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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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In the Matter of:

TEXAS UTILITIES GENERATING COMPANY

(Comanche Peak Containment Sump Performance Meeting)

Location: Bethesda, Maryland

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20 Attachments

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

MEETING WITH ADVISORY PANEL ON

COMANCHE PEAK CONTAINMENT SUMP

Nuclear Regulatory Commission
1717 H Street, N.W.
Room 1130
Washington, D.C.

July 27, 1984

The panel met, pursuant to notice, at 9:00 a.m.

NRC STAFF MEMBERS PRESENT:

SPOTSWOOD B. BURWELL
AL SERICIZ
B. MANN

PRESENTERS AND STAFF SEATED AT THE TABLE:

R. IOTTI
T. ANDREYCHEK
T. BENGEL
D. WHYTE
L. KATZ
S. HYDE
D. PURDY
M. CHIRUVOLU
C. LI
H. SCHMIDT

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PROCEEDINGS

MR. BURWELL: Good morning. I am Spot Burwell. I am the project manager for Comanche Peak, here at the NRC. The subject of the meeting this morning is the Comanche Peak Containment Sump performance.

Earlier, in early June we had a submittal by the applicant concerning the performance of the sump, which it was intended to show the failure of the painting has no significant impact on the performance of the ACCS, or stated another way, that failure of the painting would not compromise safety of Comanche Peak. We met on the 7th of June and that meeting was similarly transcribed. As a result of that meeting, the applicant submitted a combined report, that is it combines the input into the earlier reports, and modified the earlier reports to respond to our comments made by the staff at the June 7th meeting. I would, I believe perhaps you might want to correct me, that the later submittal, in effect, supercedes the other, the earlier two reports, since additional work was done over the period of June 7 to June 29th.

Since receiving this report in...transmitted to us by the Texas Utilities letter dated June 29, 1984, the staff has been reviewing this, and as a result we ended up with a need to understand the

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relation of some of the information given in that report, and needed to have certain clarification.

Today, I would hope for an open free discussion. With that, I guess we can get down to some business. Okay, with that, the first item on the agenda deals with a need to discuss certain of the uncertainties associated with blow resistance developed to calculate the containment flow philosophies. In effect, our questions go to details of flow analysis, I guess in section 5 of the report. With that I will turn the questions over to Mr. Sericiz.

MR. SERICIZ: My name is Al Sericiz. I am with the division of safety technology. The questions that I raised with regard to the review of the report submitted, this being the Comanche Peak containment sump performance, fell into two to three areas, perhaps just let me try to give you a background on where I am coming out, and then I will take up the first subject that Mr. Burwell introduced.

The debris transport aspect, this deals both with the insulation and the paint. This is velocity dependent. I understand how you put the network together conceptually in your report. However, in looking through that analysis, as I had raised the question before, there are uncertainties when one

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models in a one-dimensional simplified flow resistant network that are analyst dependent. What I mean there, is you can go into a variety of textbooks or references, and there is engineering judgement that enters into it, particularly when you are modeling the actual plant layout, versus the simplified layout. This is what I meant by uncertainties. Perhaps the submittal was driven, or rather, the submittal as I read it would show the variability due to water level. Maybe there was an interpretation that that was meant by uncertainties. It was useful to have that water level that would exist and what is considered normal or nominal. My uncertainties question goes back to when you model a flow resistance network, with like six to eight resistors, there is a variability, and I would like to come back to that.

For Mr. Iotti's benefit, my questions were raised by the analysis in section 8 which I guess in my way of looking at it, dealt with the paint chips raining down, and either settling out or being transported, principally are interrelated to other parts of the report where the calculations that are shown for small particle paint chips, those quarter inch and less, are determined at least analytically. I emphasize that, analytically.

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It is estimated, to transport a velocity, which are in the range that you calculate, you have a 94% blockage. There appears a dicotomy (phonetic) or paradox there to me, if your calculations...I have looked at the references. I don't have questions on how you pull the equations from the references. If you are saying that the paint chips come out and settle out, in section 7, I believe says that the small diameter paint chips are capable of being transported to velocities on the order of 3/10's and 4/10's of a foot or higher. Just, you know, I would like to put that picture together. Where I come out in the final analysis. These are two pieces of information or subsets of debris, insulation and the paint. Then, I have to make a judgement of what is the blockage that I should actually use?

If I go to Section 9, there are some blockages, in fact there is a curve. There is a shaded region that indicates a 35-50% blockage. This is without any insulation because the conclusion was drawn that the velocities are low enough and containment insulation would not transport. There is an analysis in Section 8, that deals with a 94% blockage.

MR. PURDY: I don't see that number 94 in Section 8. We can only find it in Section 2.

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MR. IOTTI: Well, let me stop you, because it is in that range. In this case, when you have 24 square feet open, that is really close to 90 percent.

MR. SERICIZ: 94%. Okay then. I understand how that is related to the Western Canada Tests. I will withdraw my statement that it was in Section 8, 94%. So, I have three numbers that I am trying to deal with, 35%, 50%, which ties back to assumptions on paint failure, and do I make my judgement on the 94% blockage or what. I was hoping that in this meeting, at least with the first two areas, this is the treatment of the paint chips falling out in Section 8, versus the transport calculations in Section 7, saying they would move laterlly for forward. On resolving that aspect, it is no nevermind for a lack of a better term.

But, the debris transport, which could be either paint or the insulation, would be velocity dependent. Maybe that is the best place to come back to, and I guess my way of looking at it is, I would like to look at, listen to, or hear;use the blackboard, how did you model some of these openings that the contractions, expansions. They have turbulent effects. I don't know what is in the plant, because I haven't looked...you know...I haven't looked at plant drawings. Let me, perhaps also, you had similar questions. If you

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want to add to that, then we take that subject first. Unless, you want to reverse it, because of plane reservations.

MR. IOTTI: No. That shouldn't take very long.

MR. LI: Following this same subject on the broadway assistance, the table in this instance is in terms of (inaudible). So, I would like to see how you derive or append the broadway assistance parameters.

MR. PURDY: Let me make a couple of points first. I am eventually going to turn this over to Meduka (Phonetic) when we get into your questions. But, first of all as a combination of effects, what we tried to say is that section 8 analyzed near field effects, and the other section analyzed what we might call far field effects. The two being defined as near field effects where the particle essentially intersects the screen before it hits the bottom of containment, and the parfield effects being where the particle is far enough away so that it tends to settle to the bottom of the containment, and then be transported along.

What we tried to say is that our upper limit estimate of the Farfield effect is that 50% of the screen is blocked. But then, the nearfield effects add to that, and the combination of the two results in twenty four square feet of screen, being available for

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flow of fluid through the sump. Twenty-four percent being approximately 87-1/2% of the total screen.

Twenty-four square feet is equivalent to 12-1/2% of the screen area being available for flow. In other words, 87-1/2% to blockage. There is a number of 94% valves in Figure II, section II, but that is in error, and we will clarify that in a rash. I tried to put it in terms of square flow area, because by the way Western Kenebe finds screen blockage, and total screen blockage is a different thing so we had confusion when we use the term screen blockage.

MR. SERICIZ: I appreciate the clarification, could I just have another clarification on the nearfield and corefield. On the nearfield, are you then talking of those effects that are discussed or analyzed in Section 8?

MR. PURDY: Yes.

MR. SERICIZ: To clarify my impression on that also, does deal with the paint degree being analyzed as particulates. That, when you add your nearfield and farfield. Let me just write myself a note. You are saying that you are coming up with 87-1/2%? Okay. For my own clarification, also, I will accept your point about errata, but that is not a principal topic.

Then, the number that we should look at for

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accepting your conclusions would be this 87-1/2%, is based on a 50% blockage which results from the farfield efects.

MR. PURDY: Yes.

MR. SERICIZ: The paint particles or whatever that are described in Section 8, in combination too. Again, I am coming back to, should I use 35%, 50%? You are telling me to use 87-1/2%?

MR. PURDY: Eighty-seven and a half percent, right. Total blockage to all effects.

MR. LI :So this is additive of those in effect, near the pier.

MR. PURDY: Correct. But, actually, a better way to, a basis would be to talk about all the close qualities being available for flow. This way we are talking the same across the board.

MR. SERICIZ: I accept that point fine, I am just trying to understand your terminology. There are different subjects to discuss in diffe[illegible]t sections.

MR. CUIRUVOLU: I would [illegible] clarify one thing. We do mention in the stud[illegible] tha[illegible] these (inaudible) effects are not (inaudible), you don't add one to the other.

MR. IOTTI: As we get into the discussion, we will demonstrate to you why they are really not.

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As now presented, it is the combination of farfield and near field additives that leads you into this approximate 24 square feet being available.

MR. PURDY: And the disussion is in Section 9 of the report.

MR. BURWELL: What I'm confused on is exactly how you are doing this additive. Are you saying that the, when you...

MR. PURDY: We have a screen, and what we are saying is that it will flow in this direction. We keep up to a height of 50%.

MR. BURWELL: To determine the flow rate...

MR. PURDY: No. I want to talk about flow rate separately, because that is another subject. I think there might be some misunderstanding. What we are saying is that due to farfield effects, we pile up paint chips to a height of 50% of the screen. Okay. Then, that is covered in, I guess, 5, 6 & 7.

MR. SERICIZ: That I wasn't sure of, I think it was Section 7.

MR. PURDY: Well, actually, the final number is given in Section 9. The background is given in Section 7, and the final number is given in Section 9, in graph 9.1.

Then, the Section 8 particle, so to speak

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would have drift down this way. Now, one thing that we did not cover is a time and sequence. But, what we are saying is let us assume that these particles come first. Then a particle can come down here and land on the heat, in which case it will add to the angle of the opposed.

MR. IOTTI: It will add on to this because this matters. Actually, there is quite an overhang over this.

MR. PURDY: Yes. Right. Then, a particle can also come in here and block the upper part of the screen that was not blocked by the heat particles. Dr. Iotti's analysis shows that there is an area up here that is not blocked. That is with 24 square feet of lead screen area comes from.

MR. SERICIZ: I understand where that comes from, but you have got the diagrams on the board. At some point in time, if you are making these postulates, you will have increased this...

MR. IOTTI: Velocity.

MR. SERICIZ: That's right. You will come into the velocity range that you make your final determination on. That is where my question is drawn from, that I have what would be a lateral left to right velocity, I think in a range, I think it numbers yours

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from 4/10's of a foot or something like that. I go back an I look at the analysis that was presented in Section 7.

MR. IOTTI: Global transport.

MR. SERICIZ: I just want to put this together...

MR. IOTTI: Let me see if I can explain it to you. To reasonably transport, is that these also transport laterally. The problem is that here, they are also have a difference in pulling downward. They are still coming down at an angle. When the downward component is zero, because they are near the floor, then they can only transport laterally.

MR. CUIRUVOLU: I will try to explain the Section 7 transport.

MR. PURDY: I want you to wait on that. There is one other point that I think we need to make fairly early in the game, because I am not too sure that it is understood. That is a total flow rate is not set by resistances on the containment floor. The total flow rate, and therefore average velocity is set by flow rate through the external pending. What we have is a pool of water down there, that we draw.

MR. SERICIZ: I understand what you are saying.

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MR. PURDY: Well, if you understand that, then I will relax. You may go ahead.

MR. LI: The transporter, actually in Section 7, we go from very conservative assumptions. We assume that all of the paint in the containment fails. Then, we also assume that all the paint in the containment fails as somehow 1/8" particle size. That is the worst case that can be in the transporter, at the same time being plugged, that particle size would plug the screens, which have nominal openings. The way we did this was we took our flood levels separately from the ground floor storage level of the containment. We did the upper level based on the containment sprays. We took the clear openings in the upper level, like staircases, other openings, as we calculated the water flow to various openings in the upper levels. Then, we transported the paint from all upper levels to the lower level at 808. We did the lower level analysis, just like Dave mentioned to you, based on a cube, a flow of water available in different zones. We calculated the velocity through each opening and subchannels in that zone.

MR. SERICIZ: Are we diversing that these questions are the same...

MR. CUIRUVOLU: I just want to go the to main

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point. The main point is the transport of particle's 808 level is not by, is by a mechanism, which is the particle settles to the ground, and it slides all of the ground due to the friction in the paint particle and the ground, and the drag of the water on the particle. This is exactly the methodology that NRC has used on insulation and other material.

MR. SERICIZ: Let me come back to that point. Let me make a clarification. The NRC methodology, that is referred to as a NRC subcontractor report, and represent an NRC methodology. I make that point because this meeting is on the record. Nonetheless, the analysis that you show here, I am familiar with. But, since you come to that point, this is the place that I find, at least in my own line, somewhat of a diconomy. That is, if I take your analyses, I take it and I look at, I recognize what you are doing. There is a tradeoff between friction, and if you will, hydrodynamic drag. The numbers that you are showing here for transport of these small particles, by this I mean a quarter inch an smaller. My reason for focusing on that is when we come back and discuss what is happening on the surface, that you have, and you have already postulated these particles, for whatever size and shape, you consider small particles as getting there, and forming some

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annual repose. Then, in the analysis in Section 8, says there is a rain out, and a fall out.

Now, these analyses here, in Section 6, which I am referring to a different tables that indicate transport velocity summaries, paint thickness, and so on, indicate that when you are talking in particles in a range of a 1/4" or lower, that they have the capability to transport at velocities on the order.

I am looking at velocities here in table 62-8 ranging from .27 to .5.6. My point is that they are in the range that the other analysis is correct. If I may, I would just like to the blackboard for just a moment. In supplemental diagram, if I had, I made some assumption, that is an assumption of time that this volume of paint would come and form this. Then, maybe this is where the problem comes. The paint is drawing out, I will draw this lip that you have here, the overhang, to get back to that. I guess, for lack of a better way. Again, because there is fallout, doing something like this conceptually. When I do this then, what I have, these particles are still moving here.

My questions come, when we have got some velocity, in Section 6, the set of these were on the floor, and there was some interaction between friction and this and the smaller particle...in other words, the

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smaller size that it can go through the screen, the better the chances on the type of analyses, because of the drag consideration it will pick up in transport.

MR. IOTTI: Sure.

MR. SERICIZ: My question is, okay. To make the postulate that it rains out. I don't have a problem with that. What I am asking is how do I reconcile the type of analysis in Section 7, or other similar types. We are getting into a region where these forces are important on such particles. The particles actually won't want to pick up, and go higher.

MR. IOTTI: I'll answer the question. To answer your question, I think that the best way is to have ou look at some of the finite difference analysis that we have done. We look at all of these different effects, and I can't put them on the board, but we will have to work from these sheets, if you can bear with me.

MR. SERICIZ: Sure.

MR. IOTTI: I thought that you really had two concerns. One is that the rate of the particle, the particle itself been causing to the flow, and into the screen.

MR. SERICIZ: Yeah. There is an uncertainty in that type of analysis.

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MR. IOTTI: Right. I will show you that I recognized the uncertainty, and took an alternate path to arrive at the same answer. We end up the same answer in different ways. The other uncertainties, and now that you have this built up, and there is loose particles here, is when the velocity here is sufficiently high now to boost those up.

MR. SERICIZ: Yeah. You are getting into a contraction zone.

MR. IOTTI: So what we did, we found that the only way that we could answer that question was to find that first set of analysis, when we took, and you can just bear with me for a minute. This represents a differnt stage of blockage. Okay. This is the important one, because one of the things that is fairly, it is not clear from the report is that the near vicinity of the sump, the velocity actually drops, now that you have suction from all sides. From the .08 velocity to containment, you have around .04 here. Four feet. This is strictly from continuity standpoint.

So that, one of the things that you will find out is that this is built up, and it really doesn't occur, per se. It kind of drops off intially, before it gets there.

MR. CUIRUVOLU: We took a worst case to get

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that buildup in that shape at the screens. In reality what would have happened, is the paint would have formed a layer on the ground...

MR. IOTTI: All over, parallel.

MR. CUIRUVOLU: Right.

MR. IOTTI: The next thing, this is crucial. We ran different stages of blockage. This represents a stage where you are not looking at, essentially, a two dimens'onal picture, here. This is about a 5-1/2 inch opening here. We see that there. The reason that we chose that is that this becomes a separate autrix (phonetic). The black trajectories are the paint that would be on the steel, specifically around 1.4, 1.5., a 5 mil thickness. The blue is the concrete, which is specific gravity around 1.8 to 2 and much thicker, 20 mils. When you start out with a screen completely unclogged, you move out about 4 feet, and this would be the separate autrix for the paint particle, that are from the steel.

As you move up, you come to a point where the farthest difference out from there, for this 5. type inches open, here. You tried, what you see here, is that ther are certain distance out of these particle, where, as you clog progressively up, some of the paint particle will be swept, as you say, to resist this

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effect into the screen. No question about it. You see that effect, for instance, see this trajectory, this black trajectory here. Around this point the particle turns because of the upper flow, and goes right into the screen. So, of course, what this says is the 5.63 may be opening at which you can define the zone of influece. That is the distance away from this edge at which you will be collecting the particle from near region effects. Because, as it turns out, it is almost with the initial state.

But, you will actually clog more than that. So, we also ran this 2". In two inch, you don't see this blotted. That looks very complicated, but here is the 2" case, enlarged. Now, what you saw in our report was with the assumption that the particle would tumble, this is fear, you actually do not clog. If you start making the assumption that we did not question that, when the report was submitted, it may not be aimed here. You can actually, perhaps, start eating up into this two inches for the same phenomenon, because the velocity gets rather high. In any case, you will end up with approximately a 2", but this is an enlarged version of this table.

MR. SERICIZ: Okay. When you say finite elements, what you are doing.

MR. IOTTI: Finite difference.

MR. SERICIZ: What you are doing, you are basicallly running a three dimensional flowfield here.

MR. IOTTI: It is a two dimensional flowfield.

MR. SERICIZ: Well, you represent with two dimensions.

MR. IOTTI: Right. And the reason you see some flow up here, because there are openings on the other side of the screen, and we will have to let the flow go sometplace. Now, of course we can improve on this, but one of the things that you can quite see the velocities, even from the small openings, the velocities that are high, are just in the vicinity of the opening.

MR. SERICIZ: This is why I raised the question, because there was analalysis that was treating things here, and I recognize that from this analysis there can be an interaction. You are confirming that.

MR. IOTTI: Absolutely.

MR. SERICIZ: You mention though, what square footage is the two inches?

MR. IOTTI: That gives you about 12 square feet on the top. Okay. Then, due to other reasons, there is about another 12 square feet of that in other

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portions of the screen so that the total portion is about 24. Just so we understand one another. The 24 is not all that is open. It is about 12 square feet.

MR. SERICIZ: That clarification is useful, because I am just using numbers out of your report.

MR. IOTTI: Yeah. Let me get to the alternative, because, see, one thing which should be obvious to you now, is that there are certain uncertainties in how you model the drag on those particles. I said alright, suppose that instead of in modeling as a sphere would I have no problems in having modeling as an equivalency where a model is a disc. We have seen statuses. We have seen a report of damping through that equasion on the rotation of motion, which actually makes it impound. What happens is that you could be sweeping particles, perhaps more than you think.

We took another approach, we actually went back to the plan, and investigated all of the steel, which is an example of the kind of steel that you see aroud the sumps. Okay. This is typical plotting, in case you are interested. This is only one sum, the right sum. We defined, from this charge, the separate autrix for the concrete, and the quarter steel paints. We then went to see that all of the steel paint

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actually fall within, this is within about almost four feet, it is not quite four feet. In the blue, it would be the concrete, which is almost a foot and five inches.

Any concrete or steel which falls within this distance, has a chance of raining out, and going into the streams. Okay.

MR. SERICIZ: Concrete or steel paint.

MR. IOTTI: Concrete or steel paint. You will see, with all of this. Then, we plotted this whole thing up, because this now becomes independent with this type of assumption, for the dry coefficient, which is another way to look at it. So, here in blue, you see that the concrete can effect you. In blue orange, because of course is also in the blue, is the steel paint What you start finding, remember I said there was another 12 square feet, that...Right here there was an overhang that covers the overhang of the sump. There is no steel that can get there from this corner. There is very little concrete that can get there. That is where you get whether you are in a 12, or actually it could be as high as 40 square feet.

On this side, likewise, there is regions where you had very little steel, and you can only get maybe four square feet of concrete. Each of these

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segments is approximately 4 foot long, by 5.75 feet high. These numbers were presented as the square footage of steel over. The concrete it's plain, just because of the ceiling. So, it is 1 X 4, it is 4 square feet, everyone of these blocks.

What you will find if you take this approach is that this area of the screen will remain open, essentially. Seven square feet, plus some concrete, here we have ͻ square feet of steel, plus four square feet of concrete. So, that is 11 square feet of screen left open. Here, you have approximately 9 square feet. On his side here, there is a grading that would bring additional paint from floor above 8.32. All of this part would be clogged, but right here you have approximately 6 square square feet on the side that would remain open. So that is 12, 12 square feet of air, maybe 30 square feet on the sump. On this sump, you have right here, and here, a total of 14 square feet, and 14 square feet of paint, that can go in over about 40 square feet. So, you get about 12 square feet here, in this corner here, you get about another 12 square feet.

So, again, this 24 square feet, now this is strictly from a mass of paint, versus the area...

MR. LI: So this area available is all the

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configuration that you...

MR. IOTTI: That is correct. We actually sent teams to look at the paint. Well, we can't actually tell you how it gets there, it is just that there is paint that can fall there. You just take the ratio of the area of the screen to the ratio, to the total area that it can fall under. If you have got something left over, it has got to...

MR. SERICIZ: I hear what you are saying, but I'm not sure that I understand it. You are talking in an equivalency of a square feet of paint. You are saying that you are taking that as a percentage of screen area.

MR. IOTTI: No. What I am saying is the following.

MR. SERICIZ: Then I didn't understand you.

MR. IOTTI: You have a screen.

MR. SERICIZ: Yeah.

MR. IOTTI: Let's forget this for the time being. What we said is that from this distance to this distance, any concrete that falls within this distance, will go to the screen. We find the largest difference, where here is steel, and this one is concrete.

I can evaluate how much steel exists on the ceiling, as pipe supports, pipes, whatever, in this

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area. So, this gives me, A, square feet of steel, and that here I have B, square feet of concrete.

MR. BURWELL: Can you identify the approximate dimensions?

MR. IOTTI: This is approximately four feet, and this is 11.5 inches. Actually, if you want to be precise. I hate to put down precise numbers, but that is 45 inches. Okay.

Now, if you could total up all of the square footage, A plus B, square feet. This, of course has C square feet. So, what you are really doing is A + B over C is the percentage clogged.

MR. SERICIZ: Okay. That is what I thought, but I wanted to be sure.

MR. IOTTI: So we decided to also take that approach, because of the uncertainties that are involved in these other transport mechanisms. You can try to be as precise as you want. Let me make one final point. One of the things that we find out, in this finite difference analysis, is that the near field velocities on the floor, had to be on the order of .004. Okay. Well, yeah. That is what a hand calculation would tell you from the old intenses.

What I am trying to say is on that basis, all of their debris wouldn't get me that. They would start

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dropping out as they approach, and this is also if you were to start building something. You would essentially build it flat. Actually, what heppened here on the bottom, you would actually see this, as opposed to that. You would actually be dropping down. So, that is another way of saying that if you want to consider the near term and the far term field, even though we added it with the first term, they are really not additive when it comes right down to it.

Any accumulation that you get at this bottom, is really going to be due to the rainout as opposed to the flow.

MR. CUIRUVOLU: I'm going to correct that statement, Bob. We did say in the approach that there are not additives. So, we did not, in any time.

MR. IOTTI: Well, I guess that this a confirmation. In reality, they turn out to be non additives.

MR. CUIRUVOLU: The reason that we took the triangle approach, in some blockage, is that we said, very conservative number, for a block is numbered, if we have to get in a block is numbered. Otherwise, we do not postulate that break. That will form the shape to block...

MR. SERICIZ: Okay. You are helping me out by

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making these numbers, because there are different numbers put together in different places in the report.

MR. IOTTI: It is confusing, but we may be fortunate that the final number that you arrived for one of the sums, by this alternative method is also approximately 24 square feet, but yet is higher. That is a coincidence, it is not a...

MR. SERICIZ: Okay. But the 24 square feet is, that would be going back to what has been termed the additive method.

MR. IOTTI: Right.

MR. PURDY: That is presented in the report.

MR. SERICIZ: With today's terminology, we seem to be discussing, to be coming back to 24 square feet, and that is based on an additive method.

MR. IOTTI: Yes.

MR. SERICIZ: Okay. The 24 square feet is based on an additive method.

MR. IOTTI: That is correct.

MR. CUIRUVOLU: No. If there is no blockage from long field transport...

MR. SERICIZ: That is not what is in the report.

MR. IOTTI: What the report, right now says, is that you have 50%, plus whatever you get from the

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near field, you end up with about 24 feet left.

MR. SERICIZ: That is what I was reading, and I end up saying to myself, do I do that, or do I say something else.

MR. CUIRUVOLU: It is my fault.

MR. SERICIZ: I understand what you are saying, and as IU say, the meeting is a good clarification meeting. When we are talking here, we seem to come back to 24 square feet. We are talking in additive method.

MR. IOTTI: Anyhow, that kind of shot my votes too. We actually ran the finite difference to assure ourselves that those were properly defined, that we would be able to see this viscus effects, the screen progressively clogs. Of course, physically, it probably won't happen through in that fashion. It will be random.

MR. SERICIZ: Yeah. There is a time dependence, and so on. Okay. But, yeah, if you are going in and you are doing that, fine, then you are probably getting some reasonable approximation.

MR. IOTTI: We, of course, did a sensitivity study on the reorganization.

MR. SERICIZ: What are you using as you drycol efficience then on these particles, one?

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MR. IOTTI: No. The drycol function is a function of...

MR. SERICIZ: Are you taking a function of velocity of the Reynolds number?

MR. IOTTI: Yeah. It is for a disk. It is for a pitching disk. Now it has an angular component to it. We even went back and derived, what they call the angular momentum component of drag, which is under standard drag. Both of them are, too. So, we think that we have defined the behavior of the party as accurately as possible, for those particles.

MR. SERICIZ: Okay. That is where you are coming back to this 12 square feet, plus you get another 12 square feet from somewhere else. Okay. That puts it in a perspective. I think that answers my questions on what is happening in that little region with the two dimensional mobilization analysis here. Its treated, it sounds like it has. I am not prepared at this meeting to sit down and go through every equasion, but I understand what you are saying.

MR. IOTTI: Well, for your information, we used a code that you yourselves probably have used, the Beacon code, which is, of course, the decendent of the sola codes, which are of course a descendent of KFIX. We have used no slip condition for it is at the bottom.

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It is the proper behavior. The field appears to behave properly, when you look at it. You have to ignore the very top, because there we have to let some flow out to simulate the other opening that is on the other side of the screen. In the vicinity of the hole, the feel of presentation is correct.

MR. LI: So, your studies when your equasions in a free flow area, down to, lets say, two inches. The whole thing, then the velocity is going to slide.

MR. IOTTI: Oh yeah. You can see it. It is extremely flat there, the two inch. This is relative to magnitude. You can see this is the magnitude of the vector. Compare, but see, it quiesces a little bit quicker for the 2", than you do for the 5". That is reasonable, because, you know if you have to move out so many diameters before you got back to the pool. So, here the velocities will be higher, but the zonal influence will be less. Okay. Also, you get a very large component of vertical velocity. This, of course is exagerated so that it appears at a very large angle. You can see that it is about .7 feet, right up here, right in the zone below. You have a .7 feet per second upward, as well as a horizontal components. You will behave as you might expect.

MR. SERICIZ: Now, were these analysis then,

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were these analysis a basis for drawing your conclusions in Section 8. Do these analysis come after that? I am just trying to put myself in perspective.

MR. IOTTI: No. These were analyses. These were done to present a conclusion in Section 8. They were also, then used to take this approach also. So they were used for both.

MR. SERICIZ: For both, alright.

MR. IOTTI: They were the basis for both analyses.

MR. SERICIZ: Okay.

MR. BURWELL: Dr. Iotti, we talked a great deal about decay, when you state you pointed out drawings and sketches. If you can summarize, basically, what you have said for the record, so that it will be a little simpler for a lamen to understand.

MR. IOTTI: Okay. Maybe I ought to restate what the concern is. The concern is articulated by several individuals around the table. It is that as the paint debris, chips, whatever, progressively occupy increasing areas of the screen, the velocity of the screen will increase. The velocity toward the screen, but away from the screen will also get higher. As a result of this increase in the flowfield, there is a tendency where particles that are either raining into

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the pool, raining through the water, or a particle that might be transported through the floor in the center of the screen to be dragged along the increased flowfield due to the viscus effects or turbulent effect into the screen area. To address that concern, we developed a model of the near sump pool, and this model was executed using a finite difference, utilizing the Beacon code, and the results of the model show the flow fields that exist in the vicinity of the sump for different percentages opening, free flow area, the sump screen. What those models indicated, the region of influence was here being defined as the region in the vicinity of the opening of the screen where velocities are considerably higher than the farfield velocities. It varies with the opening remaining in the screen. As a result of this increased velocity, it is possible for particles that are reigning in the pool to be transported to the screen and clog it up to a certain level. At some point, because of the geometry of the screen, and because of the flowfields being built, the particles will no longer be transported to the screen.

That results into a band near the top of the screen, which is approximately two inches high, screen area which is left unclogged. One other conclusion of

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this finite difference in modeling is that the velocities near the floor, which had been assumed to be of the order of (inaudible) feet per second in the farfield transport analysis, in reality are much lower. In fact, they are approximately half of that. The conclusion which can be drawn from those, is taht rather than the debris being transported against the screen, from the farfield transport phenomenon, you will actually be dropped off before it reaches the screen, so instead of having the accumulation to a certain angle of repose, you may have a flat accumulation at the bottom, or actually a depleat of the region near the screen.

MR. SERICIZ: Let me be sure I understand that last statement. I understand that conceptually. If I didn't have any debris, and I just did a very simple calculation of keel gray (phonetic) zero blockage, I come up with .08 feet per second.

MR. IOTTI: Not really, you would come up at about .04.

MR. SERICIZ: I'm sorry .04. .08 feet per second corresponds to 50% blockage. Now, you are telling me, when you model the flow field, you are finding a floor velocity of .04. But, that would go with what, the 50% blockage. In other words,...

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MR. IOTTI: No. It would also go...Yes..it would go with a 50% blockage. In fact, it would still go with a much higher blockage than that.

MR. SERICIZ: I'm sorry, but it would come back to the .04. I was thinking of .08 feet per second. It was the zero blockage. That's right. It is the zero.

MR. IOTTI: As you move farther away from the sumps, of course, the velocities go up, because you are channeling flow.

MR. SERICIZ: Okay. Without going back that far, let's just say that I have that sump sitting in a free space.

MR. IOTTI: It would go back to the .04.

MR. SERICIZ: Right.

MR. IOTTI: So, what the analysis did, in fact, confirm its first check, that it did match what the hand calculation told you. They also tell you it is not distributed uniformly. Actually, it isn't a slight distribution, very slight distribution.

MR. CUIRUVOLU: I'd like to add one more thing which you brought out, I am not sure. We did include all the paint in the near sump zone in that quantity that we said would be transported in Section 8.

MR. SERICIZ: That would correspond to this 45

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degree angle of repose?

MR. CUIRUVOLU: Yea. We did all the paint in that area, plus on the liner, the entire paint, concrete...

MR. SERICIZ: I'm not personally prepared to argue pro or con, whether that is super conservative or conservative. My own feeling is that it is a conservative assumption. But, people who deal with the chemistry and failure mechanisms should evaluate that spot. I understand what you did, and I understand how you laid it out. I recognize now, that I was correct in looking at all of this as an additive.

MR. IOTTI: Yeah. The additive thing, just want to state for the record. The rainout mission, there was no attempt for us to take out or subtract portions of paint that would be trapped in crevices because of the configuration of the supports upon where the paint appeared. Whatever paint is there comes down, all of it, concrete and steel.

MR. LI: Yeah. Actually, the quantity you actually define is based on that angle of 45 to 300, the angles. That is the portion that actually contribute to that 50% blockage.

MR. CUIRUVOLU: It is actually 35-50%, depending on the normal paint or concrete paint.

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MR. LI: Yeah. I am trying to clarify when you say all the pan, what I mean is not all the pans. The pan that is falling into that angle.

MR. CUIRUVOLU: In that estimate, that is some sort of correct. It is said in the report, 0 to 45.

MR. SERICIZ: Go ahead and ask your question, I think I know which one you are going to ask.

MR. LI: 45 angle you used, could make that point. It seems to me that the region extends to go beyond 45 degree. So, I want to know how that 45 angle was defined? The zone in which we put the paint into the neofree analysis, as compared to farfield analysis. The farfield analysis depends that you be contribute in that farfield 50% implying, based on the pan debris falling into that angle.

MR. CUIRUVOLU: The immediate simplicity is then...

MR. LI: No. I am the far field, the far field analysis.the outside thing.

MR. CUIRUVOLU: I didn't understand your question really, so I better wait for you to explain the contents of it.

MR. LI: Ok. Let let me clarify my question a little more. That your farfield hence quality roots is defined based on the amount that falling into that

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segment between forty-five degree and three hundred fifteen degree, something like that, I don't know about other end. My question is how that forty-five degree was determined. The reason I looked upon forty-five degree, doesn't have any particular meaning. This region expands to beyond forty-five degree.

MR. CUIRUVOLU: Ok. The reasoning is, we evaluated in section 6 the velocity required to transport the pan partical. we determined that the critical velocity required to transport the partical as .273 per second, and this is very conservatively estimated, not taking credit for high intensity paints. We assume the lowest density of the paint. So, this is the lowest number one would want to look at as far as the critical velocity for transporting paint.

Then we in chapter 5, we looked at the available velocities. In fact it took ten million radious zones. We did these various zones, and our system was entered in tables in chapter 5. We find that if you see the zones 3 and the zone 4's. The velocities in those zones are below .27, so the paint that's reaching the sub would drop out. But still, we welcome the regulation that that sector of 45 degrees in the immediate sump zone right on up to the sector on the other side we assume all the paint, irrespective of

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whether it is transportable or not is available to clog the sump. So we just took that number and added it to the total quantity, (inaudible) any transport for that immediate sump zone.

MR. LI: Yeah the immediate sump zone included zone 6 subsection 4C. Do you include all ...

MR. CUIRUVOLU: No, no, no. because those velocities are villa transportable velocities.

MR. LI: So you say according to the velocity calculation zero, you conservatively assume that some extra 45 degrees.

MR. CUIRUVOLU: Correct, yeah, right. We consider it really (inaudible) because it is so close to the sump we said it is better from the coliterate point of view to assume that ...

MR. LI: So you arbitrary conservative number.

MR. CUIRUVOLU: Yes it is just a more conservativable thing.

MR. LI: Does not correspond into any of this so ...

MR. CUIRUVOLU: We did lot more coservative things in this. We assumed that the entire liner up to the spring line, all the paint would just come to that floor. It's so conservative.

MR. LI: I just want to understand how that 45

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degree angle is derived ...

MR. CUIRUVOLU: I know but I'm trying to emphasize to you that we tried to add everything that we could see to that number, just so that we don't jeopordize in any analysis because we neglected to ...

MR. SERICIZ: A question please, while you're onthat point. In terms of relating that to quantities, is table 6225 then the table that we should look at or is there an alternate that's a better table?

MR. CUIRUVOLU: No, 6225 is a good table, yes.

MR. SERICIZ: Ok, can I ask some questions just to be sure there, ok. What you've got are 3 elevations, and you're working within the geometric definition, so this 88,824 at the bottom, that would represent what you use to come up with what blockage? You know, going back to the angle of repose. Ok, but what blockage, you know going back to the angle of repose. Ok, but what blockage, what do I relate the 88,824 to?

MR. CUIRUVOLU: Ok, this is the quantity of paint.

MR. SERICIZ: I understand that, but now ...

MR. CUIRUVOLU: Yeah, I am explaining, answering the question. This is the quantity of paint that we postulate would be transported, and this is

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very conservatively postulated, not taking credit for higher densities of concrete coolings, higher densities of zinc based coolings, so this any paint. But if you consider all this paint is concrete paint, you would have 35% blockage, which is 50% ...

MR. IOTTI: No, no, no. The 88 something is corresponds to the lower part.

MR. PURDY: No, no, no. Here's the line, I think Mr. Sericiz, I did. Wait a minute relate it to this thing.

MR. BURWELL: What thing are you refering to?

MR. PURDY: Well first, 6.2-25 gives a number of 88,824, and you come over here to figure 9.1, and that same number appears essentially on the lower scale. The lower horizontal scale. It's up to 88,000 because it's a little less intended to pass square feet of concrete potiums.

MR. IOTTI: No, but it's also. There's two figures

MR. CUIRUVOLU: I know what we did.

MR. PURDY: Wait a minute, just wait a minute, Bob. That the 88,000 is at the base of this line here which you see, if you assume that is a concrete, 88,000 totally concrete coating it gives you the 50% flow of lot.

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MR. SERICIZ: 50 or ...

MR. PURDY: 50. This straight line goes straight up to 50%.

MR. SERICIZ: Yeah ok, ok.

MR. PURDY: That is simplest way of qualifying things.

MR. SERICIZ: That is what I was trying to do, because I was trying to see how to bring one of these numbers over to this curve.

MR. CUIRUVOLU: If we assume all are this still, then you end up with 35.

MR. SERICIZ: And the reason for that is the difference in painting, in paint thicknesses.

MR. PURDY: Yeah.

MR. CUIRUVOLU: But we did not take credit for the density difference. So, if you do a more detailed analysis, it will show less blockage than we had...

MR. PURDY: But, Dr. Iotti is right. You look upward of two scales, it is in the 88,000 that gives you the 35% flow blockage. That is with the assumption of the steel, 88,000...

MR. IOTTI: What they have done is, they don't know the mix of the paint, so they assumed that it was all steel, and it was all concrete.

MR. SERICIZ: Yeah. Okay. I was just trying to

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write myself some notes, and I missed some conversation.

(End of tape.)

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MR. IOTTI: Alright. It is going to be a mix of steel and concrete.

MR. SERICIZ: No, but the next thing, it doesn't quantify the space on the floor.

MR. IOTTI: That doesn't matter.

MR. PURDY: Don't worry about that. That is a separate issue.

MR. IOTTI: We are trying to clarify now, who gets these two figures, 35 and 50.

MR. BURWELL: It is a point of clarification. Are the two figures additives?

MR. IOTTI: No. The total quantity is 88,000 square feet. What you don't know is how much of that is steel and how much of that is concrete.

MR. SERICIZ: That's why I came back. It is the quantification made on coatings. I was just trying to take this over, actually, to that curve and understand it.

MR. BURWELL: Alright. But the problem that I am looking at is this line seems to be drawn on a figure of 9.1, about 88.

MR. IOTTI: Yes. But there is two lines, in this case. That gives you, if you were to have for symerical, all of the 88,000 feet of steel, then you would have 35% blockage. If it were all concrete, it

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would be 50%. It is going to be somewhere in between. We can only define a lower bound and the upper bound.

MR. BURWELL: I thought that you were using actual concrete, and actual steel.

MR. IOTTI: The total is 88,000.

MR. LI: Where you were talking about an actual velocity feeling in Section 6. You talked about a Crico, a most conservative Crico philosophy to use the .27 feet per second, assuming it is coming from this parametrical study of your velocity study. I looked at your table 6.2-14, 15, & 16. Over there, there are some lower velocities to use, like .15, .20, and .23, which is less than the critical velocity. How do you define the frequent velocity.

MR. IOTTI: I think it has to do with what you ultimately determine is the dynamic friction coefficient.

MR. CUIRUVOLU: Right. In keeping with part of the friction analysis, to vary friction codes, and the drag function to see how sensitive all of these numbers, as well. If we point that it is not very sensitive, we have substantially lowered the deviation from our values to still look at what sensitive is. But, the report discusses the sensitivities of these transport velocities to the friction code and the

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containment static and the track coach. We determined that the sensitivity is very low, for the friction curve. The dry coach is somewhat more...

MR. LI: So, corresponding to these three tables, what are the parameters that actually go beyond the flowfield?

MR. CUIRUVOLU: The actual parameters are 621. We also did the analysis with paint thickness vary.

MR. LI: Yeah, I know. You vary off the range that goes into these three tables, and what are members that you have been realistically assumed as such that you have a....

MR. IOTTI: Point one, which is a dynamic friction deficient, which is one 1/6 of the static is low low. It is normally...

MR. PURDY: I think Meduka is right, that he could point to you in the report what he used, actually.

MR. IOTTI: I was wondering what was unrealistic.

MR. LI: That's why you don't keep a critical velocity that is any lower. It is unrealistic. Any parameters that are used, just try to ascert into range, and not very meaningful. So, the friction coefficient in .1 is unrealistically low.

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MR. CUIRUVOLU: 6.223 summarizes all the tables, and really gives you in a nutshell what the various velocities that we expect to see. The parameters we used for the study of basis of drag coat .1, friction curve status .6, friction code combined, .2. (Inaudible) to table 629.

MR. BURWELL: Six, two, nine?

MR. CUIRUVOLU: Yes. Most of them, most of the basic tables use that data. The rest of the things just used a variation to the sensitivity.

MR. LI: So, 629 is your baseline?

MR. CUIRUVOLU: All of the tables, up to 629 use the same numbers. 1.6.4, all of it. Up to 629. Then, we start to look at the effects of sensitivity over these parameters.

MR. SERICIZ: Can I ask a question while we are in those. I will ask the question from Table 6223. There, you are selecting the critical transport velocities. I would interpret that as the velocities are equal to less than that, in tank there is a move. You give a particle size. Now, let me ask a question here, because we were talking with respect to the 88,124. Okay.

MR. IOTTI: Yes.

MR. SERICIZ: The 88,124 is simply a volume

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distibution when you add it up, okay. Your analysis that resulted in either the 30 or 50% number was done exclusive of these transport calculations?

MR. CUIRUVOLU: Not exactly. The transport calculations prove that the available velocities do no exceed transport, so what we did was we transported the paint from upper flow through the opening in the sump zone...

MR. SERICIZ: What I am trying is to just be sure. That is what I thought I heard you say. Let me phrase it the way I think that I heard it. You did this transport velocity analysis. Finally, you come up with critical velocities in table 6223. Okay. If I look at those velocities, relative to your velocities calculated in Section 5, I would say that I don't have velocities in containment sufficiently high to transport paint. Is that a correct way of looking? This is step one.

MR. CUIRUVOLU: At storage level, right.

MR. SERICIZ: At 808, right. Okay. Now, if I take the next table, which is, that I refer to, which is table 6225, the 8000, then your analysis is presented in Figure 9.21, or 9.1. I simply say that I am going to put it over there, and I am either going to look at it as steel paint or concrete, and I come up

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with that blockage. I just want to be sure. That is the way that I read your report, and I wanted it in with the clarification.

MR. CUIRUVOLU: The reasoning is, we wanted it because of the wording. So, we postuluded.

MR. SERICIZ: Okay. Fine, I understand that.

MR. LI: In the beginning I asked the question about L over A versus L over B hydraulic parameters, summation of how the resistance was upheld. Because your force field was determined by your resistance term, in the tables listed, the resistance term was actually in the context, such as L over Area, pro area. If you go back to derive equations, L over hydraulic diameter. So, I just wondered how you...

MR. CUIRUVOLU: It is proportionate, because your hydraulic parameters would define it as the total cross section of area developed by the better element. So, if we are ...

MR. LI: If I...In terms of L over A, am going to have another term, wetted parameters up there. L over A times wetted parameters, then, numeric numbers would be different, wouldn't they?

MR. CUIRUVOLU: We did a sensitivity analysis after we looked at the velocity. We varied the areas cross sectional tape with each of the channels and subchannels by 10%, 20%. We also varied the differential variation in this term. You just increase the variation on one side, by increasing the, by decreasing the cross section of the areas we did in our site. We also did radiant analysis by using a different locations for the flow.

MR. SERICIZ: Okay. That's a variance. My uncertainty really comes, certain question comes. Maybe I am jumping ahead, and I apologize. If I take a look in a variety of texts or handbooks, I as an analyst can choose coefficients who can vary by 40 or 50%. Maybe we can come back to that later. They do tie into what I, what we call the variance type of analysis. But, that is where my question is coming from. If I go in, and I recognize, you know, the handbook draws the line. It says, okay, my coefficient for a contraction looks something like this. I know full well from the experimental data that went into that is a variance around that.

MR. CUIRUVOLU: But we did not use any portion, and we did not take any credit for flow expansion. The message areas we took is very conservative. What we said, if there is a matter in mechanism of the passage, we assume that narrow area continues till there is a major increasing area, or a

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major decreasing area.

MR. SERICIZ: Okay. You can put it in terms that think of. Okay, what contraction was coefficient if you assumed that?

MR. CUIRUVOLU: We did not go into the system logic. What we did was took a total system...

MR. IOTTI: The answer to his question there is usually a large one. Because, what you would have done, is that you really assume that you have a large area. You funnel it down instantly, to a much smaller area. You continue the much small area for a long time, until you find another area. So, if you were to put the (inaudible) shut, and try to come up with another area that is coefficent, you will find a very large one.

MR. SERICIZ: Well, that is where I am coming from. That's what I was trying to do. I couldn't do it out of the tapes.

MR. IOTTI: You know you can.

MR. CUIRUVOLU: We try to stick on the record.

MR. SERICIZ: That's alright. You can show me later, okay.

MR. IOTTI: What happens, is that they really didn't do their analysis by using those coefficients. They did the analysis on the variation of area.

MR. LI: The variation of area by 10% or so in

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study sensitivity, it doesn't answer my question under proresistance terms. You have, I don't have the parameters there. I couldn't assess how much difference does...Let me derive a question. I read that the actual terms, the terms that are proresistance or ...either in terms of mass flow rate or volume, you used in table substantially this...your table was related to a match in volume. Okay. Hydraulic Resistance. This is where my question is. It is not L over A. It is a hydraulic...it is also related to L over A.

MR. CUIRUVOLU: That's what it would be.

MR. LI: But, for the analysis parameters over there. Wait parameters. So, in L over A is another parameter too. It has a factor of...

MR. CUIRUVOLU: That's right. But, we find in all of those openings, the record... We do this ratio in flow. We have a total flow at one point, we are splitting the point to two high, low channels. So, the total flow is fixed by, like Dave said is the outside pumping mechanical. All comes to the containment space pumps. What you are doing is just splitting that flow into parallel ancidial pathways. So, the sensitivity to the waited parameter, if you look a the wetted parameters, all these channels is essentially constant. The number is so big, it is (inaudible).

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MR. LI: Wait a minute. Wait a minute. You say the parameters, when you split a flow, your wetted perimeter is going to be passing different channels?

MR. CUIRUVOLU: Percent in tenths, of wetted parameters along the channel is...

MR. LI: I understand the friction is constant in the bandstage (phonetic) constant, and the G's subcedes constant, A is not constant, area is not constant. I don't understand where the parameters come from.

MR. CUIRUVOLU: To look at this in the pathway.

MR. LI: Yeah.

MR. CUIRUVOLU: It is essentially the same. The water depth is the same. The (inaudible) is essentially the same, except for where there is a block. Area has a much bigger deviation than your waited parameter, because these numbers come from...

MR. LI: Okay, I assume the wetted parameters be the same.

MR. CUIRUVOLU: We also did the sensitivity to overcome, to mention that there is a cause in deviation.

MR. LI: Were the wetted parameters is, in terms of the actuality. When your area varies, wetted

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parameters varies, so, along with the area variation. So, you won't have, if you have, you don't have a constant area. You have a various area flow that goes through a different channel. Then, you have different wetted parameters. I disagree with you on that.

MR. CUIRUVOLU: Yes. I agree with you, it is different. But, the percent change is very good.

MR. LI: It's the same as the area.

MR. PURDY: No. It's not the same as the area, because two vertical legs in the wetted perimeter are constant regardless of the width. If you look, the depth of the water is what, about 8 feet. So, there is 17 feet of wetted perimeter that don't care how wide the channel is.

Can you give me, Meduka, the widest channel that we have. Do you have an idea, just give me a...

MR. CUIRUVOLU: About 12 feet.

MR. PURDY: So, there is a variation in wetted perimeter, but the variation, the absolute smallest could be is 17 feet. Because, that would be a channel of zero width. Then, the widest it could be is 17 + 12, which is 29. Which means that the wetted perimeter, in the extreme case can vary over between 17 and 29, and roughly 1.7 or so. That makes the extreme cases, and you won't find any channels that are zero width.

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MR. CUIRUVOLU: The variation is the column widths, and the radius of suctions to feet. That is all your percentage is.

MR. PURDY: I think you are correct, but the variation is taken up by the relativity study. A channel, basically, is like this water level.

(Overlapping comments.)

MR. PURDY: A channel, basically, is like this. Water level...This height is 8.6 feet.

MR. LI: Okay. That is constant.

MR. PURDY: Constant, of course. There is two sides to it. So, the only variation is the width. That, I assume is in the extreme case, a variation of 012, which means that the perimeter varys from 17.2 to 29.2. If somebody has got a calculator in here, what is 29.2 over 17.2?

MR. IOTTI: About 1.6.

MR. PURDY: 1.6. Actually, I don't think there's...what would you guess what the narrowest channel...

MR. CUIRUVOLU: Eight feet.

MR. PURDY: Well then, if it is eight feet, eight to twelve feet, I think you can see that we are talking about a variation between eight. So then, this becomes, 8 X 3 is 24, 25, 29. That is about 1.17, I

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guess.

MR. CUIRUVOLU: We could have done the way you are talking about.

MR. PURDY: That is encompassed by the sensitivity analysis.

MR. CUIRUVOLU: We could have done the way you are talking about, but what we tried to do in those studies is stay consistent with the new record type of evaluation. Because, the number for proven, so we took the lower A, which is in the new rack, as a methodology. So, we said we would not deviate substantially from the new reg. method unless we hae a strong reason.

MR. LI: I just wanted to know what the range...That explains my question that maximum difference of 17%.

MR. CUIRUVOLU: This bothered me for some time, then I made the analysis. I looked at the sensitivity. They said, it is not worth bothering to deviate from this lower A analysis here, that created a new type of evaluation which doesn't really particularly change.

MR. LI: I don't have the matching configuration in mind, so I don't know how much this perieter would effect. That explains my question.

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While we are at the systems area, there is a question that I would like to ask also, to probably correct the system. I originally wanted to talk to Sammy, before I asked. In tables 5.11, to determine the minimum water inventory...yeah, right here. In determining the maximum and minimum water inventory in the sump, I wonder this reactor cooling inventory would be the same for maximum or minimum. It seems to me, for minimum quantity over here is the way, I assume it seems to be nonconservative. If you have some water that is still residual to refuel after blowdown, refuel some water residually inside the reactor vessel, in the lower part of the piping system.

MR. IOTTI: The systems inventory is fixed. Your refill has got to come from someplace else.

MR. PURDY: It might come from the sump.

MR. CUIRUVOLU: What we took is what could start after the coolant system.

MR. PURDY: Actually, you could argue the absolute value, I guess. But, if a break is large enough to cause recirculation, which is one of the foundations of this report, the amount of refill inventory in the reactor coolant system would be a constant thing. It won't vary from side to side in breaking if the break is large enough to cause

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recirculation.

MR. LI: What I am thinking is, in the process you have a blowdown. It is blowing out all of the inventory from the reactor coolant system. Okay, then you start to refuel. You have got the water from accumulators, whatever, you have got some water into the reactor vessel. So, after that, then into later place of recirculation phase, don't you, do you have some water in inventory stay in the reactor vessel, not in the, not to contribute to the inventory.

MR. PURDY: You will stay at the maximum. It is constant.

MR. LI: Now, as far as...

MR. IOTTI: What he is saying is that...

MR. PURDY: It refills until it comes out of the break again. All of the breaks are pretty much at the same elevation, because most...There might be a small difference, say if there is a cold leg. Because, that is the lowest break on the system. But, that difference is small, because of the inventory of that down under piping. Because, if the break is anyplace, what it does it fills the reactor vessel and then it flows back through the vacuum point pipe at this rate.

MR. LI: So, the way you calculate a maximum, what do you assume that part of the inventory of

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reactor vessel...

MR. CUIRUVOLU: Yeah. We would not have taken the whole coolant system, and we would assume the maximum. We would assume the same number, that would flow out at that rate, and still retain the water that was for the flooding of the coach (phonetic).

MR. MANN: What part do you think is not conservative?

MR. LI: I was thinking about this number seems to be large. It may be, there could be some lower number in terms of some actual water staying in the reactor vessel.

MR. ANDREYCHEK: I guess it would depend on where the break is. If you have a large break, you are going to lose your primary side inventory to begin with, so actually you are going to get back in theatricals what you get out of the accumulators with a drop in the RWST. Some of that will, as long as you are going through a circulation process, that is going to be available as you back out of containment, eventually. So, I think, eventually...your total fluid inventory starts out with whatever you have in your primary system, plus whatever you would draw from your accumulator, plus your RWST, what you start with in the sump, that is it. You can't get any more after that.

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MR. IOTTI: Each indication is slightly different. What he is saying that is, alright, for the purposes of determing the maximum water level, you can assume the primary system to be empty, literally. You have to put it all in the sump.

MR. MANN: Well, we.

MR. IOTTI: Let me finish, okay. The next question is, when you go to the minimum quantity, the logical thing to do is assume that it be full. Because, what is in the vessel is not on the floor. That is really what...

MR. CUIRUVOLU: That is really what he is saying.

MR. IOTTI: No. I think that is his question that he is saying. That is the prime example.

MR. CUIRUVOLU: When we talk about maximum and minimum, we did not mean the true maximum and minimum. We still have our own conservative estimates in the maximum, that is not the true maximum that you would want to extend to. We took very conservative observation, and we said, what is the worst case lowest water level. Now, between the two, what is the worst case number, and the worst case low number. So, are maximum is truly a realistic number of what one would expect to see, and the minimum is a true conservative

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number.

MR. MANN: Why do you say your maximum is a realistic number? What is the difference between your available capacity?

MR. CUIRUVOLU: This is the refill and water storage tank, where there is only 2% of all the empty.

MR. LI: You assume all available aspects in the same for, maximum either maximum or minimum water inventory to the sump.

MR. IOTTI: I think I agree with him. I think that 12,740 should be some smaller number.

MR. PURDY: We don't know what it...

MR. IOTTI: Yeah. But it is only, generally, off the top of the head.

MR. PURDY: What we have to do is check where we got that number from.

MR. LI: I was just wondering, there is some difference. I don't know whether it is going to be the whole inventory vessel, or if it is going to be just a small (inaudible).

MR. PURDY: Look at it this way, let's assume for the moment, that it is 10% of that 12,000 number is between that and the minimum. That is only 1,200. So, I think it is a valid point, but I don't think it will effect the water level in the sump very much.

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MR. BURWELL: Off the record, please.

(Off the record conversation.)

MR. BURWELL: During the break, we had some continuous discussion on some of the numbers in the report, and I will ask Mr. Sericiz to summarize what that discussion was about.

MR. SERICIZ: The discussion, was regarding the velocities that are recorded in Section 5, and have to do with the method of analysis, which was an area distribution of analysis to determine velocity. The question that I have raised is, do the velocities reported in Section 5, represent the conservative upper bounds, or do they represent nominal values. Another way of phrasing that question is that if I lay out a resistance network using loss coefficients to develop the flow distribution network and then calculate the flow distributions, and attached to those uncertainties that go with them, would I come back with velocities equal to or less than those reported. Is that a fair statement of what I have asked?

MR. CUIRUVOLU: Yes.

MR. SERICIZ: That really relates to my original question, what are the uncertainties in velocities, or in the basis for calculating velocities repoted in Section 5.

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MR. SCHMIDT: Is that answer contained in the report, or in the analysis, or any questions that you have today?

MR. PURDY: Well, in looking at the report, before I answer the question. It says in tables 5.4.2-4.4.13, showed the combined velocity summary. These are for various conditions of low water level, high water level, and number of trains. In other words, total flow rate. But, they are for nominal resistances. Now, the 13 and 14, you address variances and resistances in this report. Where do you address that.

MR. CUIRUVOLU: The flow resistances were taken care of by the narrow pathways, and the serial pathways. The flows in the serial pathways are added. The resistances in the narrow pathways are the inward square, the square root of the inward square of resistances that we took. I think, that fairly presents the type of analysis you are looking for. That is my firm belief, that we have presented proper source flight between the parallel paths.

MR. SERICIZ: No, we are not understanding one another.

MR. IOTTI: That's not his question, his question. He doesn't agree with the flow split. He disagrees with the flow split.

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MR. CUIRUVOLU: The flow split is agreed, then the only next question is, what is the velocity.

MR. PURDY: No, no, no. That's the point, he wants to look at variations in the flow split.

MR. SERICIZ: No, my question is directly addressing, what is the variability in the velocities, ok?

MR. PURDY: The variability depending on what?

MR. SERICIZ: On what you are calculating as your flow split, but now saying that that is dependant, ok, on the type of openings, and/or equipment or plant layout that this is representing. I understand what you are doing when you analyze a parallell path situation, and distribute the mass flow by area, ok, that I dont have a problem ...

MR. CUIRUVOLU: Display the english resistance ...

MR. SERICIZ: No, I understand that, I can divide and multiply, ok. Now, if I did the analysis instead of just by inverse areas, which is what you've done. I actually sat down and I said, and for example, if we look at figure 545, which I think is a representative one. That if I started with where your source of water starts which is the steam generator cubicle 4. And I try to model that going to door 4, ok,

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and now model it as a contraction going down a straight path, making a turn and coming out and doing an expansion at what you call 4A, ok.I could go ahead and do something which is just a series of resistors which are K factors, ok. Now if I did that, ok, and then I compared that number, ok, with what you call your inverse area, or what ever you want to call it, we're still not going to start comparing a resistor, an intotal resistor. Then, do I come back with a number that I could use, that I would use then and calculate a velocity equal to or less then. The reason that I refer to 545 is that from one of your tables ...

MR. PURDY: It's 544, I think.

MR. SERICIZ: No, figure 5.4-, 5.4-5,there is a table ...

MR. PURDY: A symbol for 5.4 ...

MR. SERICIZ: Oh, I'M. Excuse me, figure 544, ok, has a velocity shown of .58, ok. That's sufficiently high that you could make the case that material is going to transport out of that compartment.

MR. PURDY: Yes.

MR. SERICIZ: Now I come out and I come into region 4A, ok. I could continue this series of calculations independant of just looking at area distributions, ok. I could then come up with

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velocities, because I know what my total head is, ok. Now I would then calculate velocities coming down. My question is that if I did that, would I come up with the number equal to or less than what they've got. Because in doing that I would go to a hydraulics handbook, or whatever, pick numbers, and I would look at what might represent the higher side, ok. And go calculate it out.

MR. PURDY: I think the answer is that we don't know because we didn't do the analysis in this way you now suggest. We did it as described in the report, which is ...

MR. SERICIZ: No, the report says $K/A \times V^2 \div 2G$. This is the Bresenrow (phonetic) report.

MR. PURDY: Ok, the Bresenrow report. Our report was based on the area method.

MR. SERICIZ: Ok, and I don't have a problem with an area method distribution,because that gives you quickly what the flow distributions are.

MR. PURDY: All we can say is that's how did it.

MR. IOTTI: I was going back to your suggestion to resolve your concern. On a sampling basis,you could go back and do, you know, a path, a particular path analysis and calculate a velocity of

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the way and compare it with what ...

MR. SERICIZ: Well this is where I'm trying to get to, if that were done, and I can't do it because I don't know your plant details that well. That type ... Just for one of these paths, and what I would suggest in fiugure 54-4, because what that does is it comes out of the compartment, decelerates according to these numbers, which says it drops out. Your figures at station 4B indicate an acceleration, this is probably due to areas. Then it drops down, I'm taking a literal view now, ok, of this figure, and the sump is fairly close to that wall and the expansion, which ties into a multitude of questions. Do I or don't I transport stuff down. Ok. I'm willing to work with these numbers, I have nop way of backing out, whether the velocities are indeed on the conservative side. If they are then your conclusions are supported.

MR. SCHMIDT: Okay. So, are you saying that you would like for us to do this additional alternate method to do.

MR. SERICIZ: That, to me represents a logical method to answer the question, are these calcs conservative.

MR. IOTTI: He can't do it, because he doesn't have the properties. He is asking us to do the analysis

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that he would have done to verify his.

MR. PURDY: Are you asking to do the analysis? Is that the idea?

MR. SCHMIDT: Is there any other way that we could get that to you without doing the additional analysis, or do you think that is really is what it would take to answer your question?

MR. SERICIZ: That's a fair question. I want to give you a clear answer. I don't have information that I could sit down and do it myself.

MR. SCHMIDT: I realize that.

MR. SERICIZ: Okay. Nor, do I feel like crawling around the plant with a 15...

MR. SCHMIDT: We have been trying to get you down there.

MR. SERICIZ: In illustrative calculation, I thought that you had laid up the system, that if I had looked at one of your worksheets, it would have become evident of your conservatism, much the same as when I saw the flow conditions from a two dimensional network. That would have been the way to do it. Now, I guess my answer would be yes. A sample calculation laid up by just stirring up from your source term, which is where the flow would start, and come down this way. Done that way, should support these philosophies as being

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representative of the upper limits. If they are, then that would support the whole network.

MR. SCHMIDT: I'll tell you what I would like to do, Spot. Can we confer here for about 3 or 4 minutes.

MR. BURWELL: Of course, off the record.

(Off the record discussion.)

MR. BURWELL: As a result of the caucus where do we stand. We have got the suggestion by Mr. Sericiz that we might want to consider doing relatively straighforward simplified alternate method of calculating velocities and we will try and do that and get back to you sometime next week, as soon as possible. I will assume that you would just reply to that as a letter would be the quickest way of handling it. I see no reason to hold a meeting. I think it is an exchange that is straightforward, and the numbers will be meaningful to us.

Okay, with that, Hal, I believe you said a minute ago that you had one or two additional items that you wanted to bring out.

MR. SERICIZ: Well, with that statement there, I'll utilitize the numbers, okay, in section 5 on velocities, that is nominal values, for the time being. And, what the suggestion that I am making is to

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minimize any further analysis is, and I will speak from figure 5-4. Let's look at, for example, what the velocity variation might be, by this alternate method, in what is represented by the quadrants being represented by the poorest note.

MR. PURDY: Well, to restrict the analysis somewhat, I have asked the people back in New York to do so far, is to start at the doorway. The doorway four. Roughly, in the analysis, as far as section 4.B, which gets you from a narrow point to a wide area, and then back into a narrow restriction again.

MR. SERICIZ: That's a reasonable way. They asked two related questions though. If you make that analysis, 4A to 4B, not considering straight flow that is coming...

MR. PURDY: No. No. No. Another reason for selecting that point is because it is a confluence stream, with the spray flow coming around from the back side...

MR. SERICIZ: From the back side reaching in here. That would be...

MR. PURDY: 4A is a great mixture point.

MR. SERICIZ: A great mixture point. Okay. And, your reasoning then for stopping then, is...

MR. PURDY: 4B is because that's...from 4A to

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4B is a pretty much a straight channel. 4A may be changed to 4C. Well, 4C gets you into another expansion again. So, it makes the analysis that much more extensive.

MR. SERICIZ: For illustrative purposes, I wouldn't have a problem if you came around, and had this mixing zone, just to address the question that I have placed on the table, and that is, do these velocities here represent upper limits. It is a mixing point in here. You have some questions, when we were talking during the caucus. I will let you speak for yourself.

MR. LI: Yeah. About the 4C, you haven't lost the change, actually from...especially from the location forces right in front of the sump. That is ultimately a very important perimeter for determining transport to...

MR. PURDY: I have no doubt that if there is anything in the screen at point 4, it will reach the sump in some measure. Then, from .4C further around the sump, the load will decay rapidly. We will get...

MR. IOTTI: Let's be very careful, because the impression that you could leave here could be misleading. It is not as close as you think it is. You have got to look at the actual drawings. Okay. It is

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close but there is more than 4 feet away.

MR. PURDY: That other drawing doesn't show that.

MR. SERICIZ: I recognize that, and that is why I am trying to be very open in asking these questions.

MR. IOTTI: This is the scale. When you come out of here, you have more than 6 feet from this edge to getting to the screen.

MR. LI: About 6 feet.

MR. IOTTI: Six feet. The edge here is like four. So, you can add another two feet to give you the strength. It is not like it is right against it.

MR. CUIRUVOLU: What Dave is saying, if anything passes 4B, where postulates that it moves. So, if we do up to 4B, and the establish that the velocities are better than what we postulated, then you can be comfortably assured.

MR. IOTTI: It doesn't matter. Because, you transport anyhow. He was really interested in what are the velocities.

MR. SERICIZ: In other words, do these represent, you know, what one could be considered. That's right. I would tend to agree with you that if you do the analysis, starting back here from bringing

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the water around from 8A, creating this mixing zone and coming through here. Looking at that, are these representative of upper limits. We can draw a conclusion from that. Just then, if not, then that raises the question in several other places. I am just quickly trying to come back to an illustrative type of calculation that says will you treat these as uppers or not?

MR. PURDY: Actually, I am sure that you will get some areas of higher velocity than what we show now. The extreme has to be higher than the mean.

MR. SERICIZ: Well, I know. I think I agree that the analysis, and I will use the term discussion, that comes with it and whatever rationale that it takes to arrive at a conclusion that is consistent and we will work with that.

MR. PURDY: Yeah. Okay.

MR. CUIRUVOLU: What we will do is we will write a new section between the two columns. 4B, 4A, and we will add one more zone in the middle to evaluate the open area between the two columns.

MR. SERICIZ: Okay. Let me just give you a feedback. The questions that I had for Bob, and I was concerned when I took a look at it. I am not saying that we need a multi dimensional flowfield analysis.

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When you look at a level of analysis that way, and you see where zones of influence and etc. The points are almost made themselves. I would like to, you know, come away with an understanding from whatever you do, that says I treat these as representative of the conclusion that you are drawing. That is, it doesn't transport. Maybe that is another way of paraphrasing here.

MR. PURDY: That is exactly what I think we can do for you to show you that our conclusion is still the same. The method on how we get to the conclusion might differ a little bit.

MR. SERICIZ: The area method I look at, is giving me nominals.

MR. BURWELL: Now, may I ask a question. Are the numbers that you are going to give us directly comparable to the subject of the report.

MR. PURDY: I would have to say no. I don't know what the numbers are yet, because I haven't developed the method of analysis yet. But, they will supplement the ones that are in the report.

MR. IOTTI: They will be correlated.

MR. BURWELL: Correlated with one method against the other. Thank you.

MR. SERICIZ: Yeah. I would look to whatever velocities that you came up with, and I would say,

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okay. Now I am going to take whatever your analysis says, and I am going to prepare, for example, one of your cases, and show a velocity of .12.42.1 centimeters. And say, okay, now I'm drawing a picture as to how I handle this.

MR. PURDY: Yeah, you are getting into a more detailed picture of some kind. The numbers in the report won't change, because they are nominals. Not nominals, they are averages. The average will not change.

MR. SERICIZ: I don't want to change the numbers in the report. Because, then we go back to another...

MR. PURDY: They won't. They can't.

MR. SERICIZ: All of this supplemental work is to show that these numbers are still correct numbers. They are used in conservative bounds to support the conclusions drawn.

MR. IOTTI: Let me ask a question since I might as well try and give myself half a chance to catch a plane, as opposed to the usual getting on while the are closing the door. Will there be any more questions for me, or can I try and go back (inaudible).

MR. LI: No.

MR. BURWELL: I take it that you did not

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really participate in the analysis on the flow into the bottom of the reactor vessel.

MR. IOTTI: You mean, the Westinghouse one?

MR. BURWELL: Yes.

MR. IOTTI: Well, sorry to... It was a nice meeting, and all that...we will send you a postcard from Bermuda. (Laughter)

MR. BURWELL: Thank you.

MR. IOTTI: Thank you.

MR. LI: I question section 5.4.1, where you assume the source from the spray and from the RHR. The location of the spray source, is to assume that 225°. Could you tell me how you determine why it is conservative.

MR. CUIRUVOLU: Okay. If you will look at the picture, figure 543, the freeflows have seven storage levels. One way is that right along the containment lineup. Another pathway is the spray on the upper flow which come through the opening in the upper flows. When we did the opening flow analysis, the larger flow occurs through the equipment hatch, which is about 224.

MR. LI: So, that equipment location is there always.

MR. CUIRUVOLU: No, that is the location of the equipment hatchway. I think it is the opening, that

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location A.

MR. BURWELL: At location A.

MR. CUIRUVOLU: Any other assumption would make the velocities lower at different points, because we are resuming all of the spray waters that start here. That is not true. The spray water is spray. It is accumulating as we go along the pathways. So, that is the reason why we consider that as a most conservative assumption. Just to be sure, what we did was a sensitive analysis, relocated in this point to another point on the left side. We determined the velocities with that location. We found that the answers tend to remain the same, and issue for...

MR. LI: You have relative location problem from here to here. How about when it is moving closer to some?

MR. CUIRUVOLU: The only two places that you have a bulk of the free flow coming is at the treadwells, or in the hatches.

MR. LI: Okay. I agree with you that most of the water comes from this here. But, the distributed water from all the way.

MR. CUIRUVOLU: Yes.

MR. LI: So, when you lump those distributed water from near by the sum, too, far away the sum, do

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you lump it? I just wonder whether that is being conservative or not.

MR. CUIRUVOLU: It is. Because, if I bring that flow down below the 270 degrees, then essentially, I will have to split the flow backwards. I will go through these compartments and with this flow, and I would have a zone of zero velocity compared to some velocity at this point.

MR. LI: No. This way. It would go this way.

MR. CUIRUVOLU: Yeah. But there is a parallel path through here. See, if you have all the flow coming down here, you have a parallel path backwards.

MR. LI: Okay. If that is the way I am talking about, you see, it is toward this direction. The distributed water from this side, and you lump it to the far away, whether you have been nonconservatively calculating your total velocity for that.

MR. CUIRUVOLU: No. I would not. In reality, the flow is accumulating uniformly along the pathway. Now, I am assuming all of it is starting at one point, which means I have much more quantity of water.

MR. LI: No. You have the same quantity of water, gallons per minute.

MR. CUIRUVOLU: No. At this point, I have much more quantity of water. At this point, at this

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location...

MR. LI: This location is the same. It is higher. But, we are looking at a flow field nearby the sump. That is where the most critical parameters arrive.

MR. CUIRUVOLU: No, the most critical for this analysis is transportability of paint from one location to another location. When I come to near sump, I don't take advantage of transport. I assume all the paint in the sump zone is available to plug the screen. So, I took care of that near sump fact by assuming that all the paint in that sump zone is available to plug it. I am making a very conservative assumption, but also assumption that it is all transmittable. So, my worst case would be, if I can transport all this paint from here, down to the sumps, then I would have more paint coming to the sumps, on top of what we issued in the immediate sumps. I would like to take all the paint from here to the sumps. I would like to get it there. So, I would like to put all flow here, and then get it there. I could not prove that the paint would not...

MR. BURWELL: Do you understand the answer, because I am not sure that I do?

MR. CUIRUVOLU: Okay. We did two things.

MR. BURWELL: Let me try, okay. You assumed

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the spray on the walls brought all the paint off the containment walls into level 808. Now, in the real world, the spray washes the paint down from the walls around the circumference of the walls. Now, do you have a sum as a conservative method of analysis that all of the paint comes down, not from directly above, what that paint on the walls is deposited in all of the spray water which is at approximately 45 degrees vertical. Now, that is really going to be a mess. All of steam generators at two compartments. Do I misunderstand what you are saying?

MR. CUIRUVOLU: What we did is, we are talking about spray water flows. That, we want to establish that the location that we picked is the most conservative for transporting the paint. As far as the quantity of paint within the containment at the 808 level comes, we assume it comes from each sector down along the liner wall, down in each sector.

MR. BURWELL: Okay. You answered the question, yes.

(End of tape.)

CHAIRMAN BURNELL: This figure is not about --.

MR. LI: Okay, now, velocity is -- well, by your calculator, your velocity field, you divide -- RH harm flow from spray flow, different forms and different location. How did you find superimposed velocity? You calculated velocity separate A and B -- from RHR flow, you have velocity cau:ed by the spray flow and you superimpose them -- velocity as the parameter to determine whether paint is transportable or not. How do you impose that velocity?

MR. CHIRUVOLU: The way we did it is we -- the quantity of water coming from this place, from Figure 543, from the source that we mentioned, and then -- compartment 1 -- well, let me go back a bit.

For the outer chill flow we did a similar flow spray based on the resistances in the pathways from the break location to the sump zones. So we split the outer chill flow proportional to the resistance -- and we have a flow --, and those numbers are given in these tabulations wher we give the outer chill flow.

CHAIRMAN BURNELL: Well, what's the -- table are you referring to?

MR. CHIRUVOLU: Orator chill flow 54, May 9 is the flow split. Channel 5 is the one steam generator compartment, channel 6 will be the second steam generator compartment. So we find that 5.1 -- per second goes through Channel 5 and 6.27 feet goes through Channel 6.

On top of this we added -- if you look at Table 5411 at Channel 3A and 4A we add the orator flow to the -- flow that was coming out of the liner and the --.

MR. LI: So you just simply erased -- those two?

MR. CHIRUVOLU: Yes. The two flows are -- and then we divide it into the -- into the -- to get the velocity, the same approach.

MR. LI: Yeah, I know the same approach you derived at 2 velocity. My question was are you just simply add these two velocity together to come up to combined velocity.

MR. SERKIZ: Wait a minute. Are you adding velocities or you're adding the mass and then getting the velocity?

MR. CHIRUVOLU: We are adding the flows, mass.

MR. SERKIZ: You're adding the flows and

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then getting velocity. That's the way I read your table 411.

MR. CHIRUVOLU: That's right.

MR. SERKIZ: You're adding the mass and in backing out of velocity?

MR. CHIRUVOLU: Yeah.

MR. LI: This is a minor question. Table 62-24, is -- you need to -- parameters of opennes. Is this in terms of -- or what? What's the unit for this?

MR. CHIRUVOLU: This is feet, length.

MR. LI: Feet.

MR. CHIRUVOLU: It's the opening length.

UNIDENTIFIED SPEAKER: It's the perimeter of the opening then?

MR. CHIRUVOLU: We have an equipment hatch -- hatch opening which does not have a curve. That's the length of the --

MR. LI: Okay, another -- in your -- one of the assumptions you use in Section 7 for calculating the debris, insulation debris generation, you discuss losing kind of a lip before break assumption, say, with no large break --.

MR. CHIRUVOLU: We -- after I think we received the comments, we prepared an amendment to modify that statement. It is a just a statement we made, does not affect the conclusions of the approach to the analysis.

CHAIRMAN BURNELL: Does not impact the results of the analysis --

MR. LI: Okay.

CHAIRMAN BURNELL: -- of the report.

MR. LI: So in other words, you --

CHAIRMAN BURNELL: You're saying you ignored that when you made your analysis?

MR. LI: Okay, if you don't assume that lip before break, even if you've got more debris generated but it's not transportable to the sump anyway.

MR. SCHMIDT: Let me ask you a question, Chang.

MR. LI: Yeah?

MR. SCHMIDT: Do you feel that we need to remove or modify that statement as it is currently stated in the report?

MR. LI: I think we're going to have problems with that, the lip for break, for this purpose.

MR. SCHMIDT: Yes, okay. Well, we have an addendum and an irata (phonetic) sheet that we are prepared to submit -- that we can submit at the same

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as this additional study results. Would that be --

CHAIRMAN BURNELL: That would be a very appropriate place.

MR. SCHMIDT: So we have -- we have several -- well, not several but a couple pages of -- changes and I think about two pages of addendum, and none of them are significant. But it includes the correction to this statement or modification to the statement we made.

MR. SERKIZ: I would suggest that, you know, you complete this analysis that we're talking about to verify the velocity and then determine how you modified that statement because in the context it is right now it does not affect the conclusion because the conclusion is based on the nominal velocities.

I don't know what the modification, for lack of a better term, might be if your conclusion after looking at the velocities more closely, what position you might want to take.

But I do support what you're saying, and that is, you know, internally, although we're using this leak before break concept for piping supports and this type of application, we recognize, you know, that it's been submitted for that purpose.

The utilization of the same would then

lead you to another, I guess what, an exemption to a GDC for another purpose.

MR. SCHMIDT: No, we don't want to do that in this context.

MR. SERKIZ: Okay. I'm just making that point to give you some feedback.

MR. LI: Yeah, especially you don't mean that.

MR. SERKIZ: That's correct. We do not mean --.

CHAIRMAN BURNELL: Well, I think the record of the staff evaluation on the matters not completed and, therefore --

MR. SCHMIDT: Well, with the exception of the -- you know, the generic letter that was issued earlier this year or last fall -- it was earlier this year -- applying to operate plants, there is -- NRC has also made a decision to operate plants --.

Well, that's irrelevant, unrelated to this so we will modify that statement.

CHAIRMAN BURNELL: Fine.

MR. SCHMIDT: Thank you.

MR. LI: Okay, that's all I have.

CHAIRMAN BURNELL: Okay, are we ready to go into the Westinghouse stuff?

UNIDENTIFIED SPEAKER: I guess so.

CHAIRMAN BURNELL: With that, shall I start? In an earlier phone conversation with Mr. Schmidt I believe I raised two questions, one related to whether or not the assumption of flaking and peeling of a containment wall paint, and assuming that it was in small particles and was able to pass the sump screen, what was the long-term -- the impact on long-term capability of the ECCS to remove decay heat?

And secondly to that or related to that was a question concerning whether the paint in the ECCS cooling fluid could collect at some point and form some type of blockage.

I understand that -- well, I have before me a letter dated July the 26th, 1984, signed by Homer H. C. Schmidt. This is logged TXX 4239, which I have not seen before, but the two addresses are those two in question.

MR. BENGEL: What that response is to is some questions that were relayed to Westinghouse in mid-July, and they were very similar to the questions that were posed during our July 25th telephone conference in which all the interested parties were involved.

The way it's broken down is is Questions 2, 3, 6 and 7 to that attachment to Westinghouse letter, WPT 74-35, answer the first question asked in the July 25th telephone conference, and that dealt with what happens if paint chips get into the cooling system.

MR. KATZ: So that letter really is more comprehensive than just the questions that came up on the 25th?

MR. BENGEL: Right.

MR. KATZ: But they're encompassed by that letter as well?

CHAIRMAN BURNELL: Let me ask you a basic question. Is Westinghouse in agreement with the -- with the conclusion that the paint which would pass through the screen would not represent a loss of decay heat removal?

MR. KATZ: The answer to that is yes, except that at the moment we've got, I think, to reiterate the assumptions that went in -- that go into that. There were some assumptions made that are outlined in the letter.

CHAIRMAN BURNELL: Not having read the letter, would it be helpful to us if perhaps you just summarized?

MR. KATZ: Yes. As a matter of fact, why don't you do that, Tom? Summarize the assumptions --

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all the assumptions -- that were made. There are two sets of them, as I recall.

MR. BENGEL: Right. What we said was in review of Nureg CR 2792 which actually discusses, say, acceptable levels of particles that are, say, permissible within the RHR pump, we came up with, say, a debris level which is identified as acceptable within the system. In the RHR pump system it would not lead to any degradation of the pump.

And what it amounted to was debris 1% by volume, .1% abrasive by volume and the ECCS fluid is acceptable for RHR and containment spray pumps and therefore we conducted no detailed evaluation of the pump based on this Nureg. In conjunction with that --

CHAIRMAN BURNELL: What basis do you make your statement about the --

MR. BENGEL: We evaluated the -- this Nureg document and what it did was it -- it was an evaluation that was done in conjunction with various pump suppliers, and they made an assessment of potential degradation to pumps based on available information that each of the various suppliers had.

And based on that, that evaluation, they came up with a table contained within the Nureg which identified acceptable levels of, say, particulate matter that could be suspended within the coolant system without damaging or degrading the pump, specifically RHR and containment spray pumps.

MR. KATZ: What's the next one?

MR. BENGEL: Based on -- based on our assumption that the levels of concentration were acceptable to the -- to the pump, we re-evaluated based on the following: The concentration of insulation and paint debris ingested into the ECCS fluid is less than or equal to 1% by volume of debris or .1% abrasive.

We assumed the homogeneous mixing of paint fines in the coolant and as part of our -- our selling out analysis, we used -- we came up with the debris density of 96 pounds per cubic foot, and it's -- this is tied to paint with a specific gravity of 1.6, which is rather conservative.

We also assumed that the thermo-dynamic properties of water were evaluated at 200 degrees Fahrenheit and 60 psia, and we made another assumption that the debris geometry is approximately circled, which is reasonably approximates a debris shape and it's conservative for our analysis.

These -- these replies address Questions 2, 3, 6 and 7, actually address the -- the first question from the July 25th telephone conference, and that is what happens if the paint chips get into the coolant system?

What effect would they have on, say, heat removal capability and potential blockage?

MR. KATZ: I think what we'd be prepared to do, Spot, if it would be helpful would be to kind of highlight and summarize the answers, even though you haven't had a chance to look at them, for your use and further study of those.

And why don't we just do that? We can point to the right guy to do that summary, and why don't you give out those assignments and let the guys do it?

MR. BENGEL: Okay. In addition to -- two questions were asked. In the middle of July some questions came in that were kind of outside the area of these two. We included the reply to those also. So those would be in Questions 1, 4 and 5 in the attachment to that letter.

Tim, why don't you -- why don't you address the first question?

MR. ANDREYCHER: Okay. Well, he took care of Question 1 pretty well, which is the basic assumption of -- the premise on which we can operate

RHR pumps over the one-year cooling time frame. Question 2 is will paint fines settle out anywhere else in the ECCS, and it's possible that the heat may settle out.

Particular locations would be where there were very low vertical flows anywhere in ECCS system and potentially in horizontal runs of pipe where there are very, very long runs of horizontal pipe because you onl, have -- being dragged down by gravitational forces wanting the paints to settle out.

However, as the paint fines settle out, if they were to settle out there, the flow area in pipe would be reduced. You would have a higher velocity in the pipe.

You would, therefore, have a higher viscous drag and you would tend to pull those paint fines along. I don't think that's a problem with blocking the core -- I'm sorry, blocking the piping.

Do you accept that? I see -- you know, you're sort of --

CHAIRMAN BURNELL: I'm listening. On the surface your statement sounds like --

MR. ANDREYCHER: Thank you. The impact of paint fines on the core, we don't feel that there's

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a problem with long-term coolability of the core, the reason being is that the maximum paint fines that can get through the screens is an eighth of an inch using a force balance and going through cold leg recirculation first.

For either a hot leg or a cold leg spray, we considered both. The maximum particle size, using the conservatively low density of 96 pounds per cubic feet, is about 38 mils.

It would require at least a 40 mil particle to begin blockage of the core. Okay, this is for cold leg recirculation in particular, one or two RHR pumps running for either hot leg or cold leg.

Now, for cold leg recirc, with only one RHR pump running, you supply a sufficient amount of water to cool the core. Any excess spills out the break.

For a hot leg break all water from the RHR pumps must first pass to the core before it can spill out in the break, therefore the core velocity will be a little higher.

Now, I based all my calculations on core velocity. That's a conservatively large number which tends to give you a maximum viscous drag, and the velocities that we determined settle out would be in the lower plenium.

And it would be lower than --. You don't have the fuel loss absorbing the flow area. So we feel that's a very -- it's a conservatively high velocity to use in estimation of viscous drag. After about 18 hours --

CHAIRMAN BURNELL: May I ask you what the vertical flow velocity up through the core is, average?

MR. ANDREYCHER: About a tenth of a foot a second for cold leg break. For a hot leg break with one RHR pump running it's about 20.5 feet a second. For two RHR pumps running it's about three-tenths of a feet a second. On an average, long-term --. Okay, these are based on -- these numbers are conservatively large numbers for using the Bash code which is our latest and greatest Westinghouse code for evaluating ECCS which predicts conservatively -- better higher flows through the core because of improved modeling techniques.

I felt they were conservative to use here because the higher velocity for the larger the debris particle, it could be supported by that velocity if you chose to go that route.

This is not -- this was not a licensing calculation --

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CHAIRMAN BURNELL: Right.

MR. ANDREYCHER: -- so I chose to use that.

CHAIRMAN BURNELL: I'm trying to understand that by a theoretical hypothesis of a phenomena.

MR. ANDREYCHER: Okay. If we were to do a licensing calculation using the W reflight code and taking the long-term coolability out of the air, the velocities in the core would be much less.

Since the -- basically there's a negative buoyancy rate since the material we're dealing with is more dense than water. It wants to settle to the bottom.

Lower velocities with a smaller viscous drag that would support the particle. Therefore, using the W -- the W reflight code for these -- this kind of evaluation would give us even smaller maximum debris size that could be supported and carry its weight into the core. So I'm using a conservatively large number in the calculation.

Plus, I'm using velocity in the core rather than the lower plenum because it again is higher. During hot -- excuse me, go ahead.

CHAIRMAN BURNELL: One other question just to understand where I'm at. Normally, your recirculation doesn't come in until somewhere between 12 to 20 minutes after the accident.

MR. ANDREYCHER: Thirty minutes.

CHAIRMAN BURNELL: Thirty minutes?

MR. ANDREYCHER: About 30 minutes.

CHAIRMAN BURNELL: All right, can you give me any idea what the fuel rod temperatures might be assuming the ECCS came on -- trying to cool it with that --

MR. ANDREYCHER: Fine.

CHAIRMAN BURNELL: -- which is surface temperature also --

MR. ANDREYCHER: Three plus the TSAT, You've crunched the core.

CHAIRMAN BURNELL: That goes to two-tenths?

MR. ANDREYCHER: TSAT --

CHAIRMAN BURNELL: TSAT, oh, fine, okay.

MR. ANDREYCHER: Pretty close to TSAT, the reason being is that once you've punched the core, it stays punched.

CHAIRMAN BURNELL: Yeah.

MR. ANDREYCHER: And you've got the core flooded at about 20 to 30 minutes and you're going into the recirculation time. Actually, if I remember correctly, most ECCS analyses for -- plants showed that we punched up to a 9 foot elevation in about

300 seconds of initiation of the large break LOCA. And typically, that's a ballpark number.

Within 300 seconds we've punched up to about 9-foot elevation. So here you're looking at 30 minutes, approximately, so you multiply 30 times 60, 180, it's something on the order of -- much, much -- several time periods longer. So we've got the core covered at that point in time. The total core is covered when we go on to recirc.

CHAIRMAN BURNELL: So we're talking about a surface temperature of --

MR. ANDREYCHER: Whatever -- no more than what -- at containment pressure, and typically, after --

MR. PURDY: It's 3280 degrees or so.

CHAIRMAN BURNELL: I was going to say looking at some of the pipe -- piping temperatures in the scenarios that were 240 degrees.

MR. ANDREYCHER: Yes.

CHAIRMAN BURNELL: So you're talking less than 300?

MR. ANDREYCHER: Yes.

UNIDENTIFIED SPEAKER: Definitely less than 300.

MR. ANDREYCHER: And you've got containment pressure plus your 12- or 14-foot head of water, so saturation temperature may be slightly over -- in the core it might be slightly over what you have in the containment, but not by a whole heck of a lot.

CHAIRMAN BURNELL: Thank you. Sorry. Now I'll let you go forth.

MR. ANDREYCHER: It's okay. Okay, now, hot leg recirculation, hot leg recirc, all the water, or if you have a hot leg break, the situation for hot leg recirculation is similar to what you have for cold leg recirculation.

You're going to maintain a level in the reactor vessel. The rest will fall out the break. And so you have relatively very slow velocities through the -- through the core and therefore very slow velocities going through the lower plenum.

Very little, if any, possibility of picking up debris and re-intraining it and recirculating it through. For a cold leg break, when you go into hot leg recirculation, all of the flow from the RHR pumps must flow through the core before it can spill out the break.

And there what we've looked at is how high can the debris bed be in the containment -- I'm sorry, in the lower plenum -- before you re-intrain some of this debris and potentially recycle it through the system.

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And we took no credit for any settling in the sump, nor anywhere else in the system for that matter. And what we see is that we can hold up to about 400 cubic feet of debris in the lower plenum of the reactor vessel before we will come up with any potential for re-intraining.

The reason for that is the maximum velocity in that lower plenum region is right where the flow turns around the keys supporting the lower core support pipe.

That's the highest maximum velocity region in that lower plenum down cumber region. And as long as the velocity there stays below about three-tenths of a foot a second, we're -- we have no difficulty, no problem with intraining any particles of sizes that would present a problem in -- the core particle sizes. It would be below 40 mils, the necessary size to block the core.

Now, based on -- therefore, our -- you know, a couple of our analyses that Gibson Hill has, and their debris settled out in the sump and going into the sump.

We don't feel that we have a problem with potential for cooling the core and their long-term situations.

CHAIRMAN BURNELL: Let me discuss this one just a little bit more. You have down cumber water and it's making a 90-degree turn to go underneath the core and then 90 degrees up again through the core.

That turn, if you lead the down cumber into the plenum, it's going to create some turbulance. With turbulance, then the settling out of all of the intrained paint into the -- into the lower head becomes more uncertain.

That is to say some of the train in coming down -- some of the paint, in coming down the down cumber, I can understand that some of it might go into the plenum, but -- I mean into the bottom head of the vessel -- but I'm having a little trouble rationalizing that water containing paint and coming down the down cumber would be pure water going up through the core.

MR. ANDREYCHER: It's not pure water. I don't argue that. As a matter of fact, if you take a look at figures -- Figure 2 in the letter, you'll see that we -- and Table 1 -- there is a residual amount of debris that always remains in the solution.

There is some debris that will never settle down. We don't make the claim it'll all settle down. There is -- the amount of debris that remains in

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the solution is dependent upon the debris size. Now, Table 2 shows the time history of debris concentration, the -- concentration, as a function of break and a number of RHR functions that are operated.

Table 1 summarizes the velocity in the core, the maximum debris size that would remain in solution at that given velocity, and what I call the residual debris mass that will remain in solution given the particle size distribution is uniform.

That's one of the assumptions I made, was that it was equally likely to get particle size of about .005 inches as it was .125 inches. That's a reasonable assumption under the circumstances.

And with that assumption of uniform particle size distribution, this is the residual debris that will fall -- that will remain in solution, assuming that nothing else falls out anywhere else in the recirculating system, if there's no other fall-out other than in the lower sump.

So no, the water does not become perfectly clean. I don't make that claim. As a matter of fact, any particle less than 11 mils, less than 23 mils, less than 36 mils, tend to stay in the solution.

MR. SCHMIDT: And this Figure 2 illustrates that for the long --

MR. ANDREYCHER: Yes. Unfortunately, it comes pretty close to coming out, so I chose to add this in the table to identify that we're not making the claim that it becomes perfectly clean.

MR. SCHMIDT: It never comes to zero?

UNIDENTIFIED SPEAKER: Now, you mentioned turbulance, and you're right, but what happens is that whatever -- down here, it's still got to go up here somewhere.

And once the water begins to go in a vertical direction, up, regardless of what it's doing down here, that's when the forces operating on any particle are either viscous forces going up in this direction, buoyant forces, which in the case of this debris which is heavier than water, the -- force is a negative point -- pull down, and the only time it would float is if your specific weight is less than that water.

In this case, the specific weight is more than water so it has to drop to the bottom, and gravity.

CHAIRMAN BURNELL: And float.

MR. ANDREYCHER: Well, floater systems is to here going up.

CHAIRMAN BURNELL: You're talking about five against the -- panel?

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MR. ANDREYCHER: Yeah, water should come right in here. So the flow has got to straighten itself out before it can go in, and that's the location that I chose to say -- to evaluate what would come out.

Now, it may be that there's going to be some stuff hanging around, floating around in here, but it's not going into the core. It will come up -- it may start off and -- that this drag will not support me and it will fall back down.

So I don't feel that we have to --.

CHAIRMAN BURNELL: You're saying the entrance to the core is not turbulent?

MR. ANDREYCHER: I'm say -- yeah, that's right, it's not -- well, in order to flow into the -- into this core pipe, it's got to straighten itself out in some way because it can't have it going in this way and bouncing back and forth. It's going to straighten. The core pipe's fairly thick. It's got to straighten itself out to go in there.

The straight line floats tend to do this, and this is a hole in the core. Straight lines tend to do this. It's got to straighten itself out, regardless of what it's doing down here.

CHAIRMAN BURNELL: Do you know that the flow up through the core pipe is lamina?

MR. ANDREYCHER: I don't care if it's lamina for this analysis. We coefficient -- the drag -- that i used is based on LOCA Reynolds Number which uses the hydraulic diameter of the spherical particle.

I don't care if it's laminar or not. I'm basing it on Reynolds Numbers --. Now, the calculations that I've performed to determine particle size as a -- to the fluid velocity on Figure 1, so that covers the Point 1 to Point 3 heat perceptive core velocities that I spoke of earlier. And that describes what's happening, what's going on.

CHAIRMAN BURNELL: You said earlier you assumed a specific gravity of 1.6.

MR. ANDREYCHER: I used the density of 96 pounds per cubic feet, yes.

CHAIRMAN BURNELL: Oh, fine. Okay, all right. Okay. I was making a wrong transfer.

MR. ANDREYCHER: Okay.

CHAIRMAN BURNELL: That's a conservative assumption?

MR. ANDREYCHER: Yes. The more dense the material, the smaller the debris size that would be supported by the fluid material.

CHAIRMAN BURNELL: Sure.

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MR. ANDREYCHER: So I used a very light fluid.

CHAIRMAN BURNELL: I just heard your number in one dimension and --

MR. ANDREYCHER: Yeah, it's okay.

CHAIRMAN BURNELL: -- and I thought about it in another dimension.

UNIDENTIFIED SPEAKER: It's stated on page 12 in --.

MR. ANDREYCHER: I have problems oftentimes dealing with SI units. I refer to system infernal rather than system international. I have a hard time with that myself.

Figure 2 is the time history of debris clean out. Figure 3 -- Figures 3 and 4 are those figures that I used to assess the maximum heighth of debris that we would have -- we could handle in the lower plenum of the core before we run the risk of the potential of re-intraining.

Now, the flow rates that are listed on the right-hand side of Figure 3, the RHR flow pump is 7800 rpm for 2 RHR --.

UNIDENTIFIED SPEAKER: GPM?

MR. ANDREYCHER: 7600 GPM.

MR. SCHMIDT: So it's 3800 GPM for RHR flow.

MR. ANDREYCHER: Right. So if using Figure 1 and Figure 3 together -- let's use Figure 1 and Figure 3 together. Okay, I want to keep from -- let's use Figure 1 first.

I want to keep -- I do not wish to intrain anything that's 40 mils, okay. I use 40 mils over here and I read down. It says that I want to keep the velocity less than .33 feet per second.

And back here I take 3 feet a second and read right across to approximately 78, which is over in this region here, somewhere between 5,000 and 10,000 GPM. The debris rate is 7800 GPM. Then we come up with about 4.75 so I -- to be on the conservative side, I went down to 4.7 feet a second.

Now, how much debris is that in volume? I take 4.7. I'm looking at about 400 cubic feet. So that's just using the data that I have available to pull out that..

I think that -- are there any problems or any questions with any of that material?

CHAIRMAN BURNELL: None at this time. I'll need to study.

MR. ANDREYCHER: Fine. Now, there was also a question on the flow area of the down cumber, which I think related to what kind of velocity or what kind of debris might be supported in those velocities in

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the down cumber. The velocity -- the flow area to the down cumber is 1 over 1.68 times the flow area in the core.

It's a smaller flow area. It's less than 1 over 1.68, so the velocites would be higher in the down cumber by the inverse of that ratio to 1.68. So if I have a fluid velocity of a tenth of a foot a second in the core, the fluid velocity in the down cumber would be 1.68 feet a second.

That's not the maximum velocity I'm concerned with. It's the keys where the core support pipe sits. That's the governing velocity for reintrainment of debris that might happen to be in that lower plenum supporting it back up in there.

The reintrain -- but some of that mass still wouldn't stay in solution. It would just sort of oscillate around in the down cumber because if it tried to fall toward the keys, it would be supported by this velocity, sort of like staying in a state of suspended animation.

It wouldn't be able to come back through the keys, but nor would the velocity in the down cumber support in carrying it back out through the hot legs. I'm sorry, the cold legs.

And what's the basis for using the fluid velocities in less than a tenth of a foot a second was a question that --

CHAIRMAN BURNELL: He's going on to page --

MR. ANDREYCHER: I'm sorry, I'm on page 13. Page 4 -- Question 4 was the down cumber velocity. Right. Question 5 is the basis of using a tenth of a foot a second. As I said, that's based on our best estimate, latest evaluation models that are currently being reviewed by the Licensing Branch, and it gives me a worst-case situation because it maximizes my velocities tending to give me maximum particle sizes that would be transported through the system.

Okay, Item 6 is not mine and I leave the floor.

MR. BENGEL: Okay, Item 6 was part of Question 2 that was asked during our July 25th telephone conference, and it was with regard to degradation with respect to -- out.

And what the two vendors -- or the two paint suppliers -- told us is that the epoxy paints, any chips that would break off from the containment wall or from the steel would remain hard and brittle in the range of 2 to 300 degrees.

They wouldn't tend to attach themselves to the core and we expect no problem at all with -- out.

MR. ANDREYCHER: As we said, the temperature in the core is going to be -- that containment plus a couple of degrees due to the poten -- yeah, that's the maximum temperature that could be in the core, this TSAT containment plus a couple of degrees --

CHAIRMAN BURNELL: Yeah, heat transfer, the forcing function.

MR. ANDREYCHER: That's right.

MR. BENGEL: We did another evaluation. We took a look at this study of our ECCS system, tried to identify which of our components were critical for long-term decay heat removal, and the items that came up were the RHR pump, several valves in the RHR system and also the RHR heat exchanges.

And based on the fall-out or the settle out of the chips within, say, the first 18 to 24 hours, our conclusion was that none of the -- none of these particular components would be degraded by the ingestion of this debris.

Question 7 was which -- will small particles settle out in the inlet plenum of a RHR heat exchanger. And, Scott, why don't you -- why don't you discuss what our findings are there?

MR. HYDE: We've identified that question on the RHR heat exchanger as to would there be potential blockage of the flow path, and the answer to that is that the heat exchanger is a vertical heat exchanger and it has -- on the tube side, which is at the bottom, the flow comes in, then goes up through the tubes and back down into the channel and out the outlet.

And what we would -- what we would conclude is that initially, in the unlikely event that you would get particles in there, large particles could potentially settle out in the bottom of the tube side channel, then, of the RHR heat exchanger.

However, the flow velocity through the tube is about 5 feet per second, and we determined that the size of particles that were being postulated, those particles, if they were maintained at 5 feet per second, would be carried through the -- keep on going out the outlet nozzle.

So the only thing we would expect in the bottom of the heat exchanger is that initially, you might get some settling out of larger particles in the bottom because the flow velocities may be lower down there.

But if we get sufficient particles in there, which is unlikely, to fill up that low velocity region, then all of the additional particles that come in after

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that time would be carried through at the velocity that occurs in the tubes themselves, which is about 5 feet per second, and the build up of particles in the bottom of the heat exchanger should be discontinued at that time.

CHAIRMAN BURNELL: The inner pleum to that heat exchanger is a small fraction of the -- of the reactor vessel, is it not?

MR. ANDREYCHER: That's correct.

CHAIRMAN BURNELL: Okay.

MR. ANDREYCHER: Very similar.

CHAIRMAN BURNELL: Therefore, your velocity is through that plenum. It would do as you say, tend to sweep the big particles out of the pipe. That would not be the point of collection; more likely the point of collection would be in the plenum of the reactor vessel.

MR. ANDREYCHER: You can use Figure 1 and the text -- to see how that might run. We'll show you a half a foot a second velocity. You could support a particle size something on the order of around .075 mils, maybe a little larger than that.

So if velocity is at 5 feet a second, you can support a pretty massive chunk of material.

MR. BENGEL: I think that kind of represents the questions that were actually directed to Westinghouse.

MR. SCHMIDT: As we understand them, based on the telephone conversation. So if there's an area that we either misinterpreted or that we didn't address, we need to know that.

CHAIRMAN BURNELL: May I take just a minute and look at something? In your report you said in your appendix that Westinghouse had a chemical analysis of all the paint -- paint made.

You looked at that from the standpoint of the source of chloride.

UNIDENTIFIED SPEAKER: Right.

CHAIRMAN BURNELL: Were there -- did you also look at that from a standpoint of whether or not there were compounds which might be shall we say altered by radiation as they go through the core to find -- to result in less desirable chemicals in the system?

MR. WHYTE: All of these paints have been tested by Oak Ridge at 3½ time 10 to the 9th rads of exposure, and there was no apparent decomposition of any kind.

CHAIRMAN BURNELL: And they remained stable?

MR. WHYTE: Right. Now, that's the data we have available.

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MR. MANN: Is that the compound, a combination temperature?

MR. WHYTE: That was only on radiation. They then ran further tests with the radiated specimens and the temperature conditions were not superimposed. They were not superimposed.

CHAIRMAN BURNELL: Do you know off hand a reference on that work by the Oak Ridge?

MR. WHYTE: There is some data by Imperial Nuclear that gives a report on what their paints are, what their paint system will do, and there's also data by Carbolane. That gives what their paints have been exposed to.

CHAIRMAN BURNELL: Do those have a number or something that we might obtain copies of that from NSIC?

MR. WHYTE: Well, let's see, there's a -- I got several reports here that include several different things, and maybe the best thing would be the entire listing.

They have an Imperial Technical Report Number 175-1-77. I've got about seven or eight reports here so I'm not sure which one --

CHAIRMAN BURNELL: Perhaps to save time you might just prepare a list of those and get it to me.

MR. WHYTE: Sure. We can do that. It would be much easier because --

CHAIRMAN BURNELL: If you can do that, that would be fine.

MR. WHYTE: No problem.

CHAIRMAN BURNELL: Just a bibliography so that if we need to pursue that further, we can go to the source. Okay, are there any other questions? I think we've covered that, but let me scan through my sheets here just a moment.

Okay, I think that's everything I have, unless, Homer, do you have any other --

MR. SCHMIDT: The only thing I'd like to say is obviously your staff has not had a chance to review this supplemental Westinghouse information and I presume that once they have a chance to review that, if you have any further questions --.

CHAIRMAN BURNELL: Yes. Now, I might close by saying that I understand that you will mail us a -- well, perhaps we should put the copy of the letter into the record just to expedite the review here.

In the meantime, I understand that you will mail this to us and --

MR. SCHMIDT: That's correct.

CHAIRMAN BURNELL: -- and we'll put it in the docket and record. With that, I propose that we put a copy of your letter in the -- have it bound into the record.

If there's nothing else, thank you very much, gentlemen. I think it was a very helpful meeting.

(Whereupon, the meeting concluded at 12:45 p.m.)

CERTIFICATE OF PROCEEDINGS

This is to certify that the attached proceedings before the NRC

In the matter of: Commanche Peak Containment Sump Performance Meeting

Date of Proceeding: July 27, 1984

Place of Proceeding: Bethesda, Maryland

were held as herein appears, and that this is the original transcript for the file of the Commission.

Joe Newman
Official Reporter - Typed

[signature]
Official Reporter - Signature

EQUATION DERIVED BY CHANG LI (NRC)

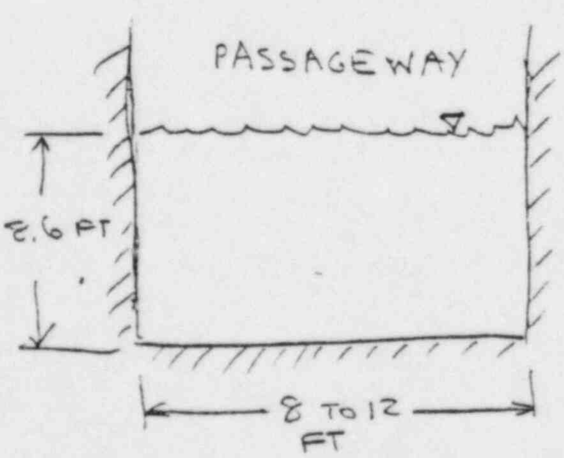
$$\Delta p = \frac{K}{2 g_c \rho} \frac{m^2}{A^2}$$

$$= \frac{\rho K}{2 g_c} (V)^2$$

$$K = \text{hydraulic resistance} = \frac{fL}{D_H}$$

$$\frac{fL}{D_H} = \frac{f L P_w}{4A}$$

DISCUSSION ON HYDRAULIC DIAMETER VS AREA.



$$\frac{29.2}{25.2} \cong 1.17$$

(1)

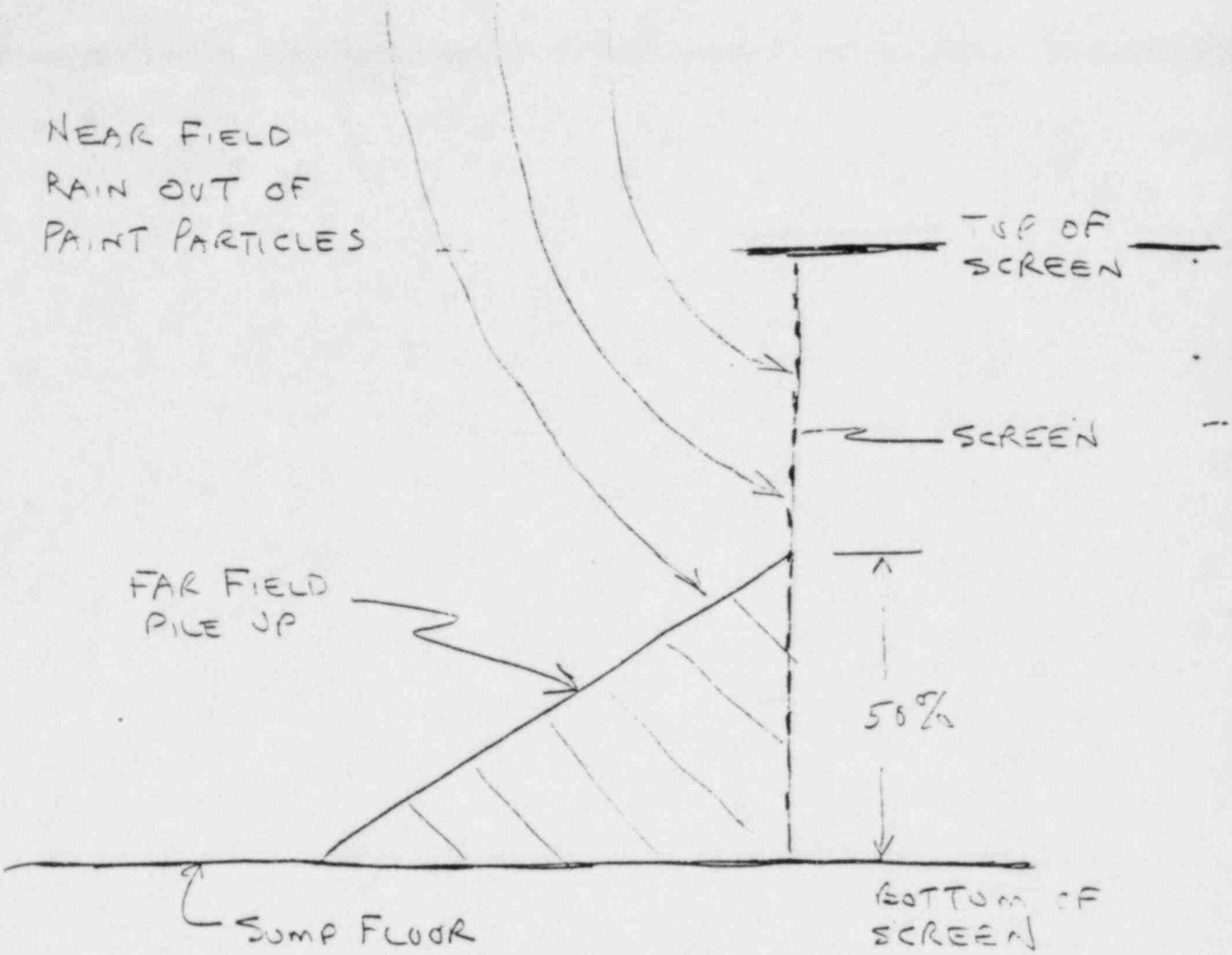
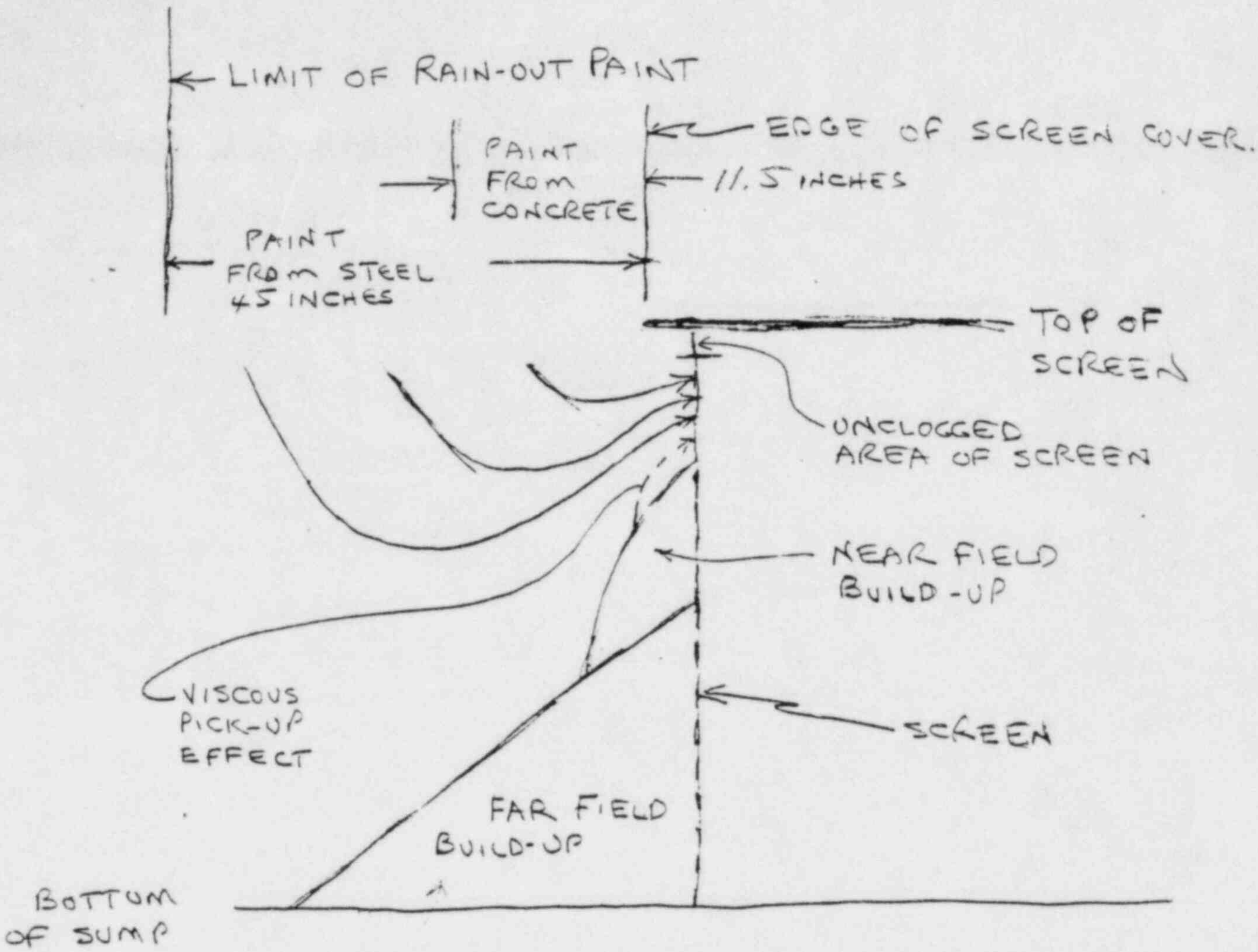


FIGURE 1

DISCUSSION BETWEEN SERKIZ AND IOTTI
ON SCREEN BLOCKAGE



FINITE DIFFERENCE ANALYSIS SHOWS THIS BUILD UP (FROM FLOOR TRANSPORT) WOULD NOT OCCUR.

FIGURE 2

DISCUSSION BETWEEN SERKIZ AND IOTTI ON SCREEN BLOCKAGE

Log #TXX-4239
File #10010
#906.2

TEXAS UTILITIES GENERATING COMPANY

SKYWAY TOWER • 400 NORTH OLIVE STREET, L.B. 81 • DALLAS, TEXAS 75201

July 26, 1984

Director, Nuclear Reactor Regulation
Attention:
Mr. B.J. Youngblood
Licensing Branch No. 1
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION
DOCKET NOS. 50-445 and 50-446
CONTAINMENT SUMP PERFORMANCE

REFERENCES:
a. Meeting of June 7, 1984 - NRC & TUGCO (Containment Sump Performance)
b. TUGCO Letter #TXX-4189 dated June 4, 1984 (Schmidt to Youngblood)
c. TUGCO Letter #TXX-4210 dated June 29, 1984 (Schmidt to Youngblood)

Dear Mr. Youngblood:

Attached for your review is additional information from Westinghouse in response to verbal requests from your staff regarding certain aspects of our consolidated report (ref. c). If you have further questions, please advise.

Sincerely,

HCSchmidt

H.C. Schmidt
Manager, Nuclear Services

HCS:sk

WPT-7435

Westinghouse Electric Corporation

Water Reactor Divisions

Nuclear Operations Division

Box 355
Pittsburgh Pennsylvania 15230

July 24, 1984

Mr. J. T. Merritt, Jr.
Assistant Project General Manager
Texas Utilities Services, Inc.
P.O. Box 1002
Glen Rose, Texas 76043

RECEIVED
JUL 25 1984
H. C. SCHMIDT

TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK STEAM ELECTRIC STATION
Containment Paint Evaluation -
Reply to NRC Questions

Dear Mr. Merritt:

Westinghouse was requested to evaluate the CPSES Emergency Core Cooling System to determine if the system function/components would be degraded by the Ingestion of Containment Paint Fines following a Large Break Loss of Coolant Accident (LOCA). Westinghouse completed this evaluation and provided a report to Gibbs & Hill which was subsequently used as an appendix to Gibbs & Hill Report "Debris Effects On Containment Emergency Sump Performance". This report was submitted to the NRC on June 29, 1984. The attachment to this letter provides a reply to several NRC Questions dealing with the Westinghouse Evaluation Results. The results of Westinghouse's evaluation indicate a negligible effect on the ECCS and its ability to maintain long term core cooling even in the conservative scenarios studied.

Very truly yours,

WESTINGHOUSE ELECTRIC CORPORATION

T. R. Puryear, Manager
WRD Comanche Peak Projects

T.Bengel/jjs/9377D:1
Attachment

cc:	J. T. Merritt (TUS)	1L, 1A
	H. C. Schmidt (TUS)	2L, 2A
	R. E. Ballard	1L, 1A
	ARMS (TUS)	1L, 1A
	J. B. George (TUS)	1L, 1A
	R. Tolson (TUGCO)	1L, 1A
	J. Marshall (TUGCO)	1L, 1A
	M. H. Phillips	1L, 1A
	M. Vivirito (Gibbs & Hill)	1L, 1A

Attachment to WPT-7435

CONTAINMENT PAINT EVALUATION - REPLY TO NRC QUESTIONS

Appendix 1 to Gibbs & Hills Report, "Evaluation of Paint and insulation Debris Effects on Containment Emergency Sump Performance" provided Westinghouse's assessment of the potential degradation of the CPSES Emergency Core Cooling System (ECCS) based on the ingestion of paint and insulation debris into the ECCS following a postulated large break LOCA. The potential degradation effects of the Emergency Core Cooling System components due to the ingestion of paint and insulation debris were evaluated based on the following assumptions:

1) NUREG/CR-2792 is applicable. Based on this paint debris 1% by volume (0.1% abrasive by volume) in the ECCS fluid is acceptable for RHR and containment spray pumps and no detailed evaluation is required.

2) The concentration of insulation and paint debris ingested into the ECCS is ≤1% by volume (≤0.1% abrasive).

3) Homogeneous mixing of paint fines in the ECCS coolant.

The questions and reply to the NRC questions are as follows:

1) What is the basis for concluding that paint fines will settle out in the Reactor Vessel?

Reply:

The basis for concluding that paint fines will settle out of solution in the Reactor Vessel lower plenum is based on a balance of hydrodynamic, hydrostatic, and gravitational forces. The significant parameters of the force balance are fluid velocity, cross-sectional area of the fine, and the difference in specific weight between the paint fines and the liquid. Known as Stokes law, this force balance is commonly used in sediment analysis to estimate the size of solid particles, References 1 and 2. The results of these analyses are discussed below.

2) Will paint fines settle out anywhere else in the ECCS?

Reply:

In general, two types of regions within the ECCS recirculation flow path may make it possible for paint fines to settle out of solution; regions in which the fluid flows vertically at low velocity (such as in the Reactor Vessel Lower plenum), and long horizontal runs of piping in which fluid velocities are low. For vertical flows, Stokes law may be applied to estimate the maximum size of paint fines that can be carried by the vertical flow.

In the case of low flow in long horizontal runs, the fluid velocity in the vertical direction may be taken conservatively to be zero. Under these conditions, the hydrodynamic force component of Stokes law results only from the motion of the paint fines settling out of solution, and all particles will tend to settle towards the bottom of the horizontal run of pipe. Thus, the tendency of all paint fines will be to migrate toward the bottom of the horizontal piping run. The viscous action of the flowing liquid, however, will be to drag the paint fines along with the flow. Thus, it is anticipated that, in smaller diameter horizontal piping runs where the velocity of the recirculating fluid is large, paint fines will most likely be swept along with the flow. It should be noted that if paint fines do settle out, the flow area of the piping is decreased, which in turn increases the viscous drag of the fluid on the paint fines to be dragged with the flow. In any case, the small reduction in flow area for the relatively large RHR piping would have a negligible effect on flow. A Study of the ECCS identified portions of the ECCS in which paint fines could accumulate. A potential area for the accumulation of fines would be in the small valves and small bore orifices in the high head SI piping. However, the high head system is not required for post-accident recirculation. The core flooding and long term decay heat removal functions are expected to be largely unaffected.

3) What is the impact of paint fines on the core?

Reply:

Westinghouse evaluated the CPSES RCS and ECCS system configuration to assess the system's ability to filter or settle out paint debris during ECCS recirculation. The results of this evaluation address both hot leg and cold leg recirculation modes.

COLD LEG RECIRCULATION

An assessment of the separation of paint debris out of solution in the reactor vessel (RV) lower plenum during cold leg recirculation following either a cold leg or a hot leg break was made based on the following assumptions:

- o Debris density is 96 lb/ft^3. (Paint with a specific gravity of 1.6)
- o Thermodynamic properties of water are evaluated at 200°F and 60 psia.
- o Debris geometry is approximately spherical (reasonably approximates debris shape and is conservative for this analysis.)

Using the preceding assumptions and performing a force balance that accounts for drag, gravity, and hydrostatic forces, a relationship identifying the maximum debris particle size that can be carried by a vertically flowing fluid with a given velocity was developed. A plot of that relationship is given in Figure 1.

The vertical velocity of the recirculating fluid in the lower plenum prior to its passing through the core support plate will determine the maximum debris size that can be carried into the core. A typical fluid velocity in the core during cold leg recirculation following a cold leg break is 0.1 ft/sec. Using the core velocity to evaluate a conservatively large debris particle size, the data of Figure 1 indicates that the maximum size of debris passing through the core will be about 0.011 inches in diameter.

The fluid velocity in the core during cold leg recirculation following a cold leg break is independent of the number of RHR trains operating. The core receives adequate flow to remain cool from the operation of just one RHR pump; any excess flow spills out the break. The fluid velocity in the core during cold leg recirculation following a hot leg break, however, is dependent upon the number of RHR pumps operating; all flow supplied by the RHR pump(s) must flow through the core before spilling out the break and returning to the reactor sump. Based on data from the cold leg break, the fluid velocities in the core during cold leg recirculation for one and two RHR pumps operating following a hot leg break are summarized in Table 1. Using these fluid velocities and the data of Figure 1, debris particle sizes that could be carried into the core during the operation of one and two RHR pumps was also evaluated. These evaluation results are also listed in Table 1.

From the data of Table 1, the largest debris size that could enter the core during cold leg recirculation is predicted to be 0.036 inches. Typically, particle sizes as large as 0.040 inches will be able to pass through the core without causing flow blockage. Also, the debris sizes given in Table 1 are conservatively large, having been evaluated using the fluid velocity in the core rather than the vertical fluid velocity in the lower plenum. Thus, for cold leg recirculation following either a hot leg or cold leg break, it is concluded that the formation of flow blockage in the core by paint debris is not a concern.

An assessment was also made of the rate at which the mass concentration of paint debris in solution would change due to settling out in the RV lower plenum. Significant assumptions of the evaluation are:

- o Debris size is uniformly distributed over the range 0.001 inch to 0.125 inches
- o No credit is taken for settling out of debris in the containment building. (This is an extremely conservative assumption.)
- o Once in solution, the size of debris particles remains constant.

The rate at which debris mass concentration is decreased, or the debris removal efficiency, was found to be dependent on the mass flow through the core. A cold leg break, having the smallest core flow during cold leg recirculation of the three cases studied, requires the longest time to clean the recirculating flow by means of debris settling out in the RV lower plenum. A hot leg break with 2 RHR pumps running, having the largest core flow during cold leg recirculation, requires the shortest time to clean the recirculating flow by means of debris settle out. Time histories of the debris mass concentration for each of the three cases considered are given in Figure 2.

In studying the debris removal efficiency of the RV lower plenum, it was noted that some amount of debris always remains in solution. Two parameters determine the amount of debris remaining in solution; the vertical fluid velocity (which determines the maximum particle size that can be carried by the fluid) and the distribution of particle sizes. The mass of paint debris remaining in solution, expressed as a percentage of the total debris mass that is initially in the system, is given for each of the three cases considered in the debris removal efficiency study in Table 1. The data of Figure 2 show that for the three cases considered, no more than 1.0 percent of the initial debris mass remains in solution.

HOT LEG RECIRCULATION

At about 18 hours after the hypothetical LOCA occurs, emergency procedures require that the ECCS be realigned so as to prevent boron precipitation in the reactor vessel; delivery of RHR flow is changed from the cold legs to the hot legs. Now, debris in the RHR flow is delivered to the core without passing through a separation volume such as the RV lower plenum, and the delivery of a large debris particles to the hot leg could result in the formation of flow blockages in the core. From Figure 2, however, it is noted that after 18 hours of cold leg recirculation there is less than 1% of the initial debris mass remaining in solution. This amount of debris is small, and is not considered to result in flow blockage of the core that is of any consequence.

For hot leg recirculation following a cold leg break, it is possible that debris deposited in the RV lower plenum during cold leg recirculation may be reentrained in solution since all RHR flow must pass through the core and lower plenum prior to spilling out the break. Fluid velocities in the RV/core barrel annulus under these conditions are estimated to be about 0.25 ft/sec for one RHR pump operating and about 0.50 ft/sec for two RHR pumps operating. From Figure 1, the maximum debris size that can be reentrained by the hot leg recirculation flow is found to be 0.028 inches and 0.075 inches for the operation of one and two RHR pumps, respectively.

Thus for two RHR pumps operating, the fluid velocity in the RV/core barrel annulus is sufficient to reentrain debris that may cause core blockage if it is reintroduced to the RV. From Figure 1, it is concluded that if the fluid velocity in the lower plenum is less than 0.33 ft/sec, only debris that is less than 0.040 inches in size may be entrained. Typically, the fluid velocity in the lower plenum is a maximum where the fluid turns to flow up the downcomer. Figure 3 shows the relationship between vessel flow rate, debris bed height, and fluid velocity as it turns into the downcomer from the lower plenum. From Figure 3, the velocity of the turning fluid is predicted to be below 0.30 ft/sec for debris beds less than 4.7 feet in height. From Figure 4, which is a plot of vessel volume versus vessel height, the debris bed volume corresponding to a height of 4.7 feet is about 400 cubic feet. Thus, it is concluded that the formation of a debris bed in the RV lower plenum during cold leg recirculation whose volume is less than 400 cubic feet is not likely to promote reentrainment of large size debris that could result in the development of core blockage when the ECCS is realigned to hot leg recirculation.

SUMMARY

It has been shown that debris which could cause flow blockage in the core will settle out in the RV lower plenum during cold leg recirculation rather than flow into the core. Furthermore, it was shown that virtually all separable debris will be removed from solution within 18 hours after initiation of cold leg recirculation. It has also been shown that realignment of the ECCS to hot leg recirculation is not likely to result in debris forming flow blockage in the core.

TABLE 1

COMMANCHE PEAK
PAINT DEBRIS SETTLE-OUT STUDY SUMMARY
COLD LEG RECIRCULATION

Event/Conditions	Core Velocity (ft/sec)	Max. Dia. of Debris in Solution (inches)	Residual Debris Mass* (Per Cent of Total Initial Debris Mass)
Cold Leg Break 1 or 2 RHR Pumps Operating	0.10	0.011	0.007%
Hot Leg Break 1 RHR Pump Operating	0.15	0.023	0.03%
Hot Leg Break 2 RHR Pumps Operating	0.30	0.036	0.72%

* Mass not separable from solution; attained within first 18hrs of cold leg recirculation.

FIGURE 1

MAXIMUM DEBRIS SIZE TO ENTER CORE
VS
LOWER PLENUM FLUID VELOCITY

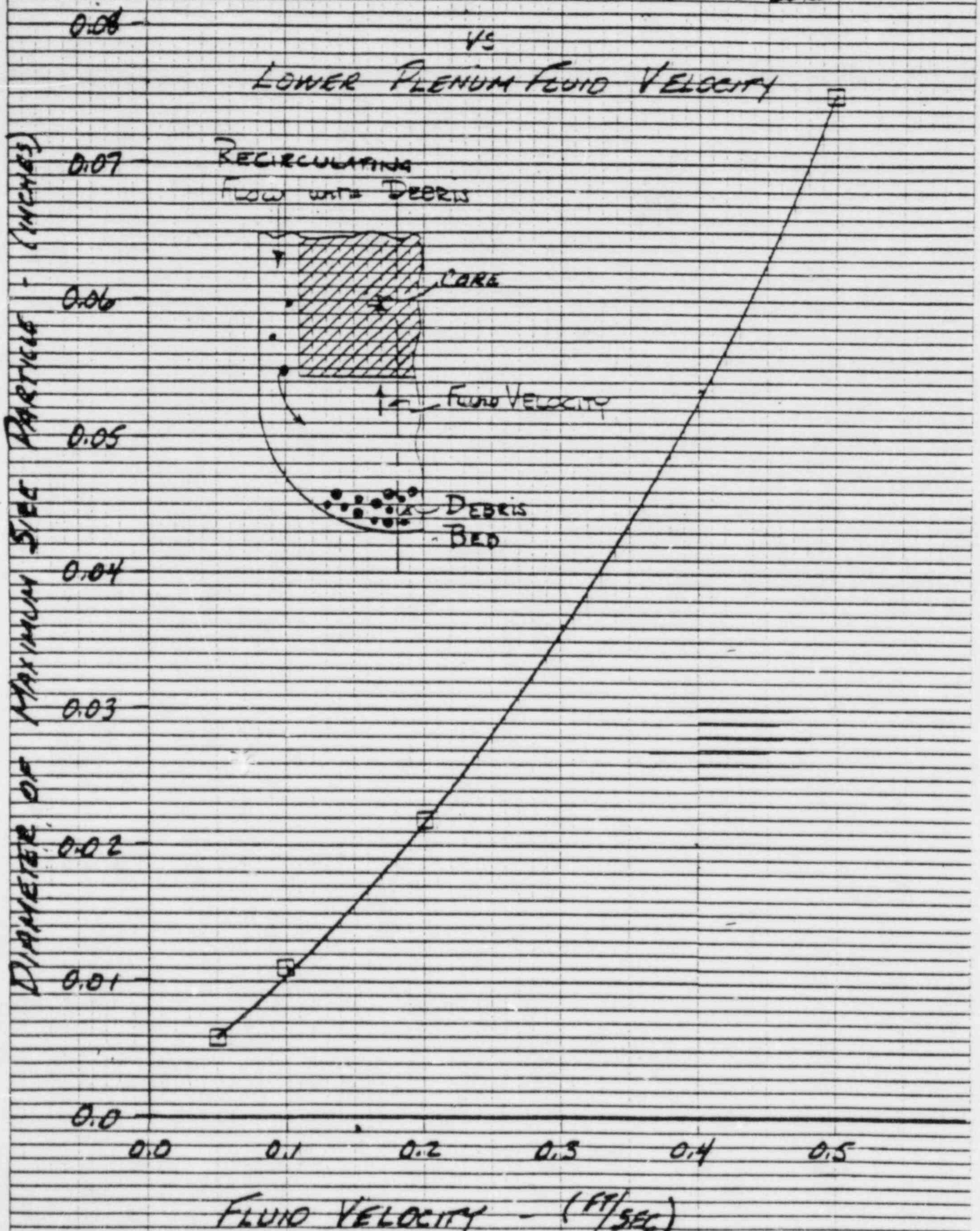


FIGURE 2

TIME HISTORY
OF
PAINT DEBRIS MASS CONCENTRATION
IN
REACTOR VESSEL SUMP

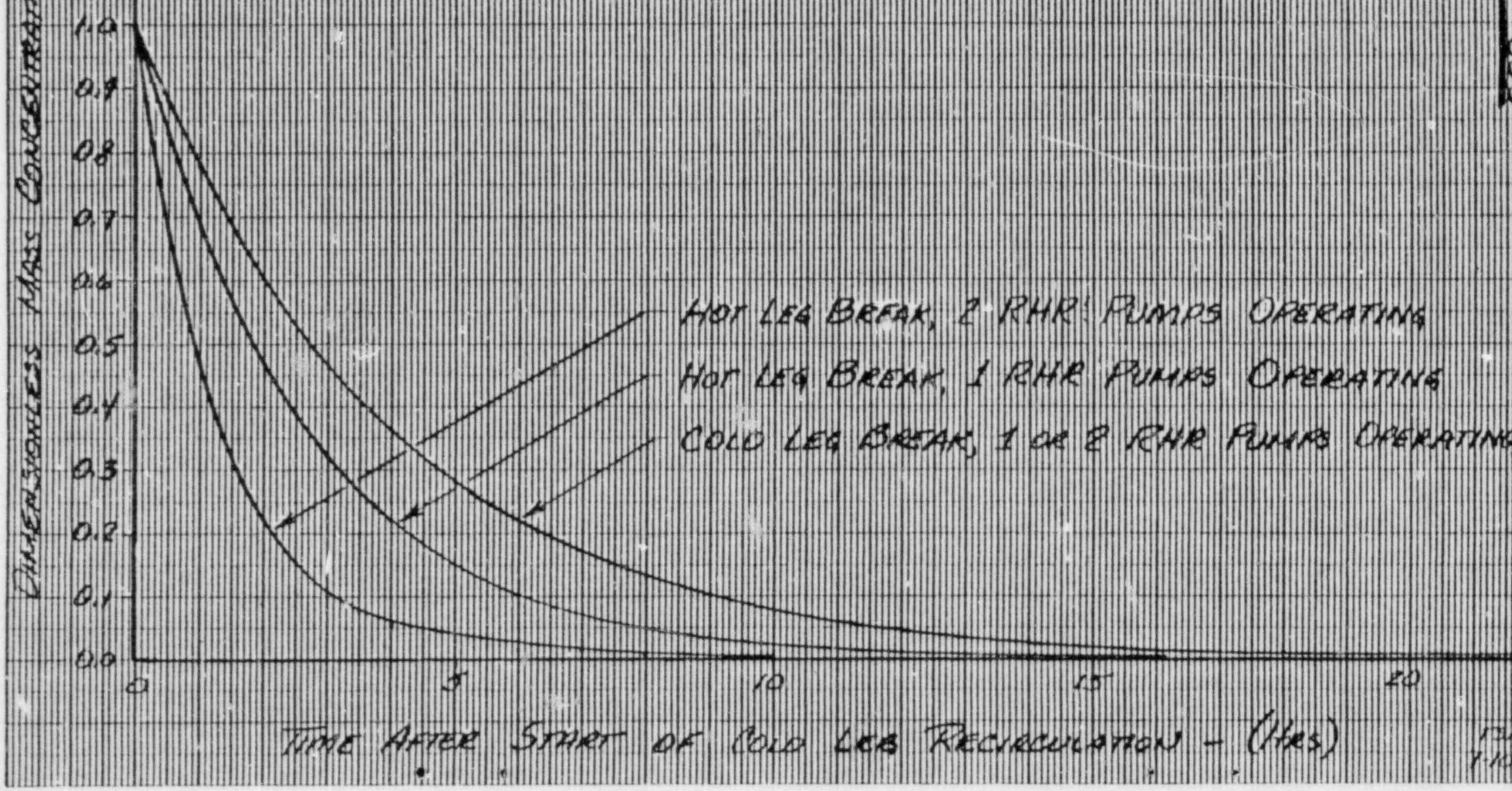


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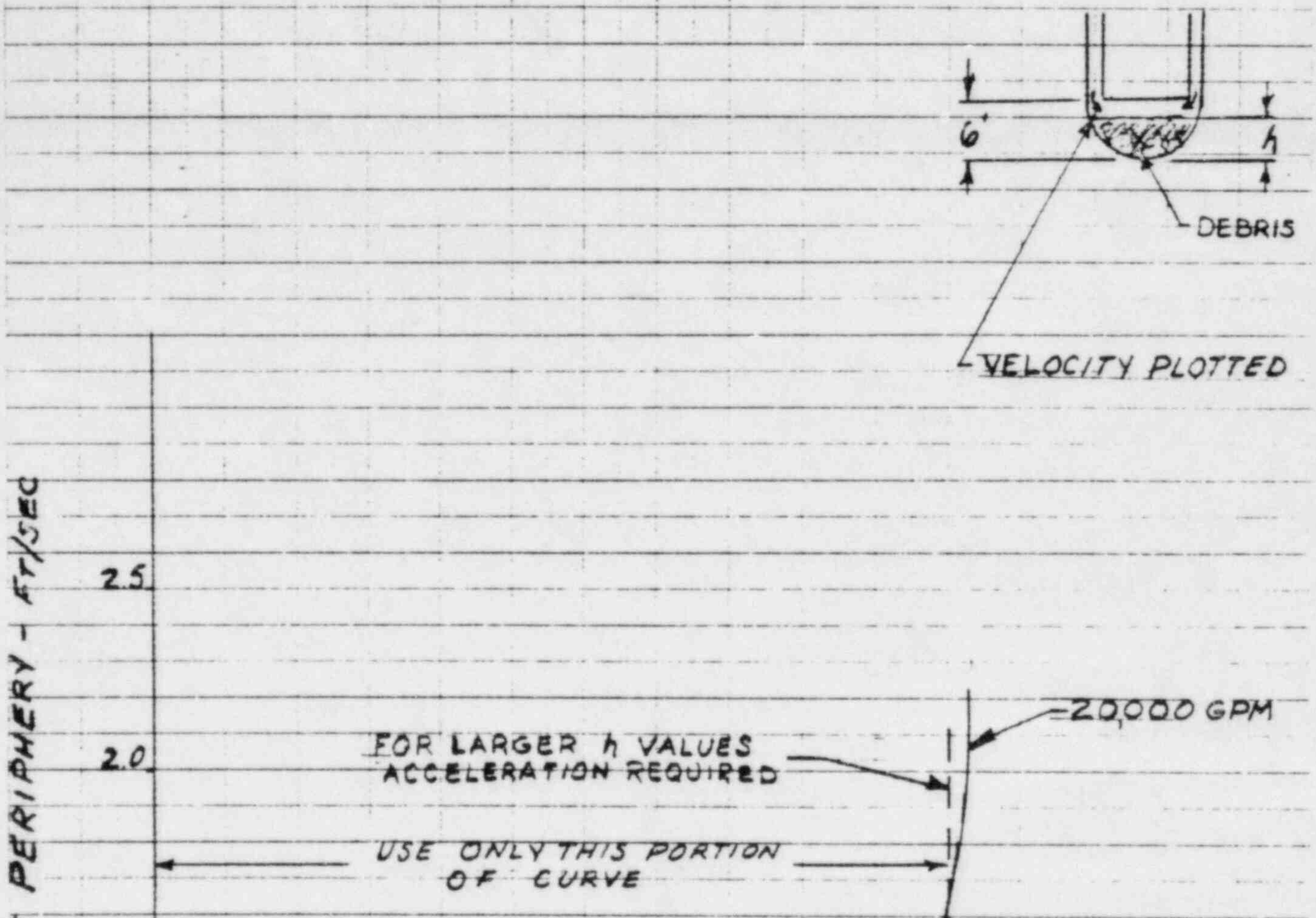
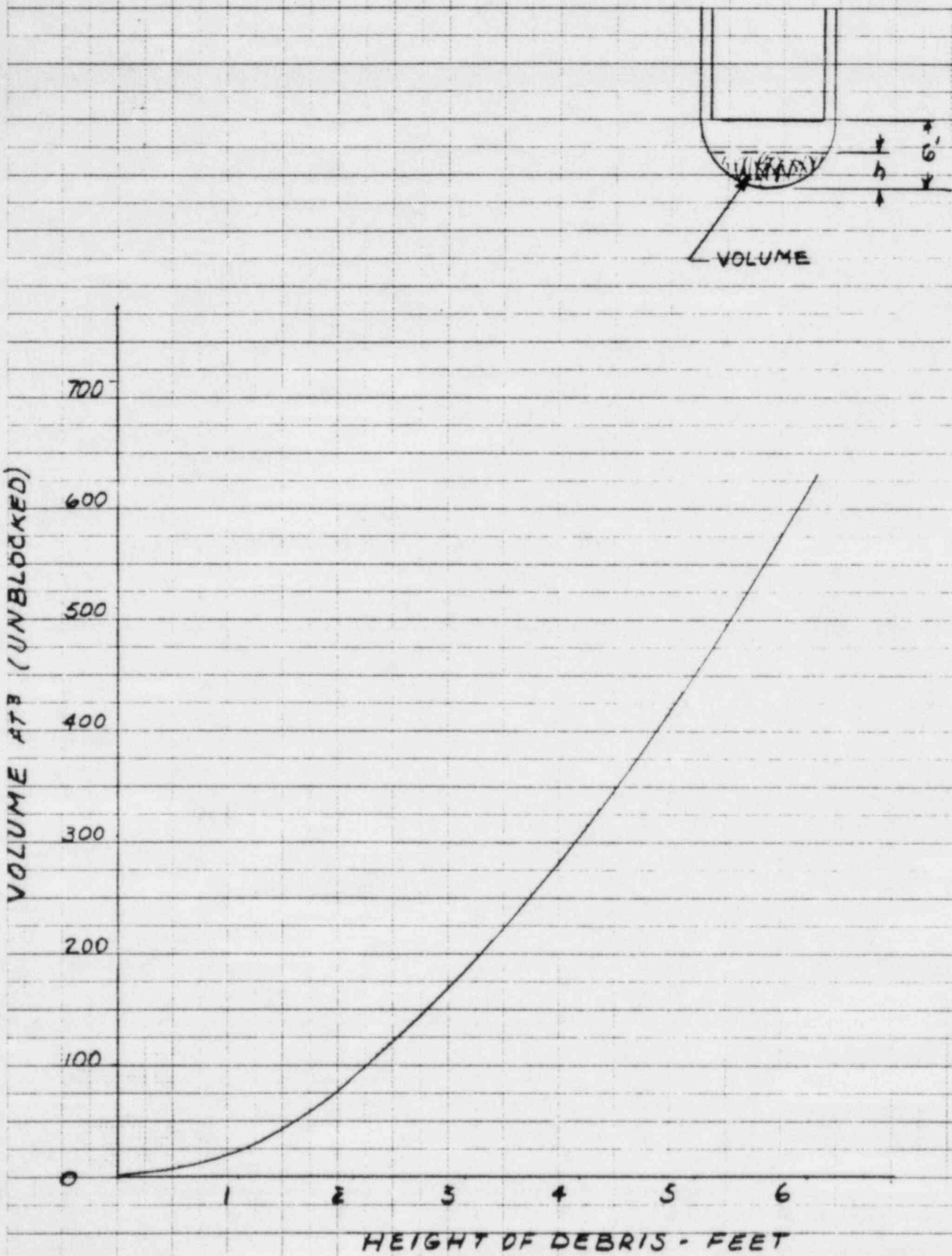
FIGURE 3



6'
h
DEBRIS
VELOCITY PLOTTED
FLOW VELOCITY AT PERIPHERY - FT/SEC
2.5
2.0
1.5
1.0
.5
0
1
2
3
4
5
6
20,000 GPM
10,000 GPM
5,000 GPM
FOR LARGER h VALUES ACCELERATION REQUIRED
USE ONLY THIS PORTION OF CURVE
h - HEIGHT OF DEBRIS ABOVE BOTTOM OF VESSEL (FEET)

FIGURE 4


6'
h
VOLUME
700
600
500
400
300
200
100
0
VOLUME FT³ (UNBLOCKED)
1
2
3
4
5
6
HEIGHT OF DEBRIS - FEET

4) What are downcomer velocities?

Reply:

The flow area near the bottom of the downcomer is about 0.59 times the flow area at the bottom of the fuel. Thus, the velocity in the downcomer is about 1.68 times the velocity in the core.

5) What is the basis of using fluid velocities less than 0.1 ft/sec in the lower plenum for the paint debris settle-out calculations in the reactor vessel?

Reply:

Fluid velocities less than 0.1 ft/sec in the lower plenum are based on core velocities of 0.1 ft/sec that are predicted to occur during cold leg recirculation following a hypothetical cold leg large break LOCA.

6) Can the ECCS heat transfer capability degrade as a result of paint chips being ingested into the system?

Reply:

Degradation of the ECCS heat transfer capability could result from chemical plate out of the paints constitutents and/or the erosive effects of the abrasives present in the paint fines.

The epoxy (two part mix) containment paint binders are thermosetting type plastics. The epoxy is hard and brittle in the temperature ranges anticipated in the ECCS (≤300°F). Based on vendor supplied information (Reference 3) these epoxy binders do not become sticky. The paint chips that are postulated to be suspended in the ECCS coolant are therefore, not expected to cling or adhere to the surfaces of the heat transfer components and are not expected to affect the heat transfer properties of the ECCS components or core.

Westinghouse's evaluation of the potential erosive effects on the ECCS and its components assumes that paint and insulation debris in concentration levels up to 1% by volume are ingested into the ECCS during coolant recirculation. A Reactor Coolant Makeup study for large break LOCA was carried out to determine the minimum acceptable ECCS flow rate required to mitigate the effects of a large break LOCA and to also identify the ECCS critical components which are essential for long term decay heat removal.

This study disclosed that when the ECCS is switched-over to recirculation (approximately 30 minutes after the initiation of the coolant injection from the RWST) core decay heat will have decreased to a value for which only one RHR train is required to provide (core boil off) makeup from the sump to the RCS. This study also revealed that there are several critical ECCS components which are required for long term decay heat removal. These components include the RHR pump, RHR valves, and the RHR Heat Exchanger.

An assessment of these components with respect to erosion degradation revealed the following:

a) The RHR pump hydraulic performance degradation is negligible for the particulate concentrations assumed for this evaluation (Paint and insulation debris ≤1% by volume).

b) The RHR valves would be susceptible to erosion damage due to suspended particles in the ECCS fluid but this pitting and potential degradation in leak tightness is not expected to significantly affect the valve operation or functions.

c) The RHR Heat Exchanger tubes would be susceptible to some abrasive erosion. However, as previously discussed (question #3) calculations indicate that more than 99% of any ingested debris will fall out within 18 to 24 hours after the initiation of ECCS recirculation. Based on available erosion data (Reference 4), the degradation resulting from the original debris concentration level (≤1% by volume; ≤0.1% abrasive) for the first 24 hours will result in less than .001 inch reduction of the tube thickness. The residual debris concentration level after the first 24 hours will be less than 1% of the initial concentration and is expected based on available data to have minimal additional erosion impact on the heat exchanger tubes or on the heat exchangers long term decay heat removal capability (1 year design basis). The tube design thickness is .049 inch of which approximately .015 inch is required to retain pressure. Therefore, .034 inch is available for erosion before failure of the heat exchanger boundry would be expected.

7) Will small particles settle out in the inlet plenum of the RHR Heat Exchanger.

Reply:

The RHR heat exchangers are vertical two pass shell and U-tube heat exchangers. Reactor coolant is on the tube side and component cooling water is on the shell side. The heat exchanger tubes are 3/4 inch outside diameter and have an .049" wall thickness. The tube side flow velocity through the heat exchanger tubes is ~5 ft/sec based on an RHR pump feed rate of 3800 GPM. Initially some drop out of larger particles could be expected to occur in the low velocity regions of the heat exchangers below the inlet and outlet nozzles. However, the flow velocities through the RHR heat exchanger are high enough to ensure that the suspended particles which enter the heat exchanger plenum and remain in the flow path are carried up the U-tubes and out the outlet nozzle.

If a sufficient quantity of particles enter the heat exchanger and settle out in the inlet channel, the settling out of particles will cease when the low velocity regions are filled with particles and all additional particles entering the heat exchanger inlet after that point will be carried through the heat exchanger tubes and out of the outlet nozzle.

REFERENCES

1) pp. 236-239, Advanced Mechanics of Fluids, H. Rouse, editor, John Wiley & Sons, Inc., NY, NY, (1959).

2) pp. 203-210, Viscous Fluid Flow, Frank M. White, McGraw-Hill Book Company, NY, NY, (1974).

3) G&H/Westinghouse TELECON (WPT-7434 Dated 7/19/84)

4) Erosion-Corrosion of Selected Metals in Coal Washing Plant Environments, G. R. Hoey and T. S. Bendar, National Association of Corrosion Engineers, (1983).