fine.

MEMBER BANERJEE: And then we will --

CHAIR CORRADINI: Fine.

MEMBER BANERJEE: -- either be satisfied or need some more clarification.

Let's move on.

CHAIR CORRADINI: Let's move on.

CONSULTANT WALLIS: Did you guys see this thing I wrote in June or July?

MR. WACHOWIAK: So we will move on by

moving back up one slide here.

CHAIR CORRADINI: Whatever you want to do to move on, move on.

MR. WACHOWIAK: We just want to finish this up.

In terms of the flow, they calculated the 1/7th by the method that Wayne said, but you've already seen these types of flows before in the PRA presentation. Depending on the break size, we have presented that 1/8th to 2/8ths or to one-quarter of the flow -- 1/7th is right in the middle there -- is what we needed in the PRA, calculated by alternate means, which is MACC, completely independent of what they are doing.

So you have seen those types of flow rates before for this plant?

CHAIR CORRADINI: Yes.

MR. WACHOWIAK: Okay.

MR. DIAZ-QUIROZ: Let's go to the GDCS check valve.

MR. WACHOWIAK: Okay.

MEMBER ABDEL-KHALIK: That first bullet on the summary slide --

MR. WACHOWIAK: Okay.

MEMBER ABDEL-KHALIK: -- where you say gas injection lines continuously vent due to sloping, and check valve design, correct?

MR. WACHOWIAK: Right. Yes.

MEMBER ABDEL-KHALIK: I mean that is the major thing.

MR. WACHOWIAK: Yes.

MEMBER ABDEL-KHALIK: Thank you.

MR. DIAZ-QUIROZ: This particular part of the presentation is on the GDCS check valve. GEH has responded to particular RAIs on this topic.

CHAIR CORRADINI: If you hit CTRL-L, you will actually get full screen.

MR. WACHOWIAK: There is a driver issue with this computer.

CHAIR CORRADINI: Okay, fine. Sorry. Sorry.

MR. DIAZ-QUIROZ: We responded to the RAI on this topic, 3.9-200. I will just quickly go over the check valve requirements, in-service testing. You already heard some of that.

Check valve type, we have spoken to vendors. We have sort of narrowed down our selection.

What's the LOCA operation? Of course, it is similar to what was previously discussed.

Hydrodynamic loads, as far as what is the process, what are we going to look at when the final pipe routing is completed.

The requirements for the check valve itself, it is to be installed horizontally, and the pipe will be held normally open or vertically and held by gravity.

There is an ITAAC for this particular valve itself to confirm forward flow and reverse flow coefficients. That is to assure that it will open and close and have the proper flow through it.

There is remote indication on the check valve, as previously discussed. That is a requirement.

The valve qualification of this particular valve will verify the applicable design requirements have been met and will also address the orientation of the valve performance, whatever orientation it is.

Of course, in-service testing will be done through the ASME OM Code. The IST program is required, again, by technical specifications.

The check valves themselves will be tested every refueling outage. Those are through those drain points, test line connections, where you will have flow test in reverse to make sure it closes.

In particular, like I just mentioned,

there have been discussions with valve vendors. We looked at several valves. One, in particular, is a nozzle check valve which we think meets the requirements that we have for this particular valve. It has got a short stroke. It is a lightweight disc, rapid disc closure, minimizes impact.

This particular valve would be installed in a vertical orientation such that gravity holds it open, and there would be a light spring on it to resist gravity, such that it is still in the open position, but sort of pretty much it is in a neutral, you might call it, position.

For example, here you have this valve here where this would be the top of the valve, installed vertical. Flow, normal flow would be in this direction.

Of course, here the valve is shown in the closed position. That would be, of course, after the GDCS injection valve opens.

As soon as the core GDCS injection pressure exceeds RPV pressure, it would push open the valve and push down the disc portion. Then, thereafter, it would just be held down by gravity itself, and flow would occur through it.

MEMBER BANERJEE: Can we just go back for a minute?

MR. DIAZ-QUIROZ: Sure. Go ahead.

MEMBER BANERJEE: Is there any sort of issue that -- you've got some indicator as to where this valve is during normal --

MR. DIAZ-QUIROZ: Right. Right. You have the stem to indicate that position. The stem, there's ways to show that indication.

MEMBER BANERJEE: Because it could be potentially closed if there was a back pressure, right, or something?

MR. DIAZ-QUIROZ: Well, the back pressure, of course, would be during the initial opening of the squib valve where potentially the check valves could see anywhere from 60 to 200 psi, depending on what the LOCA scenario is. So, even then, you would have it to where the hard seat would be on the valve body itself, and then, of course, the disc, that is what prevents backflow. Of course, it seats up against the valve body, the seat that is on the valve body itself.

So, if you are saying, potentially, you could have a stuck closed valve because of its seating after squib actuation, of course, the valve, then, at that point wouldn't function as its normal function would be. Then, at that point, it would be considered a single failure. Of course, that kind of criteria would have to go into the qualification of the valve, have some sort of reliability taken to it. The PRA sets that reliability criteria. So that would go into the qualification of the valve.

MEMBER BANERJEE: And the valve is qualified and tested under the sort of conditions that could be expected?

MR. DIAZ-QUIROZ: Right, and here, the worst-case condition for the valve is not during LOCA, where the squib valve is actuated when needed, because there is the level in the reactor pressure vessel. It is because, during normal operation, you might have this issue with a spurious actuation of a squib valve, where the check valve would see normal operating pressure of around 1,000 psi. That would be the limiting case for this valve in this case. At that point, of course, spurious actuation of the squib valve, you have an inop trench line and then, at that point, tech specs come into play.

MEMBER BANERJEE: So then you could see very high pressure differential?

MR. DIAZ-QUIROZ: Right. It could see at that point, if it were actuated before it was needed.

CONSULTANT WALLIS: Right.

MEMBER BANERJEE: Thank you.

Have such valves been used before somewhere?

MR. DIAZ-QUIROZ: Yes. These valves, these nozzle check valves are used in Europe in some of the nuclear power plants, yes.

CONSULTANT WALLIS: So, the next slide, it says that the RPV pressure could be 220 psig at the time of actuation.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: That is 220 psi on this thing closing it, not jamming it?

MR. DIAZ-QUIROZ: What was that again?

CONSULTANT WALLIS: If you've got the RPV pressure up at 220 psi --

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: -- which is on the next slide --

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: -- then the pressure from this GDCS pool is much less than that.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: So this valve is really jammed shut, isn't it?

MR. DIAZ-QUIROZ: It is closed shut.

CONSULTANT WALLIS: So I wonder, if you close it shut with too much pressure, it may jam.

MR. DIAZ-QUIROZ: Right, and then that is a reliability issue that is going to have to be addressed in the qualification of the valve.

CONSULTANT WALLIS: Right. Right. Especially that type of valve, which has a seat where it could jam up in the seat there.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: Yes.

MR. DIAZ-QUIROZ: You could budge it --

CONSULTANT WALLIS: I guess the angle of the seat is such that it won't wedge itself in there.

MR. DIAZ-QUIROZ: Right. That's part of the qualification.

CONSULTANT WALLIS: You've got to qualify it for --

MR. DIAZ-QUIROZ: Right. Right. So it would have to sustain a --

CONSULTANT WALLIS: For maybe a 400 psi pressure difference or something, something conservative.

MR. DIAZ-QUIROZ: Right. Well, in this case, the worst case, 1,000 psi.

CONSULTANT WALLIS: Okay.

MR. DIAZ-QUIROZ: Okay. Let's go on to the next slide, please.

CONSULTANT WALLIS: Another one.

MR. DIAZ-QUIROZ: I'm sorry. Go back.

CONSULTANT WALLIS: We did No. 6.

MR. DIAZ-QUIROZ: Sorry about that.

Okay. I was just discussing normal operating, meaning LOCA operation. So, again, as you stated, about 200 psi during LOCA, that is the max it could possibly see during LOCA.

CONSULTANT WALLIS: Well, you pop the valve, the squib valve, quite a long time before you actually get injection.

MR. DIAZ-QUIROZ: Right. That is to assure that there aren't any timing issues.

CONSULTANT WALLIS: Right.

MR. DIAZ-QUIROZ: When the pressure drops below the injection pressure, it is open and it is ready to go.

CONSULTANT WALLIS: It gives you the 130 seconds, which is more than the 70 seconds it takes to get that gas out of that line.

MR. DIAZ-QUIROZ: Right. Right.

CONSULTANT WALLIS: So this gets the gas out before there is any flow at all.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: Is that your argument then?

(Laughter.)

CHAIR CORRADINI: Let's move on.

CONSULTANT WALLIS: If it is closed, then you get the counter-current flow at equal volumes.

MR. DIAZ-QUIROZ: Right. In this case, right, I am talking about --

CONSULTANT WALLIS: That makes sense. That makes sense.

MR. DIAZ-QUIROZ: -- normal, expected operation during a LOCA.

CONSULTANT WALLIS: That is when you get the gas out --

MR. DIAZ-QUIROZ: Right. Right.

Then it would take some upwards of 130 seconds for the injection pressure to exceed the reactor pressure.

CONSULTANT WALLIS: Why do you open it so early? Why do you pop the squib valve so early?

MR. DIAZ-QUIROZ: Right. It is an issue with timing and having the flow ready when rapid pressure --

MR. MARQUINO: It is because the

depressurization is different for different breaks, steamline breaks versus liquid breaks. So we can't have it open at exactly the right moment in every break.

CONSULTANT WALLIS: So you have a margin of some sort then?

MR. MARQUINO: Right.

CONSULTANT WALLIS: So you make sure it is open when you need the flow?

MR. MARQUINO: Right.

CONSULTANT WALLIS: When you can get the flow? It says up to 130 seconds. What is the shortest time?

MR. DIAZ-QUIROZ: The shortest time escapes me right now.

CONSULTANT WALLIS: I was going to ask, it says, "remains closed until the reactor pressure is just above the GDCS injection pressure". What is that pressure where it is just above the GDCS injection pressure?

MR. DIAZ-QUIROZ: That is approximately 19 psi. So that is the gravity --

CONSULTANT WALLIS: So it has to drop to 19 psi --

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: -- before you get any flow? Okay. So we just need to look at how long it takes to get --

MR. DIAZ-QUIROZ: Right, and that is the pressure --

CONSULTANT WALLIS: -- from 60 to 19.

MR. DIAZ-QUIROZ: And we are talking about a pressure difference because the reactor pressure vessel and the GDCS pool --

CONSULTANT WALLIS: So this is another solution to this question about the gas. If you've got more than 70 seconds --

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: So you can skin this cat all kinds of ways.

MR. DIAZ-QUIROZ: Right, you can. That 19 psi is the pressure difference, of course --

CONSULTANT WALLIS: Right.

MR. DIAZ-QUIROZ: -- because you have the vessel itself communicates with the drywell, which is pressurized. So it is a really different step.

Again, as that pressure starts to exceed the reactor pressure, the check valve opens, and then you have gradual flow, and it increases as the reactor pressure vessel keeps going down in pressure. So you have this gradual flow buildup in the GDCS injection line.

CONSULTANT WALLIS: There is no water hammer or anything. There's no reason why there should be? There's no sudden change of flow rate? There's no condensation or anything in there?

MR. DIAZ-QUIROZ: At that point, as we previously discussed, if there is, it will exist in the horizontal end toward the nozzle.

CONSULTANT WALLIS: All right. So there is no reason for a sudden closing leading to water hammer?

MR. DIAZ-QUIROZ: Right. During the initial, of course, event of the GDCS actuation itself.

MEMBER BANERJEE: Now when you get to the stage where you can get uncovery, and if you get a sudden condensation event, that could set up a water hammer, right? Condensation shocks are very strong.

CONSULTANT WALLIS: But is it going to go down that inclined pipe, is the question.

MR. DIAZ-QUIROZ: Right. You have a vertical run, and then you have that horizontal run.

MEMBER BANERJEE: Oh, they are talking about having very cold water coming in contact with the steam, right? Generally, in the experience I have had, I have managed to shatter a stainless steel pipe.

CONSULTANT WALLIS: So, if they had a horizontal pipe, they might well be in trouble.

MEMBER BANERJEE: Yes.

CHAIR CORRADINI: You are talking the last couple of meters? Is that what you are concerned about?

MEMBER BANERJEE: Yes.

MR. DIAZ-QUIROZ: Right. So you have this squib valve that is normally closed, and that segment is, of course, at reactor temperature as it gets closer to the --

MEMBER BANERJEE: Yes, now it is, but --

MR. DIAZ-QUIROZ: Right. Once it opens, you get a quick reverse flow through it. You want to close the check valve.

MEMBER BANERJEE: Then, once the core level drops and you start to get saturated steam, or whatever, in it, and you put very cold water --

CONSULTANT WALLIS: This is like water hammer in the feedwater line of a PWR --

MEMBER BANERJEE: Yes.

CONSULTANT WALLIS: -- which actually did pop.

MEMBER BANERJEE: Yes.

CONSULTANT WALLIS: There were 18-inch pipes which grew by 2 inches from that water hammer.

MEMBER BANERJEE: It is an amazing thing if it happens, but I assume what is happening is that the thing, the water that is coming in is condensing outside. I mean condensing the steam outside. That is the argument that is being made.

CONSULTANT WALLIS: Or in a very small region --

MEMBER BANERJEE: Yes.

CONSULTANT WALLIS: -- because it is an upward-sloping pipe.

MEMBER BANERJEE: Yes. So it is not getting that high surface area that you get, that you need for a --

CONSULTANT WALLIS: And this TRACG somehow is predicting, because of some glitch in the code, some fluctuating pressures, which would have flow going both ways for a while.

MEMBER BANERJEE: Have you considered the potential for water hammer once the core uncovers?

MR. DIAZ-QUIROZ: Water hammer, if you go on to the next slide here, of course, the water hammer has a lot to do with the pipe routing itself, the configuration.

Right now, those loads on the valve have not been calculated because of that, but the GEH design process will evaluate the loads on the check valve and other components along the line because of that, and due to water hammer issues. Of course, this is going to be at the final pipe routing stage, where the valve would be qualified, of course. You will know what the valve's performance is. Then you will know the final pipe routing, and then you will evaluate what kind of loads can be seen on this check valve and this squib valve and other components themselves.

MEMBER BANERJEE: How would you evaluate the loads for that?

MR. DIAZ-QUIROZ: The loads, meaning the methodology itself?

MEMBER BANERJEE: Yes. I mean, will you postulate some --

MR. DIAZ-QUIROZ: Right. So you have to postulate, right. It would be at normal design, normal operating pressures, 1,000 psi, which is one of the issues, and then design basis conditions to LOCA conditions. Then, of course, the LOCA conditions would have to take into effect the schema from the line, which could create another water hammer effect. We do call out those design requirements.

MEMBER BANERJEE: Now, during normal operation, of course, this is full of essentially saturated water.

MR. DIAZ-QUIROZ: It is sitting there, right.

MEMBER BANERJEE: You have no issue.

MR. DIAZ-QUIROZ: Right.

MEMBER BANERJEE: In terms of when you pull it down --

MR. DIAZ-QUIROZ: Right.

MEMBER BANERJEE: -- you've got the potential.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: If you have inadvertent squib valve operation, you have 1,000 psi across this valve?

MR. DIAZ-QUIROZ: During normal standby mode, yes, there's 1,000 psi across the squib valve.

CONSULTANT WALLIS: But that would be qualified for that, too.

MR. DIAZ-QUIROZ: Well, it will have to be, yes. Yes. The DPVs themselves have the same qualification requirements, and those have been tested and have been shown to open with 1,000 psi differential across them.

So, as I previously mentioned, the valve qualification will have to verify applicable design requirements have been met for this valve and to address, of course --

MEMBER BANERJEE: But I think what Graham is saying is that 1,000 psi qualification probably is sufficient, but there has to be a way to evaluate whether you could get some steam saturation and have really cold water there.

MR. DIAZ-QUIROZ: Right, the LOCA condition.

MEMBER BANERJEE: Yes.

MR. DIAZ-QUIROZ: When you drain, partially drain the segment, and steam enters, and then you have this cold flow come in.

MEMBER BANERJEE: Yes.

MR. WACHOWIAK: I think you answered that on one of the previous slides. The condition here isn't like a pump condition, where we've got a pump providing a high head to drive that cold flow there. It is the differential pressure between the reactor vessel and the tank. So it is going to start out at zero pressure differential and then it ramps, the pressure differential ramps up slowly. So it is a trickle of water that goes to more and more water. So you don't get the initial driving of a --

MEMBER BANERJEE: Well, also, initially, you are --

MR. WACHOWIAK: To get the high contact area to drive the water hammer.

MEMBER BANERJEE: The only potential is if you drop the level and you get steam in.

MR. WACHOWIAK: Even then --

MEMBER BANERJEE: At some point, you've got subcooled water.

MR. WACHOWIAK: -- the rampup of the flow rate is from zero to trickle, to a little less. So there is no mechanism to drive all the subcooled water there to be in contact with all the steam at the same time to drive the water hammer.

MEMBER BANERJEE: No, no, no.

MR. WACHOWIAK: The steam will be moving out of the pipe at the same time as the reactor vessel.

MEMBER BANERJEE: Are you saying that the uncovery of the GDCS line will occur gradually over a period of time?

MR. WACHOWIAK: No.

MR. DIAZ-QUIROZ: No. What he is saying is that, because the reactor pressure vessel at some point does reach the same injection pressure of the line, that you will have this gradual flow rampup in the line because the reactor pressure vessel will keep dropping in pressure. So you have this gradual increase rampup in flow. So you won't get immediate full flow.

MR. WACHOWIAK: It is not like pump flow.

MEMBER BANERJEE: Yes, I realize that.

MR. WACHOWIAK: Okay.

MEMBER BANERJEE: But what I am saying is there is another event which occurs, and I am not sure at what point, when the GDCS line itself will uncover and allow steam in potentially, yes.

MR. DIAZ-QUIROZ: Right.

MEMBER BANERJEE: And you have very cold water coming in at that point because it is basically water which is coming from the GDCS tank.

MR. DIAZ-QUIROZ: Right. There is a segment where you still have that reverse flow; you still have some warm water, but you're right, that particular scenario of the water hammer has to be analyzed, and there are requirements to analyze water hammer in the line and for the components as well.

MEMBER BANERJEE: Because then you will have cold water coming in contact with steam. There is an issue as to --

CONSULTANT WALLIS: That is why you slope the line up.

MR. DIAZ-QUIROZ: Right.

MR. WACHOWIAK: So the portion that is subject to that is very small.

CONSULTANT WALLIS: Is it just like --

MEMBER BANERJEE: No, I agree that, if you slope the line up, you reduce the probability --

CONSULTANT WALLIS: For the water hammer, if you have a horizontal feedwater pipe going into a steam vessel, then you get all kinds of problems. So you don't do that. You redesign the thing so the steam can't get back in there.

MR. DIAZ-QUIROZ: Okay. This is a very quick presentation. So, in summary, the valve qualification will be the applicable design requirements are met.

There are check valves that exist, that currently exist, by vendors that can meet these requirements. Of course, qualification would happen, too.

And just the third bullet, I just want to reiterate that, as far as during LOCA operation, this will see a quarter of the normal reactor pressure, which is 1,000 psi. So it has to be qualified to be able to withstand 1,000 psi --

CONSULTANT WALLIS: Well, I am glad we got this far because what we saw for too long on this GDCS BWR review was cartoons that showed things which weren't really fully designed yet. As you know very well, the design, the devil is always in the details of these things.

MR. DIAZ-QUIROZ: Right.

CONSULTANT WALLIS: And you learn after a while that you have to have a U-bend, you have to have a slope, you have to have this, that, and the next thing.

And if you do that early on, then you don't have to spend so much time explaining things to us.

MR. DIAZ-QUIROZ: Yes.

CONSULTANT WALLIS: But when you have cartoons which don't represent all these things, it is clear you haven't thought them out, it takes a long time.

Well, I don't want to say any more.

MR. DIAZ-QUIROZ: Okay. Well, that

concludes this presentation. It was pretty short.

CHAIR CORRADINI: Okay. Any other questions for GEH?

(No response.)

Okay. I am going to change things a bit. If it is all right, I would like to take a break now. All right? We are about 25 minutes behind. Let's take a break until 10:25. All right? And we will get back together, and staff will be, still an open session, talking about their presentation relative to the GDCS.

(Whereupon, the foregoing matter went off the record at 10:11 a.m. and went back on the record at 10:29 a.m.)

CHAIR CORRADINI: Okay. Bruce, do you want to lead us off here?

MR. BAVOL: Yes. My name is Bruce Bavol. I am the Project Manager for the chapters dealing with the issues we are talking about today.

I would like to get right into it and introduce Tom Scarbrough. He is going to be discussing the GDCS line non-condensables and the check valve issues.

MR. SCARBROUGH: My name is Tom Scarbrough. I am with the Component Integrity Branch in NRO. With me is George Thomas, and he is in the Systems Branch of NRO.

So I will go through this. You have heard a lot about the system and such, so I will try not to repeat things that you already heard.

But, basically, the GDCS provides coolant flow. The staff has reviewed the GDCS design qualification and testing. Based on the review of the DCD, RAIs, and the responses, and the discussions with GEH, those all involve things that we have talked about this morning on non-condensables, closure loads, potential water hammer, all of those sorts of things.

GEH did revise the DCD to provide more specific provisions for the GDCS design and components. They had check valve design attributes. They discussed the design process, including addressing potential water hammer, things of that nature. So that is something we think we have done for the review.

In terms of the design itself, you have seen the design. You have seen that basically there are four divisions. There is sort of three separate operations there: the short-term cooling of the injection, the long-term equalizing, and the deluge line to the lower drywell.

The water comes from the different pools. There's a 44.3-feet elevation between the GDCS minimum-level pool and the center line of injection nozzles. There's ITAAC that confirms that the GDCS injection lines have no elevated piping loops and are self-venting.

So that is just an overview of the design.

Then the next figure is just a simple diagram that we pulled out of tier one. You have seen a much better drawing this morning of it. But, basically, this is an overview of the system in case you want to point to anything in particular. But I will go on to the next one.

Basically, we looked at this system in two respects.

CONSULTANT WALLIS: This is another one of these cases where the cartoon is very misleading. It doesn't show the sloping-up of the lines.

MR. SCARBROUGH: Yes.

CONSULTANT WALLIS: And even if you tried to slope up that line from the GDCS pool, it's got such a long -- it sticks out so far, which is unrealistic, that you can't slope it as they say.

MR. SCARBROUGH: Right.

CONSULTANT WALLIS: This is the sort of

thing which is very misleading to a group --

MR. SCARBROUGH: Yes, these are, in fact, the drawings that are in the tier one. They are just sort of conceptual. But you're right, that's why, in terms of we did ask for an RAI and received an isometric drawing of it to get a better feel for it, but you're exactly right, these are not clear.

In terms of the valve functional design and qualification, the GDCS valves will be qualified following the DCD provisions in Section 3.9.3. That section specifies the use of ASME standard QME-1-2007, and that is just the ASME standard which was recently accepted in Reg Guide 1.00, Revision 3, with some minor conditions that aren't really related to this subject here.

In those areas of QME-1, they talk about testing it. They have to make sure that these check valves don't stick and test it under high enough pressure that they encompass the various design pressures. So all those types of things are part of the qualification for the valves.

We did perform an audit at GEH back in July which we looked at how the QME-1 standard was incorporated into the design specs for all these valves and also the qualification. There is an ITAAC which talks about qualification in tier one. So that is how we look at that.

MEMBER ABDEL-KHALIK: Are the squib valves covered by the same standard?

MR. SCARBROUGH: Yes, in our opinion, they are because QME-1 talks about power-operated valves. Then we give examples of what those power operators are. Then we say, "and other designs", other power operators.

So, in your opinion and GEH's opinion, from our discussions with them, they consider the QME-1 to encompass squib valves. Now, in our discussions with Westinghouse, they read it a little more narrowly, but, in their procurement specs, what they have done is they have taken all the provisions, the basic provisions of QME-1, and just put them right into their specifications. So the net result is the same, but it is just how they interpreted the standard. But, in our view, it covers squib valves.

CONSULTANT WALLIS: Can I ask you something now about valve P-1 on the slide, no number?

MR. SCARBROUGH: Okay.

CONSULTANT WALLIS: Now P-1 is the block valve at the top of the pipe there, right? P-1 is a valve, isn't it? There's a block valve; at the location, it says P-1. There is a block valve --

MR. SCARBROUGH: There is a block valve. Yes, sir, there's a block valve up there.

CONSULTANT WALLIS: And if that is closed, there is a non-condensable possible problem. If that is open, there is no non-condensable problem because non-condensables have long gone out of that pipe.

MR. SCARBROUGH: These are locked-open valves. These are valves that must be verified before startup that they are locked in open position.

CONSULTANT WALLIS: They're locked open? Now I understand that is a valve which, to operate, you have to go in there and open it. You can't control it from the control room?

MR. SCARBROUGH: No. I don't know if they will have it, but they will lock those open. Those have to be, you're right, those are valves that have to be open.

CONSULTANT WALLIS: The only way there could be the kind of problem we have talked about this morning for endless time was if that valve is left closed, because if it is open, the non-condensables are long gone up that pipe, right?

MR. SCARBROUGH: Right.

CONSULTANT WALLIS: So the only thing you have to worry about is, could it be left closed? I think of TMI, where they left the auxiliary feedwater valves, 12, closed during maintenance, and they didn't know it in the control room, but they were able to open them from the control room.

If these guys doing maintenance leave that closed, they've got trouble in spades because they will never get any GDCS flow, no matter what is in the non-condensables.

MR. SCARBROUGH: Right, down that line, right.

CHAIR CORRADINI: Just two things. One, I guess they have to answer this, but just one correction for the record. For TMI, the operators have to go out into the field to open the valves.

CONSULTANT WALLIS: Oh, they have to go in there? They couldn't do it from the control room?

CHAIR CORRADINI: No. Those block valves --

CONSULTANT WALLIS: Okay.

CHAIR CORRADINI: They were out of service, closed.

CONSULTANT WALLIS: Okay. Well, they did do it. They did open them.

CHAIR CORRADINI: But they had to go out

into the field, just for the thing.

So I'm sorry. I didn't mean to interrupt you.

CONSULTANT WALLIS: So I guess you're right there. Okay.

MR. WACHOWIAK: This is Rick Wachowiak from GEH.

Those valves do not have a remote operator. It is a manual valve. You need to go into the containment to close the valve.

CONSULTANT WALLIS: So it seems to me that the non-condensable stuff is really irrelevant because the only way you would have the problem is that if that valve is closed. If that valve is closed, you've got a bigger problem in spades. So that is what you have to worry about: is there a situation where they could leave that valve closed? It is very difficult to go in there and open.

MR. THOMAS: Dr. Wallis, can I answer that one?

CONSULTANT WALLIS: You might require that it be operated from the control room.

MR. THOMAS: You know, before the system startup, they compare the lineup checking -- okay?

CONSULTANT WALLIS: Yes.

MR. THOMAS: But, also, it is verified by a second person, actually. So there is a systematic --

CONSULTANT WALLIS: But I am just saying, presumably, at TMI they had some checks, too, but they still left the valve closed.

MR. THOMAS: So there would be less probability of having a problem with that --

CONSULTANT WALLIS: So it is in terms of a PRA question. It is a PRA question.

MS. CUBBAGE: Can one person talk at a time, please, for the transcriber?

CHAIR CORRADINI: So, George, finish what you are saying. No, go ahead and finish. I want to make sure I understood.

MR. THOMAS: Okay. You know, before system startup, there would be a valve lineup checking by the operator, okay, in the plant. When he goes through that valve lineup, there is a second person verifying that valve lineup. So the probability of having a normally open valve which is supposed to be locked open, you know, it is a very, very low probability. It is very difficult to postulate that valve being --

CHAIR CORRADINI: But, from a probability standpoint, I don't want to discuss it, but that is the procedure they use.

MR. THOMAS: Right.

CHAIR CORRADINI: And that is for all the eight lines?

MR. THOMAS: Right, all eight lines, yes.

MR. WACHOWIAK: That is part of the procedure that we use.

MR. THOMAS: Right.

MR. WACHOWIAK: Since we identified this, as Dr. Wallis said, as an important lineup, we have double verification on the lineup. We require indication of some manner, we haven't decided yet, of that position in that control room.

We also incorporated into the testing of the system this flushing. The flushing procedure won't work unless those block valves are open. So we have not only verification indication, but positive evidence before we come out of the outage that those valves will be open.

CONSULTANT WALLIS: Do you have an interlock?

MR. WACHOWIAK: We do not want them to have an operator in the control room because then during operation somebody could close them after we have verified by these three independent means that they are open.

CONSULTANT WALLIS: Do you have an interlock or something that says you can't start up the reactor if they are closed?

MR. WACHOWIAK: Yes, that is the tech specs.

CONSULTANT WALLIS: It's in the tech specs? Okay.

CHAIR CORRADINI: It is not automatic though.

CONSULTANT WALLIS: Oh, it's not automatic? You don't have an automatic interlock of some sort?

MR. WACHOWIAK: No.

CHAIR CORRADINI: No.

CONSULTANT WALLIS: Okay. So all depends on the operator doing that, the people in the plant doing the right thing?

(Laughter.)

CHAIR CORRADINI: That is normal operation.

CONSULTANT WALLIS: Yes, okay.

CHAIR CORRADINI: Go ahead.

MR. SCARBROUGH: All right. Thank you.

So, on the next slide, slide eight, which now we go into the in-service testing provisions, and the safety-related valves are within the scope of the IST program and they undergo periodic assessment of operational readiness according to the ASME OM Code. That is spelled out in Section 3.9.6.

For the GDCS check valves, they have to be tested in both the open and closed directions during refueling outages. Then the squib valve initiators, every outage they take 20 percent out into a lab and test, fire those 20 percent. If any of those fail, they have to go back and pull the whole batch out. So there is a process for making sure those work properly.

Also, in the DCD, they spell out in table 6.3-3 flushing of these lines for various reasons, functional testing of the check valves, making sure the injection lines are clear, checking the venturis, and making sure the deluge lines work properly. This is all done during refueling outages. So they have these test penetrations, and they will flush out both trains, both legs of the injection lines. Then, also, this table also mentions about the laboratory testing of the squib valve initiator. So that is the IST.

Now, in the DCD itself, we wanted to make sure that the design provisions for the check valves were spelled out. These were the provisions that they included. Part of this was in response to our request for additional information.

Their long-duration submersible piston check valves are quality group A, seismic 1, class 1. There are installed horizontal pipe runs and normally held-open spring or vertical. We saw some examples of what they might use today.

They have to meet minimum flow requirements for a minimum fully open flow coefficient in forward direction and maximum fully open flow coefficient in the reverse direction, in case the valve happens to stick open during the LOCA. So those are the things.

Then, on the next page, there are some additional design attributes that are spelled out in the DCD. They have to evaluate the loads during normal operation --

CONSULTANT WALLIS: Why do you want a fully open coefficient in the reverse direction?

MR. SCARBROUGH: In case it happened to stick open, you wouldn't want too much flow. You don't want this thing like blowing backwards with a lot of flow.

CONSULTANT WALLIS: You want a low coefficient?

MR. SCARBROUGH: Yes. They give you a minimum there.

CONSULTANT WALLIS: Okay. Because it talks about a maximum.

MR. SCARBROUGH: Well, you can't have any more than --

CONSULTANT WALLIS: You want to have a lower maximum?

MR. SCARBROUGH: Yes, sir. Yes.

CONSULTANT WALLIS: Okay. Okay.

MR. SCARBROUGH: Thank you.

So you evaluate the loads and make sure that the valves remain open during normal operating conditions, which is a zero DP, and that they will close under the reverse flow.

Then you have evaluation of hydrodynamic loads, the closure loads, including potential water hammer, and you must have remote position indication in the control room. So those are all the things that are addressed as part of the design process and using the QME standard as well.

Now the squib valves themselves, we also discussed with them, including design attributes for those valves. Because, as we heard this morning, the design of those is not finalized yet.

But, in terms of the design attributes, they are horizontally-mounted, and that is something that, in terms of the sloping discussion, this is a provision for the squib valves. So they need to be horizontally-mounted.

They are straight through. They are long duration. They have pyrotechnic. They have metal diaphragm seals.

The GDCS injection and equalizing squib valves are quality group A, category 1, and then class 1.

You can have no internal fragments or missiles following actuation. You have to have a minimum --

CONSULTANT WALLIS: Or gases.

MR. SCARBROUGH: Or gases, yes, sir.

Now one of the design attributes they need to talk about, you mentioned that this morning about, could gases go through? However they do design, whether they are piston rings to hold those gases in, or if they don't have them, they are going to have to analyze, part as a qualification, that any gases that do escape around that piston do not cause any problem down in the reactor. So they are going to have to evaluate that.

Then there is a minimum flow coefficient. The valve manufacturer has to perform full-flow tests and provide that data and the remote position indication in the control room.

We did discuss the squib valve design features with GE when we did the audit in July. They are discussing with various vendors and sources, the contractors, how to go about designing these valves. Westinghouse is farther along. We have been interacting with Westinghouse quite a bit on their squib valve designs. It is quite an art almost in terms of a lot of testing going on with squib valves. So we will be interacting with them.

That was part of our closeout of the audit, was that they will let us know as they get closer for these types of valve qualification. So we are involved in those reviews as well.

CONSULTANT WALLIS: What do you mean by position indication?

MR. SCARBROUGH: Position indication. We need to be able to show that this thing is closed during normal operation. Then, once it fires, they need to show clearly that it is open and you have no blockages.

CONSULTANT WALLIS: The fact that it is fired is not good enough? They've got to actually show that it is open?

MR. SCARBROUGH: Right.

CONSULTANT WALLIS: There has to be some device that shows that the thing is fully open?

MR. SCARBROUGH: Yes, sir, and that is what they are working on right now in terms of the design that we know with Westinghouse, getting a confirmative signal to show that it really is fully open.

MEMBER ABDEL-KHALIK: Now one of the concerns that were raised earlier was that a common mode failure for these valves is that you are going to buy them from a certain manufacturer, and they are going to put the wrong squib in all the valves, and this has happened, actually.

I can see that testing of 20 percent of the valves every outage would sort of examine that problem. At least you would have 20 percent of them or a significant fraction of them open. But if they are of the same vintage, if they are made at the same time by the same manufacturer, how do you avoid that problem?

MR. SCARBROUGH: Well, if you pulled out this group and you found any of these failed, then you need to expand that to the whole batch. Then, if you find more problems, you need to expand even more.

So you might be shut down for quite a while if you start to find any failures for these because these are critical valves. If you have failures of these to fire, they will have to expand the sample out.

So that is a concern, that as part of the qualification process, they are going to have to show that the repetitive nature, the reliability of these are such that you won't get that common mode problem. If you see a problem, you will see, you will find it as part of this 20 percent sample you are going to do.

MEMBER ABDEL-KHALIK: But how do you do that on day one, when the plant starts?

MR. SCARBROUGH: Well, before they put them in there, they are going to have to have, I would imagine, a sample firing of the ones, of the batches that they put in there, so that they will be able to show that, before they put them in there, that they take a sample of that batch and fire it. But that is what I would imagine, and I think that is a very good --

MEMBER ABDEL-KHALIK: But is that spelled out somewhere, that requirement?

MR. SCARBROUGH: I don't know, but I can look into it and find out because that is a good point. They should make sure that they have a sample firing of the batch before they put it in the very first time.

We can make sure that happens because we are going to be looking at part of the qualification process. That is part of like the actuator part of the issue. So, yes.

MEMBER ABDEL-KHALIK: But just putting the wrong squib --

MR. SCARBROUGH: Right.

MS. CUBBAGE: I would like to ask GE, because I know we have had discussions about this before here.

MR. WACHOWIAK: So it is partly done with a batch control of the actuators, the pyrotechnic actuators.

Chapter 6 of the DCD describes some of the higher-level requirements on there. So, for example, the equalizing line valves and the injection line valves do not have the same batch squib initiators in them.

They are required to be from different batches. So that is one of the controls to address common mode failures. The testing is another way. So there are batch controls placed on that to preclude or minimize common mode failure. We wouldn't say eliminate, but it would tend to minimize that.

MEMBER ARMIJO: Do these devices have some sort of a shelf-life problem or do they age and lose their potency? So, when you fire them, they don't put out as much force?

MR. WACHOWIAK: In general, I think the answer to that is yes, but that is also a design attribute that can be controlled to some degree.

MEMBER ARMIJO: So the guys that make this stuff know what those characteristics are. So you would have a replacement of these squibs periodically?

MR. WACHOWIAK: Right, and there's storage requirements and there's going to be shelf-life requirements. All that would be part of the valve specifications.

MR. SCARBROUGH: Okay. So that is the squib valve discussion.

Then the flow path, which is what you have talked about quite a bit, but this is just a summary word version of it. The injection line has a U-shaped bottom where the squib valves are the lowest point. There is water between the GDCS squib valve and the RPV to prevent gases coming down from that, from the RPV. Then you have the GDCS piping self-venting back to the GDCS pool.

Following installation, they are going to have ITAAC, they have ITAAC, which provides assurance that the as-built piping does provide the venting.

CONSULTANT WALLIS: You are going to put gas in and show that it come out? Is that what they do?

MR. SCARBROUGH: They will flush water until the water comes out.

CONSULTANT WALLIS: But it provides venting though. You've got to put bubbly water in or something.

MR. THOMAS: Flushing and venting are together.

MEMBER BANERJEE: He is just being mean.

(Laughter.)

MR. SCARBROUGH: Now, during outages, and during initial startup, before startup, they are going to have to use these test connections to flush out the lines or move any gases.

CONSULTANT WALLIS: Yes, but how are you

going to show, prove that it provides venting? You asked them to provide venting.

MR. SCARBROUGH: Right. They are going to have to show that there are no high points and that the sloping analysis -- and that is something that we have heard today.

CONSULTANT WALLIS: It is not an experiment? It is just an argument?

MR. SCARBROUGH: Right, they are going to have to show it, right.

CONSULTANT WALLIS: It is not an experiment. Oh, I thought you wanted them to test something.

CHAIR CORRADINI: Wait, wait, wait. Let's back up.

I thought Said asked the question of GEH, I thought, and it was answered that there would be, essentially, within the plant startup, there would be testing for flow conditions, et cetera. Is that what we are discussing?

MR. THOMAS: Yes.

CHAIR CORRADINI: I thought that was what --

MR. WACHOWIAK: Yes. This is Rick Wachowiak from GEH.

There's an ITAAC to confirm that the lines vent, and our thoughts now are that we would use combinations of inspections and testing using the existing flush lines and possibly --

CONSULTANT WALLIS: I'll tell you what you do. You close the block valve. You fill that with gas. You open the block valve, and 70 seconds later you show the gas is gone.

(Laughter.)

MR. WACHOWIAK: So you purposely try to block the line?

CONSULTANT WALLIS: No. If you want to prove that it provides venting, do it.

MR. WACHOWIAK: We will need a procedure that has similar attributes to what you just stated.

MR. SCARBROUGH: Okay. Then the actuation of the water head sweeps the water out, sweeps the air out, and any gases.

So the bottom line on this is the GDCS is designed to allow the gravity-driven reactor coolant flow upon squib valve actuation. There's ITAAC, which confirms that the piping is installed in accordance with design. And there's IC activities during outages to remove the gases that might interfere with the flow.

Now, with that said, this morning we have heard some things which are more important than we heard in the RAI response. One is the sloping issue. That is something that we will be talking to GE about in terms of increasing the specification of that in documentation, either in DCD --

CONSULTANT WALLIS: Excuse me. You didn't hear about sloping the lines until this morning?

MS. CUBBAGE: No, we were aware that the lines had a requirement to be sloped, but I think there is a question about the level of specificity of the degree of sloping.

Because we heard GE this morning talk about a certain sloping, but then they backed away and said, whether they had the adequate space, it might be different sloping. So I think we might want to discuss with them pinning down a minimum sloping.

MR. SCARBROUGH: Yes, the sloping is one of the design parameters that was laid out specifically. So we need to talk more about that. So we will also be talking about some of the other responses to make sure that it is clear as to what the basis for some of their answers are in the RAI. So we will be talking about that as well, based on some of those things we heard this morning.

So, with that, that's our presentation.

CONSULTANT WALLIS: So you think the non-condensable gas problem doesn't exist, apparently? You haven't raised that? You haven't said why you think it doesn't exist.

MR. SCARBROUGH: Well, we did ask questions in terms of non-condensables, and they provided answers in terms of the design without the high points in the lines. They talked about the flushing activities during the --

CONSULTANT WALLIS: Why don't you just put it to rest? Why don't you say the block valve is locked open, and because the block valve is open, any gas in the line will vent to the GDCS pool, and it will be gone? So there will be no gas on that side of the line. The gas on the other side will vent to the vessel. So there's no gas in the line unless the block valve is closed. If the block valve is closed, then they have a major problem quite apart from non-condensable because they can't get any water out of the thing. Why don't you just say that and put the whole thing to rest, instead of all this long discussion?

MEMBER BANERJEE: Well, you also have to say the check valves will be open.

CONSULTANT WALLIS: Yes, say that, too. But, you know, just say it. Just don't leave it hanging as if it is still something that they might be asked about, if you are convinced.

I am not telling you what you must think. You think it yourself. But say something like that. Put it to rest.

MS. CUBBAGE: The staff position is that the design of the system allows for self-venting, that the system will be flushed prior to starting up every outage, and that is our position.

CONSULTANT WALLIS: You have to explain that, therefore, there is no problem, because this problem has been raised and talked about for a long time. Maybe you ought to explain why this problem we spent so much time on for some reason isn't a problem. You have to explain that very clearly, I think, not just say that they are going to make them vent. Say they will then.

MEMBER ABDEL-KHALIK: Because it is a real problem that was solved by design.

CONSULTANT WALLIS: Well, okay. So convince them -- you know, say why it is solved, why the design solves the problem. Explain that.

MR. DONOGHUE: This is Joe Donoghue from

the Reactor Systems Branch.

That is what the SER is going to say.

CONSULTANT WALLIS: Here it says they are going to design it so it works. You have to say you have looked at the design, and you are convinced that it will work. You just have to say that.

MS. CUBBAGE: Right.

CONSULTANT WALLIS: Okay, say that then.

MR. DONOGHUE: That's what we are saying.

CONSULTANT WALLIS: Yes.

CHAIR CORRADINI: Are we in violent agreement?

(Laughter.)

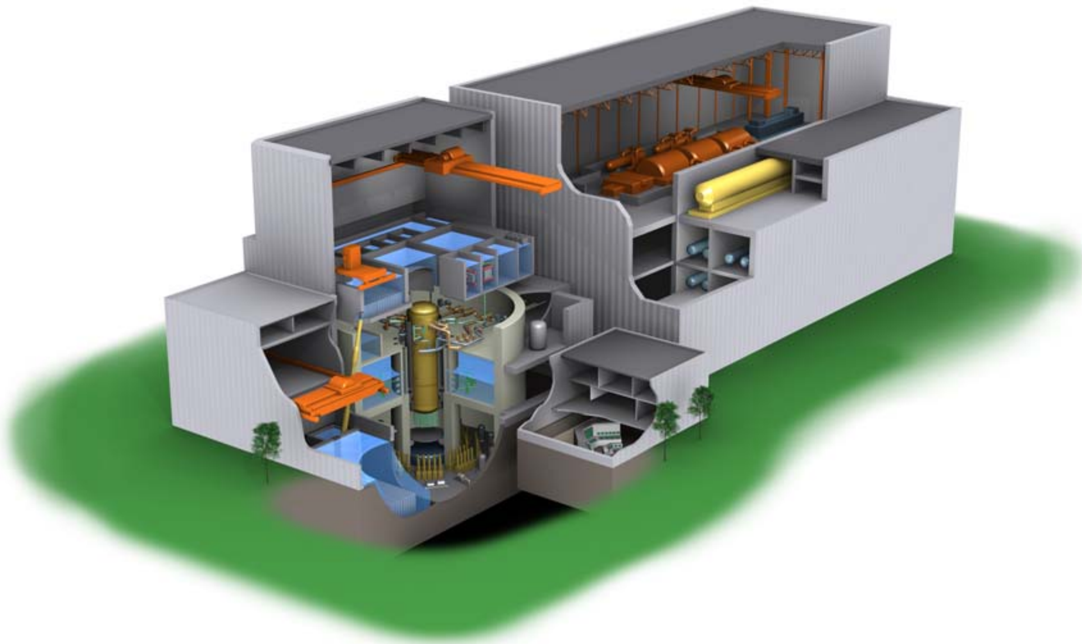
Okay, good. All right. So I will let the staff go. Thank you very much.

Now we are going to have to go into closed session. So we close the current bridge line and open up the other bridge line for the GE folks.

So those that aren't supposed to be here, please leave.

(Whereupon, at 10:55 a.m., the above-entitled matter went out of open session and into closed session.

ESBWR
Non-Condensable Gas in GDCS Line
ACRS Meeting



Wayne Marquino
Jesus Diaz-Quiroz

October 21, 2009

HITACHI

Agenda

- GDCS Operation – During a LOCA
- GDCS Injection Line Configuration
- Inservice Testing GDCS Injection Lines
- Sources Non-Condensable Gases
- Alternate Calculations - GDCS Flow
- Summary

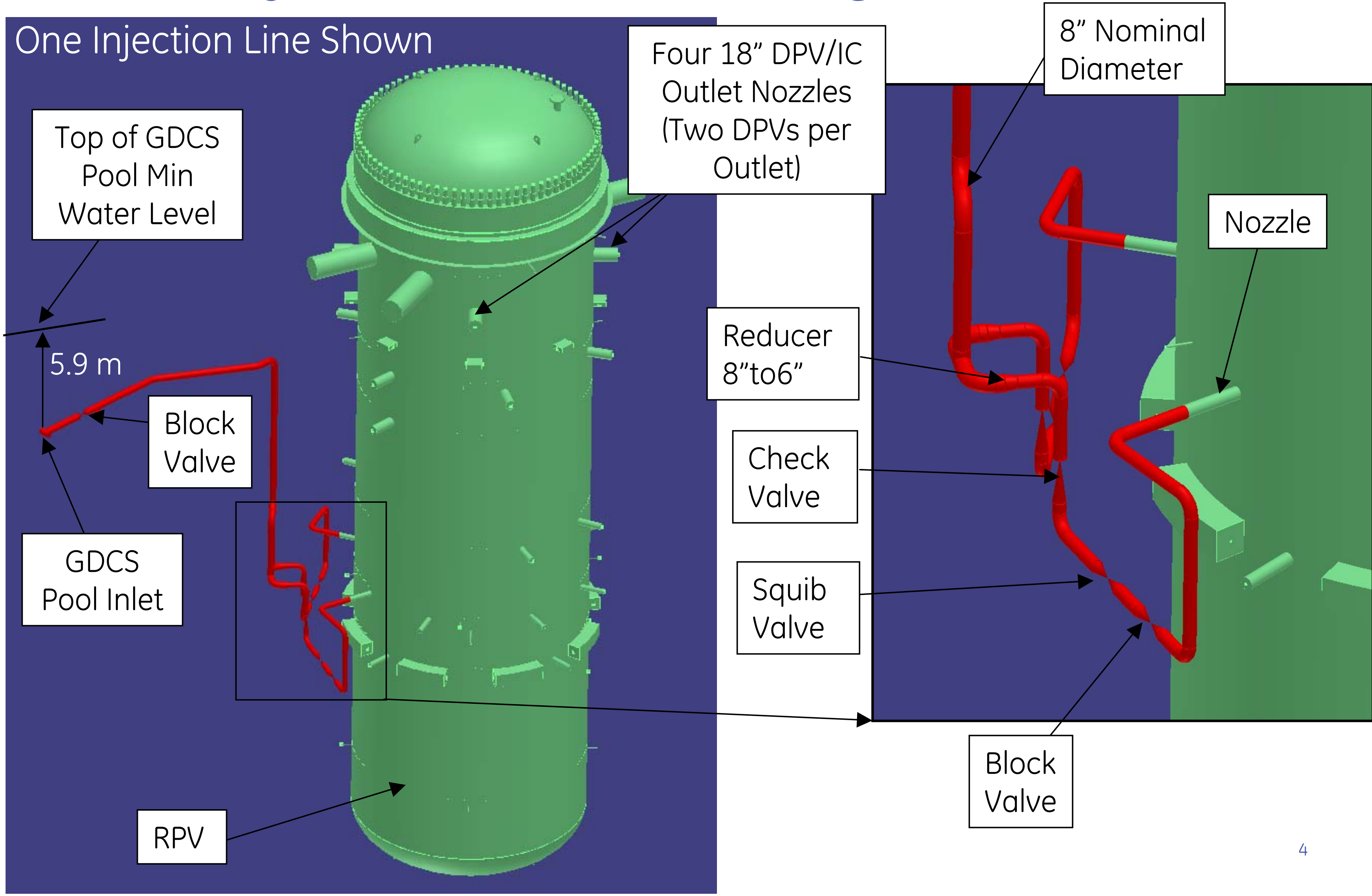
GDCS Operation – During a LOCA

Progression of LOCA till GDCS Injection

- Loss of Coolant Accident: Line Break at Normal Water Level
- Level 1 Reached
- Confirmed Level 1: ADS/GDCS/SLC Timer Initiated
- DPV Actuation Starts: 50 Seconds after Level 1 Confirmed
- GDCS Injection (Squib) Valves Open: 150 Seconds after Level 1 Confirmed
- GDCS Check Valve Closes: RPV Pressure Greater Than GDCS Injection Pressure
- GDCS Flow Begins: RPV Below Maximum GDCS Injection Pressure
- RPV Steam Flows: DPVs Remain Open

RPV and GDCS pools communicate with drywell during LOCA - RPV via break and opened DPVs; GDCS pools via gap between top of pool wall and drywell ceiling.

GDCS Injection Line Configuration



GDCS Injection Line Configuration

Piping

- Four 8” Nominal Diameter Injections Lines – Approximate Total Length 18 m (from pool inlet to 8”to6” reducer)
- Each Injection Line Branches into Two 6” Nominal Diameter Lines – Approximate Total One Branch Line 10.9 m (from 8”to6” reducer to RPV nozzle)
- Components for Each Branch Line: 8”to6” Reducer, Check Valve, Squib Valve, Block Valve, 3”Throat Diameter Nozzle, Test Line Connections at Upstream of Squib Valve and Check Valve and Downstream of Squib Valve

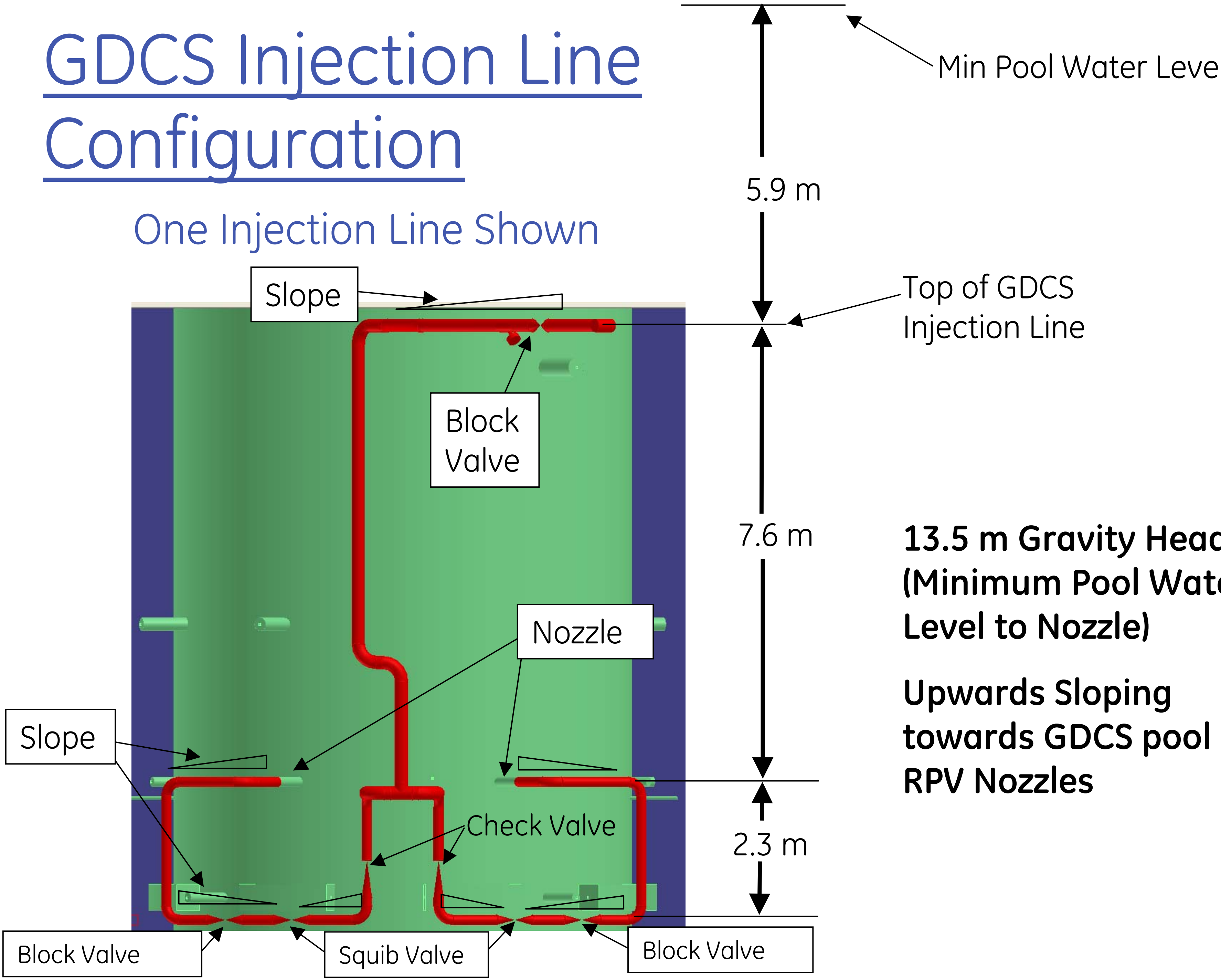
Sloping of Horizontal Runs

  - Upstream of Squib Valve – Sloped Upwards Towards GDCS Pools
  - Downstream of Squib Valve – Sloped Upwards Towards RPV Nozzles

Injection Lines Vent to GDCS Pools and RPV Nozzles

GDCS Injection Line Configuration

One Injection Line Shown



13.5 m Gravity Head (Minimum Pool Water Level to Nozzle)

Upwards Sloping towards GDCS pool or RPV Nozzles

Inservice Testing GDCS Injection Lines

Flush GDCS Injection Lines Every Refueling Outage Inservice Test Program Required by Technical Specifications

- Upstream of Squib Valves
    - Block Valves Closed and Test Line Connections Used to Test Check Valves and Flush Line
- Downstream of Squib Valves
    - Test Line Connection Used to Flush Line

Sources Non-condensable Gases

GDCS Standby Mode

- Dissolved Gas GDCS Injection Lines
  - Low Pressure Upstream of Squib Valve Remains In Solution
  - High Pressure Downstream of Squib Valve Remains In Solution
    - Small Segment Between 6” Pipe and Nozzle – Nozzle is a flow restrictor with maximum 3” throat diameter

Sources Non-condensable Gases

GDCS Injection During LOCA (Squib Valves Opened)

- Dissolved Gas GDCS Injection Lines
  - Piping Upstream of Squib Valve, Approximately Same Pressure as Standby Mode – Gas Remains in Solution
  - Downstream of Squib Valve Pressure Drops Due to Depressurization of RPV and Gas Comes Out of Solution
    - Small Volume Compared to Pipe Segment
  - Although Injection Lines Are Not Primary Route for Escaping Steam, Steam May Enter Injection Lines Potentially Carrying Some Gases
    - Steam Entering Quenched by GDCS Flow
- RPV – Radiolytic Gases
  - Gas Production in Core – Exits RPV with Steam via Break and DPVs

Sources Non-condensable Gases

- Gas can not enter last vertical portion of the injection line.
  - Counter current flow can not exist in this portion of the line, because the liquid will be flowing up. Gas will not flow down under these conditions.
- There is no adverse pressure gradient which would cause gas to be forced into the injection line from the RPV.
  - Squib valve and check valve block the flow path until there is a pressure gradient which supports from the GDCS pool toward the RPV.

Alternate Calculations – GDCS Flow

- Conservative Hand Calculation Using Trapped Noncondensable Gas in GDCS Line, with Elbow CCFL**
  - Net Effect - GDCS initiation would be delayed a maximum of 70 seconds
- Additional TRACG Sensitivity Analysis
  - 1/7th GDCS Flow - No Core Heat Up
  - GDCS injection delay of about 400 sec can be tolerated (i.e. to 900 sec) without heat up
- PRA Success Criteria – 1/8 to 2/8 GDCS Flow for No Core Heat Up
  - Two GDCS squib valves credited in PRA (2 out of 8 valves opening) but sensitivities show one squib can can still provide sufficient flow (1 out of 8 valves opening)

Alternate Calculations - Elbow CCFL Effects on GDCS Flow Due To Trapped Non-Condensible Gas in GDCS Line

- Conservative Hand Calculation → Net Result: Effective GDCS flow initiation Delay of 70 seconds
  - Scenario: Trapped non-condensable gas flowing out of GDCS Line to GDCS Pool under Elbow CCFL conditions
  - Answers the question: "What if the GDCS Line has trapped non-condensable gas , how will it degrade GDCS flow due to Elbow CCFL?"
  - Uses Prof. Sanjoy Banerjee et al CCFL data** for air-water flow in elbows in the form of Prof. Wallis CCFL Correlation: $j_g^{*1/2} + 0.57\, j_l^{*1/2} = 0.45$, and filling of closed volume initially occupied by gas $j_l = j_g$
  - Conservatively assumes GDCS line filled with 0.98 m^3 non-condensable gases.
  - Total NC gas "escape time" from GDCS line to GDCS pool calculated

****See Backup Slide for References**

Summary

- GDCS Injection Lines Continuously Vent Due to Sloping
- During LOCA RPV Vents to Drywell And GDCS Pool Airspace Also Vents to Drywell
- Alternate Calculations with Elbow CCFL a Maximum 70 Second Delay of GDCS Flow
- TRACG Sensitivity Show a Maximum of 400 Second Delay of GDCS Flow Tolerated
- TRACG Sensitivity Show 1/7 of GDCS Flow Can Accomplish Core Cooling
- PRA Success Criteria – 1/8 to 2/8 GDCS Flow for No Core Heat Up

Backup Slides

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**References

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ESBWR
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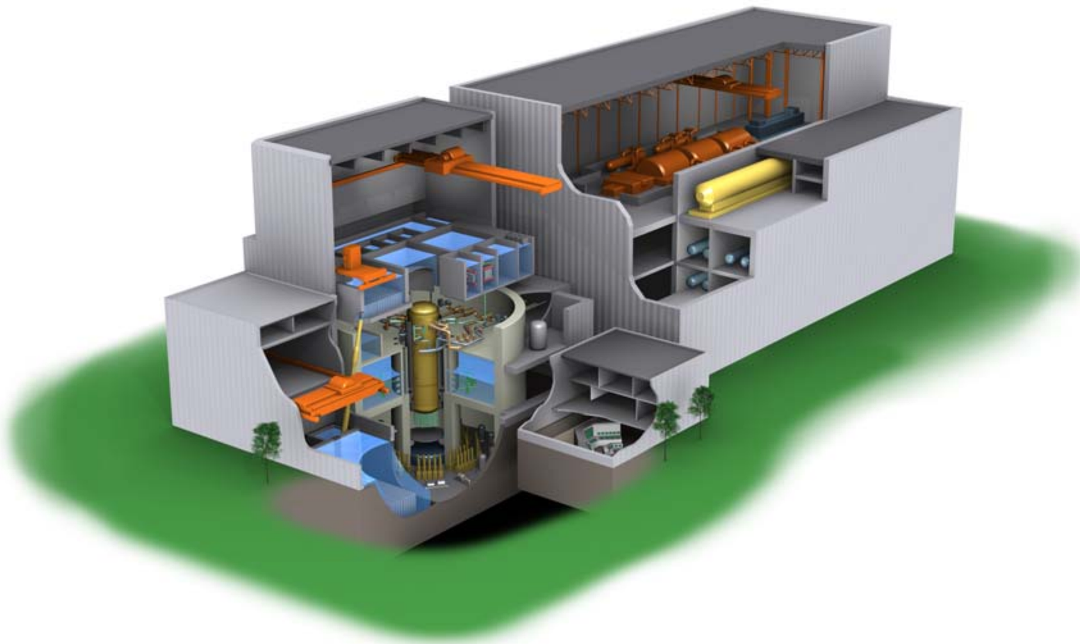

Wayne Marquino

Jesus Diaz-Quiroz

October 21, 2009

HITACHI

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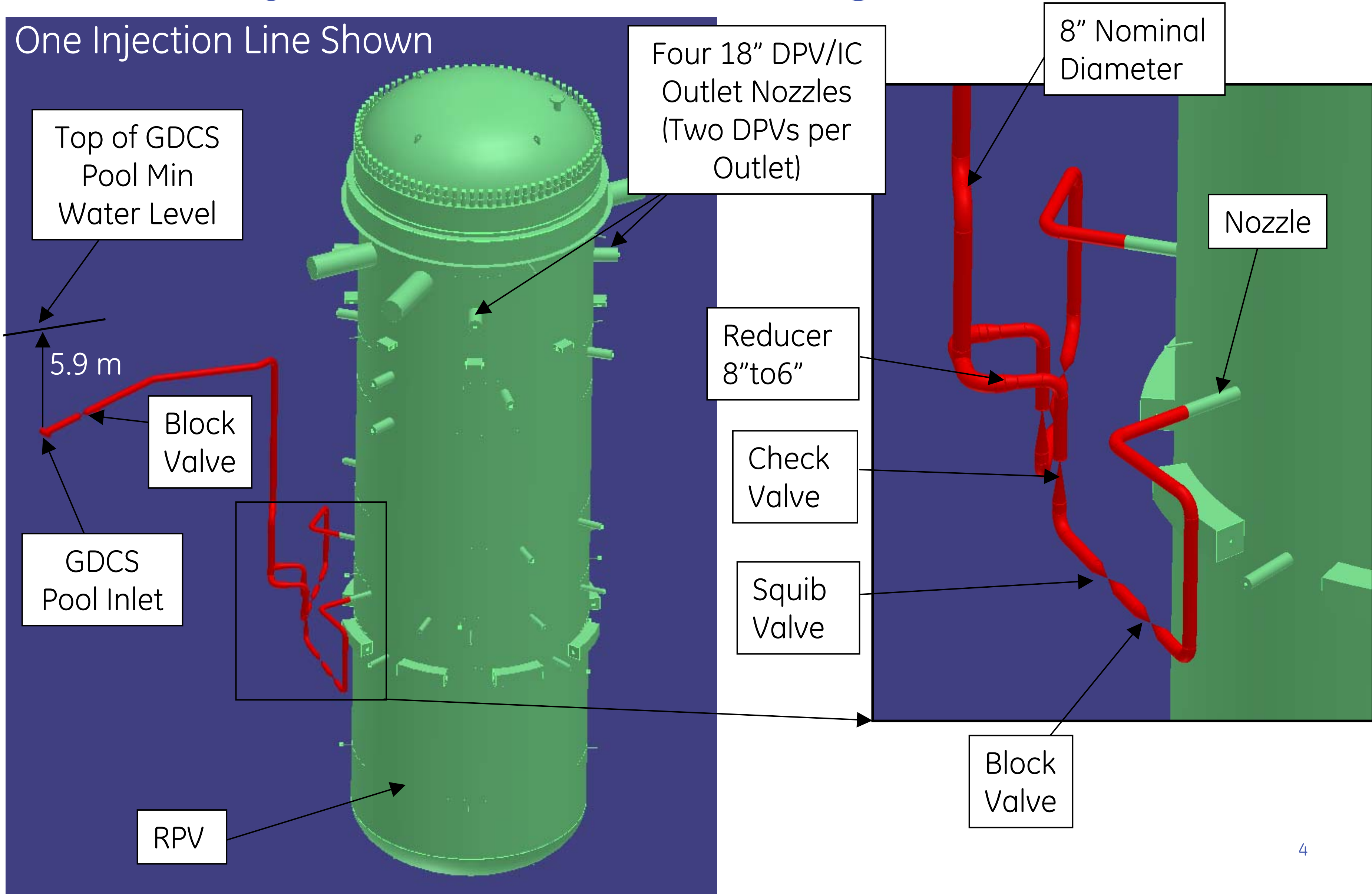

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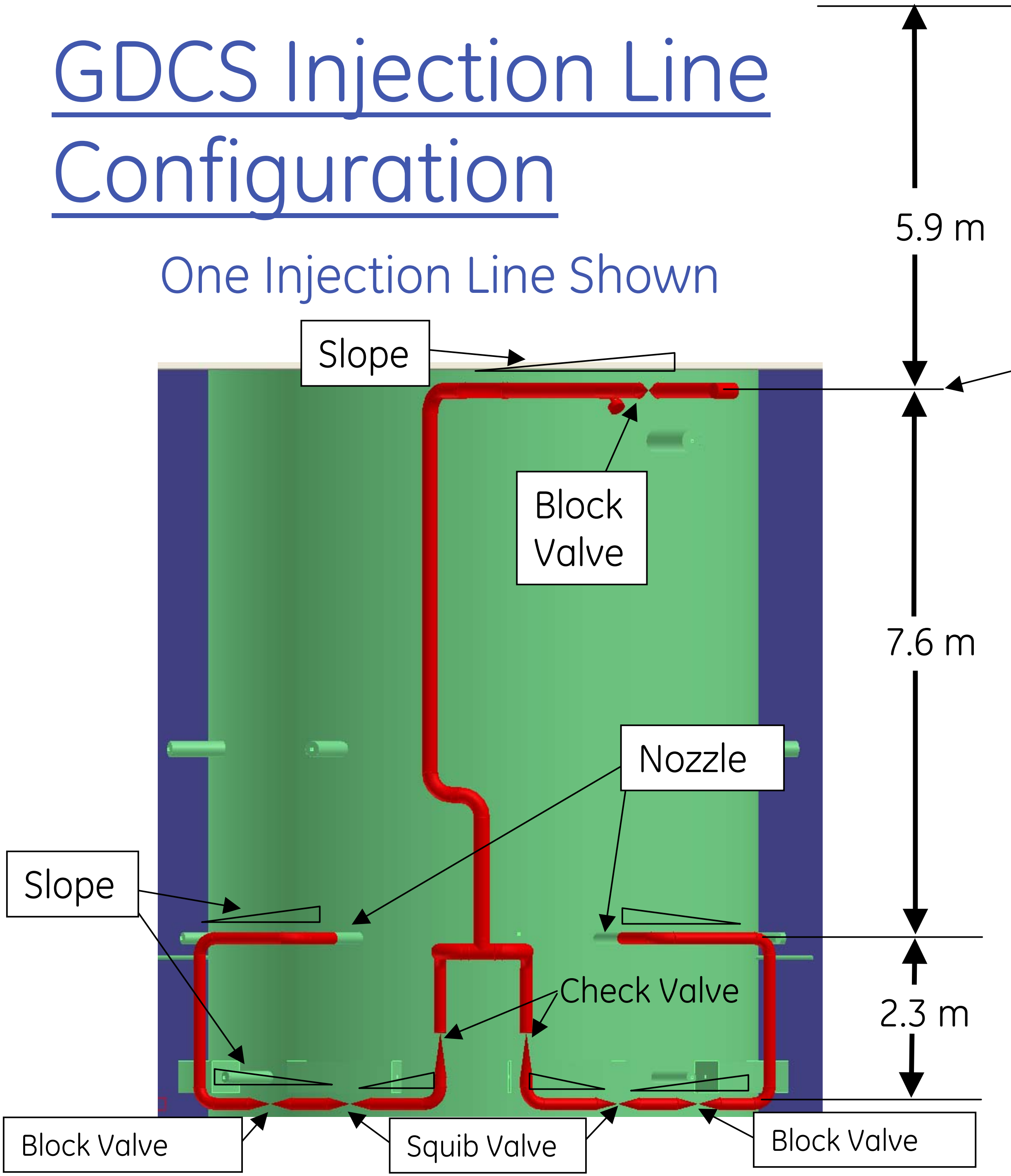
- Upstream of Squib Valve – Sloped Upwards Towards GDCS Pools
- Downstream of Squib Valve – Sloped Upwards Towards RPV Nozzles

Injection Lines Vent to GDCS Pools and RPV Nozzles

GDCS Injection Line Configuration

One Injection Line Shown



13.5 m Gravity Head (Minimum Pool Water Level to Nozzle)

Upwards Sloping towards GDCS pool or RPV Nozzles

Inservice Testing GDCS Injection Lines

Flush GDCS Injection Lines Every Refueling Outage Inservice Test Program Required by Technical Specifications

- Upstream of Squib Valves
  - Block Valves Closed and Test Line Connections Used to Test Check Valves and Flush Line
- Downstream of Squib Valves
  - Test Line Connection Used to Flush Line

Sources Non-condensable Gases

GDCS Standby Mode

- Dissolved Gas GDCS Injection Lines
  - Low Pressure Upstream of Squib Valve Remains In Solution
  - High Pressure Downstream of Squib Valve Remains In Solution
    - Small Segment Between 6” Pipe and Nozzle – Nozzle is a flow restrictor with maximum 3” throat diameter

Sources Non-condensable Gases

GDCS Injection During LOCA (Squib Valves Opened)

- Dissolved Gas GDCS Injection Lines
  - Piping Upstream of Squib Valve, Approximately Same Pressure as Standby Mode – Gas Remains in Solution
  - Downstream of Squib Valve Pressure Drops Due to Depressurization of RPV and Gas Comes Out of Solution
    - Small Volume Compared to Pipe Segment
  - Although Injection Lines Are Not Primary Route for Escaping Steam, Steam May Enter Injection Lines Potentially Carrying Some Gases
    - Steam Entering Quenched by GDCS Flow
- RPV – Radiolytic Gases
  - Gas Production in Core – Exits RPV with Steam via Break and DPVs

Sources Non-condensable Gases

- Gas can not enter last vertical portion of the injection line.
  - Counter current flow can not exist in this portion of the line, because the liquid will be flowing up. Gas will not flow down under these conditions.
- There is no adverse pressure gradient which would cause gas to be forced into the injection line from the RPV.
  - Squib valve and check valve block the flow path until there is a pressure gradient which supports from the GDCS pool toward the RPV.

Alternate Calculations – GDCS Flow

- Conservative Hand Calculation Using Trapped Noncondensable Gas in GDCS Line, with Elbow CCFL**
  - Net Effect - GDCS initiation would be delayed a maximum of 70 seconds
- Additional TRACG Sensitivity Analysis
  - 1/7th GDCS Flow - No Core Heat Up
  - GDCS injection delay of about 400 sec can be tolerated (i.e. to 900 sec) without heat up
- PRA Success Criteria – 1/8 to 2/8 GDCS Flow for No Core Heat Up
  - Two GDCS squib valves credited in PRA (2 out of 8 valves opening) but sensitivities show one squib can can still provide sufficient flow (1 out of 8 valves opening)

Alternate Calculations - Elbow CCFL Effects on GDCS Flow Due To Trapped Non-Condensible Gas in GDCS Line

- Conservative Hand Calculation → Net Result: Effective GDCS flow initiation Delay of 70 seconds
  - Scenario: Trapped non-condensable gas flowing out of GDCS Line to GDCS Pool under Elbow CCFL conditions
  - Answers the question: "What if the GDCS Line has trapped non-condensable gas , how will it degrade GDCS flow due to Elbow CCFL?"
  - Uses Prof. Sanjoy Banerjee et al CCFL data** for air-water flow in elbows in the form of Prof. Wallis CCFL Correlation: $j_g^{*1/2} + 0.57\, j_l^{*1/2} = 0.45$, and filling of closed volume initially occupied by gas $j_l = j_g$
  - Conservatively assumes GDCS line filled with 0.98 m^3 non-condensable gases.
  - Total NC gas "escape time" from GDCS line to GDCS pool calculated

**See Backup Slide for References

Summary

- GDCS Injection Lines Continuously Vent Due to Sloping
- During LOCA RPV Vents to Drywell And GDCS Pool Airspace Also Vents to Drywell
- Alternate Calculations with Elbow CCFL a Maximum 70 Second Delay of GDCS Flow
- TRACG Sensitivity Show a Maximum of 400 Second Delay of GDCS Flow Tolerated
- TRACG Sensitivity Show 1/7 of GDCS Flow Can Accomplish Core Cooling
- PRA Success Criteria – 1/8 to 2/8 GDCS Flow for No Core Heat Up

Backup Slides

Alternate Calculations - Elbow CCFL Effects on GDCS Flow Due To Trapped Non-Condensible Gas in GDCS Line

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**References

H. Siddiqui, S. Banerjee, and K. H. Ardron, Flooding in an Elbow between a Vertical and a Horizontal or Near Horizontal Pipe, Part I: Experiments, Int. J. Multiplase Flow, Vol. 12, No. 4, pp 531-541, 1986

K. H. Ardron and S. Banerjee, Flooding in an Elbow between a Vertical and a Horizontal or Near Horizontal Pipe, Part II: Theory, Int. J. Multiphase Flow, Vol. 12, No. 4, pp 543-558, 1986

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United States Nuclear Regulatory Commission

Protecting People and the Environment

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
SRSB - Reactor Systems Issues

OCTOBER 21, 2009

SRSB - Reactor Systems Issues

Outline of Presentation

- Brief the Subcommittee on reactor systems issues:
  - Non-condensables in GDCS Line
  - Design of GDCS Check Valves
  - *TRACE Confirmatory Calculations (IE)
  - *NEDC-33326 GE14E Initial Core Design Nuclear Report
  - *Critical Power Testing (NEDC-33413P)
  - *Stability/Chimney
  - *Feedwater Temperature Operating Domain (NEDO-33338)

- Answer the Committee's questions

* Meeting discussion will be Closed due to proprietary material.

United States Nuclear Regulatory Commission

Protecting People and the Environment

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review Non-Condensables in GDCS Line & Design of GDCS Check Valves

Presented by

Thomas Scarbrough - NRO/DE/CIB2

George Thomas - NRO/DSRA/SRSB

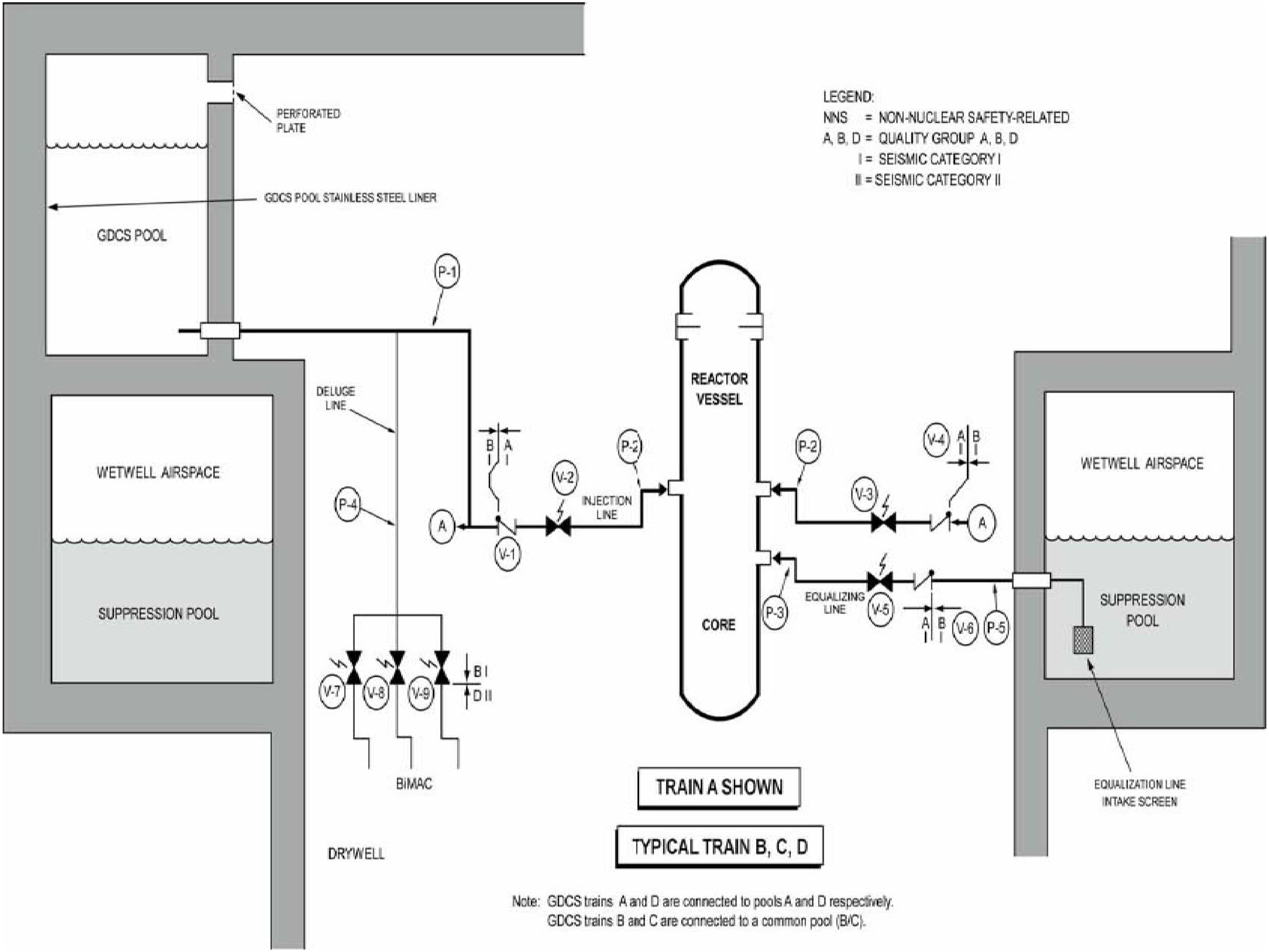
October 21, 2009

Introduction

- ESBWR Gravity-Driven Cooling System (GDCS) provides emergency core cooling following reactor depressurization in case of loss of coolant accident
- NRO staff reviewed GDCS design, qualification, and testing based on ESBWR DCD provisions, RAI responses, and discussions with GEH
- GEH revised ESBWR DCD to provide more specific provisions for GDCS design and components

GDCS Design

- GDCS has 4 divisions with each division consisting of short-term cooling (injection) system, long-term cooling (equalizing) system, and deluge line to lower drywell
- GDCS supplies cooling water from GDCS pools and suppression pool using explosive-actuated (squib) valves, check valves, and normally open block valves
- Minimum Elevation change between minimum water level of GDCS pools and centerline of GDCS injection line nozzles is 44.3 ft
- ITAAC confirms that as-built GDCS injection piping has no elevated piping loops or high point traps from squib valves to pools and to RPV nozzles



Note: GDCS trains A and D are connected to pools A and D respectively.
GDCS trains B and C are connected to a common pool (B/C).

Valve Functional Design and Qualification

- GDCS valves will be qualified to perform their safety functions in accordance with ESBWR DCD Tier 2 Section 3.9.3 provisions
- ESBWR DCD specifies use of ASME Standard QME-1-2007 for qualification of active mechanical equipment accepted in Regulatory Guide 1.100 (Revision 3)
- NRC confirmed application of QME-1-2007 during audit of GEH design and procurement specifications in July 2009
- Qualification will be verified by ITAAC listed in ESBWR DCD Tier 1

Inservice Testing (IST) Activities

- Safety-related valves within scope of IST Program undergo periodic assessment of operational readiness in accordance with ASME OM Code as described in ESBWR DCD Tier 2 Section 3.9.6
- ESBWR DCD Tier 2 Table 6.3-3 specifies flushing of GDCS lines for functional test of check valves, GDCS injection lines, venturi within GDCS reactor pressure vessel (RPV) injection nozzles, and deluge lines during refueling outages
- ESBWR DCD Tier 2 Table 6.3-3 also specifies laboratory testing of initiators in squib valves

Check Valve Design Attributes

- ESBWR DCD Tier 2 Section 6.3.2 specifies design attributes for GDCS check valves, including:
  - Long duration submersible piston check valves
  - Quality Group A, Seismic Category I, ASME Section III Class 1
  - Valves will be installed in horizontal piping run and held normally open by spring, or in vertical piping run and held normally open by gravity
  - Valves will meet requirements for minimum fully open flow coefficient in forward direction and maximum fully open flow coefficient in reverse direction

Check Valve Design Attributes (continued)

- Design process will evaluate loads on valve disk during normal and design-basis conditions to ensure valves remain open under normal operating conditions (0 DP) and will close under low reverse DP/flow conditions
- Design process includes evaluation of hydrodynamic loads, including potential water hammer effects
- Remote position indication

Squib Valve Design Attributes

- ESBWR DCD Tier 2 Section 6.3.2 specifies design attributes for GDCS squib valves, including:
  - Horizontally mounted, straight through, long duration submersible, pyrotechnic-actuated, non-reclosing valve with metal diaphragm seals and flanged ends
  - Quality Group A, Seismic Category I, ASME Section III Class 1
  - No internal fragments or missiles following actuation
  - Valves meet minimum flow coefficient at full GDCS flow
  - Valve manufacturer performs full flow test and provides test data
  - Remote position indication

GDCS Flow Path

- Each GDCS injection line makes U-shape bottom loop with squib valve at lowest point with no elevated loops
- Water in GDCS line between squib valve and RPV will prevent gases from entering this line segment
- GDCS piping from squib valve to GDCS pool designed to be self-venting
- Following installation, ITAAC will provide assurance that as-built GDCS piping provides venting
- During refueling outages, test connections allow for flushing GDCS lines to remove any gases
- Upon GDCS actuation, water head sweeps away gases that might come out of solution during plant operation

Conclusion

- GDCS designed to allow gravity-driven reactor cooling flow upon squib valve actuation following reactor depressurization
- ITAAC will confirm GDCS piping installed in accordance with design
- IST activities during refueling outages will remove gases that might interfere with GDCS flow

Discussion/Committee Questions