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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

February 16, 2006

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, taken on February 16, 2006, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
THERMAL HYDRAULICS SUBCOMMITTEE

+ + + + +
MEETING
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ROCKVILLE, MARYLAND

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THURSDAY

FEBRUARY 16, 2006

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The Subcommittee met in Room 2TB3 at Two
White Flint North, 14555 Rockville Pike, Rockville,
Maryland, at 8:30 a.m., Graham B. Wallis,
Subcommittee Chair, presiding.

PRESENT

- GRAHAM B. WALLIS Subcommittee Chair
- RICHARD S. DENNING Subcommittee Member
- THOMAS S. KRESS Subcommittee Member
- WILLIAM J. SHACK Subcommittee Member
- SANJOY BANERJEE ACRS Consultant

1 NRC STAFF

2 RALPH CARUSO Designated Federal Official

3 MICHELLE EVANS RES

4 TOM HAFERA (by teleconference) NRR

5 ERVIN GEIGER RES

6 SHANLAI LU NRR

7 MIKE SCOTT NRR

8 ROBERT TREGONING RES

9 MATT YODER NRR

10

11

12 OTHER PRESENT

13 TOM ANDREYCHEK Westinghouse

14 MAURICE DINGLER WOG

15 ANNE P. FULLERTON Naval Surface Warfare Center

16 BRUCE LETELLIER LANL

17

18

19

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A-G-E-N-D-A

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

8:31 a.m.

CHAIRMAN WALLIS: Please come into session. Good morning. This is the third day of our meeting on sump screens. We have an extra presentation early this morning about downstream -- possible downstream effects on fuel, or the way that fuel bundles are organized, the shapes, and the passageways, and all that sort of thing.

Mike Scott is going to make the introduction.

MR. SCOTT: Good morning. What we'd like to do is shed a little additional light, both from the NRC staff and from the industry, regarding the question of what happens with debris going downstream from strainers, especially in consideration of the fact that the staff is pushing the industry to enlarge its strainers.

So, we'll start off with Tom Hafera, of the NRR staff. Tom, unfortunately, got snowed in up in Pennsylvania by this blizzard we got over the weekend, so he couldn't be here personally, but he is on the phone.

And so, Tom, if you hear me okay, if you'd please share perspective with us on that issue I'd

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1 appreciate it.

2 MR. HAFERA: Okay, Mike, thank you.

3 Yes, the staff has been working with the
4 owners group contacts, reviewing the WCAP, regarding
5 downstream facts, and the WCAP does address, it has a
6 chapter and appendix specifically related to
7 downstream effects in the reactor vessel.

8 We also had a contractor help us develop
9 staff guidance, and we issue a draft paper for how the
10 staff is going to review the issues associated with
11 downstream effects in -- and we have a tendency to say
12 the fuel, but it's actually the vessel. You take
13 vessel as a whole.

14 So, we've done a lot of work ahead, but at
15 the same time we still have some issues associated
16 with the WCAP. We've identified those, and we have
17 some ongoing discussion with those.

18 Critical things to keep in mind with
19 downstream effects in the reactor vessel, not only do
20 you have to identify your source term, in terms of how
21 much debris is going to penetrate through the screen,
22 whatever the new screen design is, but each -- most
23 reactors have, and particularly all PWRs are open
24 course, and most reactor designs have openings outside
25 the fuel assembly region that provide significant

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1 openings that will provide flow, or at least maybe not
2 necessarily flow, but at least a path for the water to
3 go and get to the fuel and cool the fuel through
4 emersion.

5 Distinct issues -- but also, you know,
6 other issues are, if you -- hot leg breaks and cold
7 leg breaks are going to behave significantly
8 differently, because your low pressure point in the
9 system, in a cold leg break, is at the inlet side of
10 the core, essentially, and on the hot leg break your
11 low pressure point is at the outlet side of the core.
12 So, for evaluating effects for a cold leg break, the
13 flows at the bottom of the vessel are very low, you
14 are going to get probably a high degree of settlement,
15 if not complete settlement, but at the same time you
16 won't compact any debris, so you probably won't create
17 any significant head loss there.

18 For hot legs, on the other hand, you are
19 going to have high flow through the core, the debris
20 will all pass through -- either pass through the core
21 or the bypass paths, and then go back to the
22 containment floor where it has an opportunity again to
23 either settle or be captured.

24 If you think dynamically in terms of hot
25 leg breaks, the best example I can think of is I hand

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1 drew an electrical circuit modeling the flow paths, so
2 you end up with very multiple flow paths and multiple
3 resistances through the system. You use your
4 fundamental centrifugal pump curve with a system head
5 loss curve, you recognize that if you increase the
6 resistance at the bottom of the core to infinity, all
7 that essentially does will create flow, increased flow
8 through the other core paths, and probably the most
9 significant one is you can -- if you are injecting
10 cold leg into the cold leg, and you increase the
11 resistance on the core inlet to infinity, it will just
12 back up flow backwards through the loop, and it will
13 end up dumping into the hot leg onto the top of the
14 core, and, therefore, you will still keep the core
15 under water and it will probably cool.

16 Now, there are some questions in regard
17 to, you know, how does debris interact in high boric
18 acid concentration, and boron precipitation, and
19 operators -- there's operator actions associated with
20 flushing the core out periodically, so that could also
21 be effective in flushing debris out, obviously. So,
22 there are a number of other issues, and we've
23 discussed these with the WOG, well, we've identified
24 these with the WOG, and there's ongoing discussion.

25 So, right now our position is, there are

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1 some issues with downstream effects, and how does the
2 particulates and fibers interact in the vessel, but at
3 the same time we don't see it -- we haven't identified
4 anything that would want us to stop putting in larger
5 strainers. We don't necessarily feel that this would
6 -- because you are on the discharge side of the
7 centrifugal pump, and taking centrifugal pump theory
8 and plastic fluid mechanics, it really doesn't appear
9 to be something that would cause a catastrophic
10 failure.

11 And, I think one of the best examples I
12 heard of was, one of the people I'm working for, or
13 working with, with Reactor Systems, explained to me,
14 you know, the TMI core melted and relocated and then
15 resolidified, so it had areas of complete blockage.
16 But, at the same time when they put water back in
17 there it cooled, and it found a way to cool itself.
18 So, it's a pretty gross -- pretty -- you don't
19 necessarily need a real highly technical or exact
20 method to get this water in there, the water will find
21 a way.

22 And so, we are working on that, and we
23 think we've got -- we think we've got a path of
24 success. Even as late as last week, I discussed this
25 with Mo Dingler and Tim Andreychek, we felt that the

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1 fuels people -- and I also discussed this a little bit
2 with the Framatome guys last week, the fuels people
3 believe we've identified those areas that need to be
4 investigated a little farther, and we think we've got
5 a path going forward to give us the answers that we
6 need.

7 MR. SCOTT: A point to emphasize here is
8 that the staff's expectation is that the industry in
9 evaluating its modifications to increase the size of
10 the strainers will consider downstream effects, such
11 as, and including, those related to inside the vessel
12 and the core. So, nobody puts in a MOD without having
13 done that analysis.

14 CHAIRMAN WALLIS: Can I ask a question?
15 You mentioned the head from the
16 centrifugal pumps, now are there some locations of the
17 break where the actual driving head for flow through
18 the core is not from the pumps, it's from natural
19 confection of the head in the downcomer or something,
20 because of where the break is? The pump doesn't
21 necessarily always pump through the core.

22 MR. HAFERA: That's correct, Dr. Wallis.
23 Again, that was as I explained, the difference between
24 a cold leg break and a hot leg break, and you have to
25 recognize that the fluid dynamic differences in a cold

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1 leg break, the majority of your flow will,
2 essentially, bypass the core and go back out around
3 the downcomer or annulus region and out the break.

4 However, you know, the flow is still --
5 still goes into the -- there's an amount that will go
6 down the downcomer into the -- and then back up
7 through the core based on gravity and the differential
8 water levels. And again, if you think of it in terms
9 of an electrical circuit, and you say to yourself,
10 okay, that's my flow characteristic with no debris
11 whatsoever, and I say to myself, okay, now I have a
12 resistance at my bottom core plate, or my bottom fuel
13 screen, if I take that resistance and change it to
14 infinity what does that do to the entire system.
15 Well, it creates a higher resistance at the bottom of
16 the core, it causes back pressure into your cold leg
17 injection that will, essentially, force flow backwards
18 through the reactor coolant pump through the steam
19 generators, into the hot leg, and then dump onto the
20 top of the core.

21 And, your pumps, your pump discharged head
22 can easily overcome that, because that's only about a
23 60 foot head. So, there's really not -- and again, if
24 you block the bottom of the core you still have
25 alternate flow paths, in particular, the B&W designs

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1 have flow holes and slots, the Westinghouse designs
2 have flow holes through the baffle, and the shield --
3 the thermal shield area, that still provide large,
4 very large, in relation to the screen hole size, flow
5 paths to get water into the core region.

6 CHAIRMAN WALLIS: It looks to me as if we
7 really need a subcommittee meeting on this subject, to
8 clarify all these issues. You talked about complete
9 settlement at the bottom of the vessel, well, there
10 may be enough debris to fill that area, that volume,
11 and if you are going to then rely on dumping on top of
12 the core, I'm not quite sure how it works out when you
13 have debris-laden material dumped on top of the core.

14 You may well be right that everything is
15 fine, but I think we need to have a proper technical
16 discussion of it.

17 MR. HAFERA: Bill, don't characterize as
18 everything may be fine, I would much more -- I would
19 rather characterize it as, it has to be analyzed based
20 on the screen design chosen by the utility and the
21 vendor.

22 You are correct, depending upon the screen
23 design, depending upon the amount of debris, that has
24 to be evaluated, in terms of how much debris is
25 actually going to build up in the bottom of the

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1 vessel, or how much debris will actually build up on
2 top of the core. And then, once that is evaluated,
3 and the WCAP has that methodology in it how to do that
4 evaluation, and then once that evaluation is done most
5 likely, the most likely success path then is to look
6 at when does it occur, in terms of probably, you know,
7 it's going to be hours most likely, it's going to be
8 on the order of hours after the onset of
9 recirculation, and if you say to yourself, well, just
10 as an example, I say three hours in, three hours after
11 the onset of recirculation, I reach a point where my
12 debris load is approaching something that I consider,
13 you know, not good, well then I have to initiate hot
14 leg recirculation faster, which all plants have as
15 part of their emergency operating procedures for boron
16 precipitation control.

17 So again, to characterize is to say it's
18 okay, well, I wouldn't go that far. I would say it
19 needs to be evaluated. It needs to be evaluated using
20 good engineering judgment, and it needs to be robust,
21 and most likely it will -- it may, it may result in
22 changes to your emergency procedures in terms of, you
23 may change from, say, a plant may right now under
24 existing circumstances go to hot leg recirculation
25 eight hours after recirculation for boron

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1 precipitation control. Well, they may need to change
2 that to five hours. They may need to change that to
3 three hours. But again, for them to find that out
4 they are going to have to do a robust evaluation, and
5 that has to be looked at, and it's part of the factors
6 that need to be considered are, what's the screen
7 design chosen, what's the amount of debris that's
8 going to bypass, what are the characteristics of the
9 debris that are going to bypass, and what are the
10 other system interactions associated with downstream
11 effects, and how does that all fit in.

12 CHAIRMAN WALLIS: I think we probably have
13 to move on, but I do have a comment. I find it
14 difficult for this subcommittee to reach any
15 conclusion about whether or not you are on a success
16 path when we have to wait for evaluations of every
17 possible incident in every possible reactor with every
18 possible change to the screen. This is really rather
19 difficult for us to get hold of.

20 MR. HAFERA: That is correct also, and
21 that's why -- and our approach has been, because a lot
22 of that is -- and it goes even -- the next step even
23 goes farther, and that is, a lot of that is plant
24 specific. So, you really cannot, from a generic
25 standpoint, evaluate it, and say, yes, this is going

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1 to be okay, or this is not going to be okay. The only
2 thing you can do from a generic standpoint is outline
3 the methodology that you are going to use, what the
4 critical parameters are that you need to identify and
5 include in your evaluation, to make sure that that
6 methodology is done the right way and is robust.

7 And, essentially, that's what the WCAP at
8 least aims to do. At this point, we are not sure it
9 does or doesn't do that, but that's where our
10 discussions with the owners group and the fuel vendors
11 and people are headed, because we recognize from our
12 perspective it's more advantageous for us to get a
13 single approved methodology that then all the plants
14 could use, rather than trying to evaluate 60 million
15 individual plant-specific configurations.

16 DR. DENNING: You know I hear that, but I
17 think that there's no reason why you couldn't take an
18 example. I mean, we heard yesterday or the day before
19 about active screen designs in which it sounds like
20 there's a very large fraction of fiber that's going to
21 pass through the screens. I'd like to see an example
22 of the cold leg break and have somebody run through
23 and tell us how much material is really passing
24 through that system, and see an analysis.

25 I don't think that we're going to feel

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1 comfortable until we see that analysis and get a
2 chance to get into the details of the assumptions,
3 like the entrainment of fibers or particulate in the
4 upper plenum if you stagnate up there, and some
5 indication of how much mass we are really talking
6 about winding up in the system.

7 So, I hear you saying you can't do a
8 generic analysis, but we certainly could see some
9 example analyses in the area -- in the regimes in
10 which we think there could be the most problems.

11 MR. HAFERA: Yes, I agree. I agree that
12 would be a good thing, and I think we are headed in
13 that direction, we are just not there yet, because
14 most plants have not completed their downstream
15 effects analysis as of yet.

16 MR. SCOTT: If I could, I'd like to ask Mo
17 Dingle to show you a couple of slides that he's
18 brought in to illustrate --

19 CHAIRMAN WALLIS: Can we thank Tom first?

20 MR. SCOTT: Certainly.

21 CHAIRMAN WALLIS: All right, thank you,
22 Tom.

23 MR. SCOTT: Tom, if you'd stand by, we may
24 have additional questions for you.

25 MR. HAFERA: Sure.

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1 MR. DINGLER: I'm Mo Dingle from Willow
2 Creek and represent the owners group also.

3 There is some discussion last couple days
4 of what a fuel assembly was, and the bottom of the
5 grid, so we wanted to show, and we worked these up
6 late last night, so it will be the first, and Tom will
7 do this, we are still working through some of the
8 issues, so I'll give you a high level here.

9 We wanted to show you what the core looks
10 like, the bottom. This is where most of the flow will
11 come up through.

12 CHAIRMAN WALLIS: So, it's coming in from
13 the bottom, and it's going through something called a
14 protective grid.

15 MR. DINGLER: That's what I call the P
16 grids.

17 CHAIRMAN WALLIS: Which looks something
18 like a screen.

19 MR. DINGLER: Right, and these openings
20 are about the size -- the same size we talked
21 Wednesday about.

22 CHAIRMAN WALLIS: And, if that screen gets
23 blocked we are told the flow will go somewhere else?

24 MR. DINGLER: This is a diagram of some of
25 the alternate flow paths.

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1 CHAIRMAN WALLIS: But, in normal
2 operation, not much flow goes that way. It's designed
3 to go through the protective grid, presumably.

4 MR. DINGLER: There, but there is still
5 even during ops some of this.

6 CHAIRMAN WALLIS: There is some of it, but
7 it's not the main flow path.

8 MR. DINGLER: The main flow path comes
9 down the cold leg, up through this way, and here is
10 the hot leg.

11 So, when these -- a lot of plants have
12 these openings, the B&W, the upflow plants have the
13 openings right here.

14 CHAIRMAN WALLIS: Now, we have experiments
15 on how rod bundles behave in the normal operation. I
16 don't know if we have experiments on how they behave
17 when the main flow path is blocked and the flow is
18 coming in through these other passageways.

19 MR. DINGLER: I can't speak for that, Dr.
20 Wallis.

21 MR. CARUSO: Mo, you are not showing how
22 the flow that goes up the side of the baffles gets
23 into the core. It comes up through the --

24 MR. DINGLER: Right here.

25 MR. CARUSO: -- through the flow nozzles

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1 themselves, into the core which is open to the side.

2 MR. DINGLER: The core is right here, so
3 in other words you've got some of it going through the
4 baffle barrels and that is right through in here.

5 So, you have openings all the way up
6 through here.

7 CHAIRMAN WALLIS: So, it comes in from the
8 outside and has to somehow get to the middle of the
9 core?

10 MR. DINGLER: Correct. It comes up,
11 here's the core plate, it comes up and there's the
12 protective grids are right here for normal ops to keep
13 threading down --

14 CHAIRMAN WALLIS: Right.

15 MR. DINGLER: -- and then we've got the
16 flows that will come parallel and up through this.

17 MR. CARUSO: So, you are saying -- you are
18 talking about bypass flow between the bottom bracket
19 on each fuel assembly. The assemblies sit in a grid,
20 and you are saying that between two assemblies on
21 those flat faces on each side, okay, the bottom
22 nozzle, excuse me --

23 MR. DINGLER: On this is the bottom
24 nozzle.

25 MR. CARUSO: -- on that bottom nozzle

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1 there's another one right next to it, and there's this
2 tiny little gap between the two of those, and you are
3 saying that there's bypass flow up through that gap.

4 MR. DINGLER: There is some, but what I'm
5 showing --

6 CHAIRMAN WALLIS: What you are showing is
7 a bigger flow.

8 MR. DINGLER: -- is much more flow, I'm
9 saying the core is right here, and assume it's all
10 blocked, the flow will come up and it will go out here
11 in the baffle barrels and through openings.

12 CHAIRMAN WALLIS: It will come up,
13 essentially, on the outside of the core, around the
14 core.

15 MR. DINGLER: That's the outside of the
16 core.

17 CHAIRMAN WALLIS: And, somehow it has to
18 percolate into the middle.

19 MR. DINGLER: That's correct.

20 CHAIRMAN WALLIS: Someone has to analyze
21 that kind of a situation, presumably.

22 MR. DINGLER: That's correct.

23 MR. ANDREYCHEK: If I may, this is Tim
24 Andreychek from Westinghouse. There's typically an
25 angular gap on the order of an order of an inch, an

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1 inch and a half, for the upflow plants that provides
2 a flow path.

3 Under normal operating conditions, that
4 provides cooling flow to keep the baffle barrel region
5 at acceptable temperatures. It provides a fairly
6 large flow area in that circumferential gap to provide
7 flow.

8 There are, I want to call them pressure
9 relief holes up the height of the baffle barrel at
10 certain locations, that provides for flow to go back
11 into the core, should the bottom nozzles become
12 blocked.

13 DR. BANERJEE: How big are these holes?

14 MR. ANDREYCHEK: They are on the order of
15 approximately two inches.

16 DR. BANERJEE: And, the barrel?

17 MR. ANDREYCHEK: The baffle barrel gap is
18 about an inch and a half angular gap that runs around
19 the periphery.

20 MR. DINGLER: What we are saying is, we
21 are still working with the staff now.

22 CHAIRMAN WALLIS: You are showing me a
23 figure, and you are saying that's probably what
24 happens, but I don't see any kind of code calculation
25 of what happens.

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1 MR. DINGLER: And, I wasn't -- between
2 6:30 last night and 10:00 --

3 CHAIRMAN WALLIS: Yes, but it seems to me
4 something like that might be needed. I mean, if you
5 are going to really technically convince us, you might
6 have to have a --

7 MR. DINGLER: We are not arguing that.

8 CHAIRMAN WALLIS: -- whatever your
9 appropriate code is that you are going to use for
10 this.

11 MR. DINGLER: Yes, we are not arguing, I'm
12 not here to present all the detail technically, late
13 last night --

14 CHAIRMAN WALLIS: See, it's not good
15 enough to just talk about the problem.

16 I agree that there could be some flow that
17 way, but we need to know how much it is, and whether
18 it's enough, and so on.

19 MR. CARUSO: Can I ask a question?

20 CHAIRMAN WALLIS: Yes, Ralph.

21 MR. CARUSO: If you have holes that
22 communicate from the bottom of the lower plenum up
23 through the baffles, the baffle region, and then into
24 the core, that are on the order of an inch, an inch
25 and a half in size, why do you bother installing

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1 debris screens on the bottom of the fuel, okay, to try
2 to catch debris during normal operation to avoid
3 having it come up into the core region? If you
4 already have these other inch and a half holes all
5 over the place that provide lots of bypass flow into
6 the core region, why do you need debris screens on the
7 bottom of the fuel bundles?

8 MR. DINGLER: I guess to simply it a,s the
9 head loss up this way is much lesser than through
10 here, so the flow goes up through -- most of the flow
11 goes up through here at this point, during normal ops.

12 DR. BANERJEE: I guess Ralph's question
13 is, if you get this cross flow, and it brings debris
14 in, it will just deposit it in an outer ring, and the
15 inner fuel --

16 MR. CARUSO: The reason why those debris
17 screens are there is because people don't like to have
18 debris get on their fuel during normal operation, and
19 cause damage to the fuel during normal operation.

20 So, the vendors have been very good at
21 designing these debris screens to trap all that
22 debris, to make sure that it doesn't get up into the
23 fuel during normal operation. It would defeat the
24 purpose of installing those debris screens to have a
25 parallel flow path, with holes an inch, an inch and a

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1 half in diameter, that allow debris to flow up around
2 into the baffle region, and then get into the core
3 from the side. That defeats the entire purpose of
4 installing debris screens.

5 MR. ANDREYCHEK: The debris path is a
6 torturous path, and you are talking about 98 percent
7 or so of the flow going up through the core. That's,
8 basically, a leak flow for normal operating conditions
9 to keep the baffle barrel region cool.

10 And, the reason the holes are there is to
11 provide, during an upset condition where you
12 depressurize the reactor quickly, pressure release
13 yield implode or explode the baffle barrel region.
14 You know, it's not a main flow path under normal
15 operating conditions.

16 CHAIRMAN WALLIS: So, I think what you are
17 saying is that you need much less flow at this time
18 after a LOCA when you want to cool the core and
19 maintain a normal operation. So, having what used to
20 be a 2 percent flow path now becomes an adequate flow
21 path.

22 But again, we'd have to see that. We'd
23 have to see --

24 DR. BANERJEE: Except now the fuel acts as
25 the debris screen in cross flow, and the fuel will

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1 take out the debris in the outer region.

2 CHAIRMAN WALLIS: So, what happens to the
3 middle of the core?

4 I don't know, if you are going to cool it
5 from the top, I don't know what CCFL looks like when
6 you have debris in there. So, there's a lot of
7 interesting technical questions here.

8 MR. DINGLER: We understand that.

9 CHAIRMAN WALLIS: You've indicated that
10 there may be ways to cool the core, which may be
11 perfectly satisfactory, but these are all maybes at
12 this point.

13 MR. DINGLER: Based on the investigation
14 we have done so far, some plants will have more
15 challenges. As you heard, with the active sump
16 screen, some have very -- have very little.

17 CHAIRMAN WALLIS: So, is there going to be
18 a WCAP or something that addresses these in technical
19 terms, rather than just sort of saying you've got to
20 calculate all these things, but actually gives a lot
21 of example calculations?

22 MR. DINGLER: As Tom says, we are working
23 with the staff, and one section gives a generic
24 evaluation for it, this is -- you had a lot of
25 discussion on proprietary information, just on the

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1 normal between the two fuel vendors that we have,
2 proprietary becomes very commercialized, and we are
3 working through some of those issues.

4 CHAIRMAN WALLIS: I think that's for
5 existing plants, how about something like the AP 1000,
6 are we going to have to revisit that and have
7 calculations of this kind of way of cooling the core?

8 MR. SCOTT: Yes, this is unresolved for AP
9 1000.

10 MR. DINGLER: I think that should be
11 addressed with the AP 1000 folks, I'm not prepared to
12 answer that.

13 CHAIRMAN WALLIS: You have a new reactor,
14 so you can make the calculation for that, it's not
15 going to be plant specific, or is it going to be,
16 again, plant specific, because the debris is plant
17 specific, even in an AP 1000.

18 MR. DINGLER: I can't answer that, because
19 I don't even worry about an AP 1000, I'm worried about
20 existing plants.

21 CHAIRMAN WALLIS: Some people must be
22 worrying -- must be thinking, nobody ever worries in
23 this business, thinking about it.

24 MR. DINGLER: Thinking about it, I'm not
25 even thinking about AP 1000 right now.

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1 The other one is, I guess the next slide
2 is --

3 CHAIRMAN WALLIS: Are we going to have
4 these slides available to us, or are they proprietary?

5 MR. DINGLER: You've got them right in
6 front of you.

7 CHAIRMAN WALLIS: We have them somewhere,
8 oh.

9 MR. DINGLER: Yes.

10 The next one was just to show that there's
11 plants that have more bypass, others are going to have
12 more challenges.

13 And, as Tom said, in other words,
14 dependent on that I wanted to give you a perception,
15 the last slide is the free volume of lower plenum.
16 It's based on reactor vessel design and reactor vessel
17 size, really what we should say is, we've got between
18 300 to 375 cubic feet of free space down there to
19 settle. In other words, I'm not here to say that all
20 -- I'm just giving you a perspective that the lower
21 plenum can act as a source of debris collection, and
22 give you a sense of the volume. That's all I'm here to
23 say.

24 CHAIRMAN WALLIS: That's useful, thank
25 you. That's good.

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1 MR. SCOTT: Is that it?

2 MR. DINGLER: That's all I have, yes.

3 CHAIRMAN WALLIS: We have to compare it
4 with the numbers we've heard already, about the amount
5 of debris, don't we?

6 MR. DINGLER: That's correct.

7 CHAIRMAN WALLIS: And, we are going to
8 hear in the next presentation about bypass -- screen
9 bypass?

10 MR. SCOTT: The next one is throttle valve
11 clogging.

12 CHAIRMAN WALLIS: The throttle valve
13 clogging study is really about screen bypass so far,
14 or is it going to talk about -- we'll find out.

15 MR. SCOTT: Before we go on, Tom Hafera is
16 still on the phone, do you all have any other
17 questions for Tom?

18 MR. HAFERA: Hey, Mike?

19 MR. SCOTT: Yes.

20 MR. HAFERA: I guess I'd like to just add
21 one other thing before I answer questions, and that
22 is, listening to some of that discussion, I think it
23 sounds like some critical ideas were identified, but
24 things that have to be recognized, you know, you can
25 do a quick back-of-the-envelope calculation, Q is

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1 equal to $M \cdot \Delta H$, and you can determine what
2 type of flow rates are needed, you know, recirculation
3 doesn't happen until at least 30 minutes after reactor
4 trip. So, if you take a 3,000 megawatt core, and you
5 use 30 minute decay heat, and your ΔH is
6 determined by your sump pool temperature, and
7 saturation conditions for containment pressure, you
8 can do a quick calculation and you find out that you
9 can handle decay heat at that time by about 200 gallons
10 per minute. So, it is, it's a very small amount of
11 water that needs to be added to the core to maintain,
12 you know, to remove decay heat.

13 The other thing to recognize, and I heard
14 some discussion, you know, you talk about differences
15 between normal operation and post LOCA, you know,
16 normal operation your reactor coolant pumps are
17 running, they are 90,000 gallon per minute pumps, so
18 you are pumping a lot of water through the core, very
19 high velocity, that's what your fuel screens are for.

20 Post LOCA, your fuel, you know, your flows
21 are extremely low, and again, if you talk about a cold
22 leg break, where, essentially, you are cooling the
23 core via natural circulation, you actually have --
24 you'll have a circular flow within the core, in terms
25 of, you'll have upflow in the center, and you've

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1 actually have downflow on the outside, and what that -
2 - you have to keep that in mind, too, because that
3 prevents you from building up the debris bed, because
4 you have eddies and flows that really mean you don't
5 get a consistent -- you know, you don't have like
6 laminar flow where your flow vectors are all in one
7 direction. It just doesn't happen that way.

8 MR. SCOTT: Yes, I think the committee,
9 although they are certainly interested in the
10 conceptual -- the concepts like you are talking about,
11 they want to see the results of the analyses.

12 DR. KRESS: We want to see some trace
13 calculations.

14 DR. BANERJEE: Not trace, how does trace
15 get those eddies that you are talking about?

16 MR. HAFERA: I'm sorry, Dr. Wallis, I
17 couldn't hear you.

18 DR. KRESS: Dr. Wallis is no longer with
19 us, this is -- he couldn't take anymore -- this is the
20 Co-Chairman, Dr. Kress, talking.

21 Never mind what I said.

22 MR. SCOTT: Do you all have any questions
23 for Tom?

24 DR. KRESS: No.

25 MR. SCOTT: Okay.

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1 Tom, we are going to go ahead and go into
2 the research presentations. If you want to continue
3 to listen in, you are welcome to.

4 MR. HAFERA: Okay.

5 MR. SCOTT: And, thank you very much for
6 phoning in.

7 MR. HAFERA: Thank you.

8 DR. DENNING: WE ought to really thank Mo,
9 too, for being brave enough to --

10 DR. KRESS: Mo, thank you, we appreciate
11 it.

12 So, Rob, you are up next.

13 MR. TREGONING: Yes, this is back on the
14 original schedule.

15 The next presentation is going to be on a
16 test program to look at throttle valve clogging, but
17 as you are going to see it's more of a surrogate for
18 clogging in general under certain flow conditions,
19 restricted flow conditions within -- that may occur in
20 some places within the ECCS system.

21 As co-presenters, myself and Bruce
22 Letellier from Los Alamos. The objective of this work
23 on slide two was to evaluate the effect of insulation
24 debris on blockage. We wanted to look at where, to
25 some extent, but it was really just a more qualitative

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1 assessment of where, there was no quantitative or no
2 rigorous study of where that was applied during this
3 project. And, we wanted to evaluate these effects on
4 surrogate HPSI throttle valves.

5 Motivation, we talked a little bit about
6 this yesterday, the throttle valves are one possible
7 source of performance degradation, due to flow
8 restrictions. I think as Bruce mentioned, it's one of
9 the smaller clearance areas, typically, within the
10 ECCS system. So, it's a potential trap for debris.

11 Also, prior to this program there was
12 really little information on the severity of nuclear
13 valve degradation due to these blockage phenomena.

14 This is a two-phase effort, as Dr. -- as
15 Professor Wallis mentioned. Phase I, which we weren't
16 prepared to discuss in depth today, although we can
17 certainly field questions and bring that into the
18 discussion, was a scoping study to examine the
19 variables that affect the amount of debris which can
20 pass through the sump screen or sump strainer screens.
21 That's a bit of an alliteration I'm not ready to
22 handle yet this morning. That work is being
23 completed, and it's documented in NUREG/CR-6885, so
24 that was Phase I of this study.

25 And then, what was done is based on some

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1 of the ingested debris characteristics in Phase I that
2 were measured and observed. Those same
3 characteristics were then ingested into a closed loop
4 to measure blockage within the throttle valves, and
5 that's Phase II of the program.

6 The presentation today is going to focus
7 primarily on Phase II. We did provide a brief
8 overview on this topic in the July meeting, but today
9 is obviously going to be much more extensive, in that
10 most of the testing, in fact, all of the testing, has
11 been completed.

12 The regulatory use I can go through
13 quickly. Again, this is to aid in the staff's
14 evaluation of the generic letter responses, and,
15 specifically, we are hoping to use the data to at
16 least determine variables that are important to
17 consider when determining if ingested debris is a
18 problem, and it may lead to blockage in some of these
19 regions downstream of the ECCS strainers.

20 DR. KRESS: Now, that particular throttle
21 valve, it's totally blocked, there's two of those,
22 right? It depends on which sed loop you are in?

23 MR. TREGONING: At least.

24 DR. KRESS: At least.

25 If they all get blocked, then you

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1 completely block the ECCS flow to the core in all the
2 units?

3 MR. LETELLIER: Under high pressure
4 injection, you may, but there are multiple injection
5 paths, and we talked a little bit about that.

6 DR. KRESS: But, each ingestion path has
7 a valve like this of some kind in it.

8 MR. LETELLIER: Yes.

9 DR. KRESS: So, each of those valves might
10 possibly get blocked.

11 MR. TREGONING: It is conceivable,
12 certainly, although blockage is one of the things we
13 didn't investigate in this project. We just were
14 looking for the onset of blockage. We didn't evaluate
15 any, you know, post blockage operator action that
16 could be taken, potentially, to alleviate the blockage
17 concerns, you know, cycling the valve or things like
18 that.

19 I mean, there may be some things that the
20 operator could do that could clear it out, yes. We
21 didn't look at that in this program at all.

22 Quickly, status, before I turn it over to
23 Bruce. The testing is complete. We have an initial
24 NUREG/CR that we are preparing for publication. We
25 are still reviewing it. We are planning to have a

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1 final version ready for publication in March. We'll
2 be sending it to Ralph some time in the near future
3 for your review as well.

4 And, with that, I'd like to turn it over
5 to Bruce, and he's going to go into more of the
6 technical details associated with the testing and the
7 results.

8 MR. LETELLIER: Very briefly, I'd like to
9 acknowledge the team members at Los Alamos, Crystal
10 Dale and Pratap Sanisdavan, and also our graduate
11 student at the University of New Mexico, Felix Carles,
12 who did most of the real work.

13 You might say I'm just the pretty face,
14 but then I know things will vary.

15 The questions that you asked, Dr. Kress,
16 about the operation of the HPSI system are very
17 relevant. Rob explained a couple of the reasons that
18 we chose the HPSI throttle valve gap in order to
19 examine the phenomenology of potential blockage.

20 One is simply that it's one of the
21 smallest identified internal gaps that you can find,
22 but on the other hand it also has some of the higher
23 velocities. And so, if we are able to observe onset
24 of blockage under those conditions, then, perhaps,
25 there's motivation to look further into other areas of

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1 the core, like the fuel channels and the spray
2 nozzles, et cetera.

3 But, as you said, there are multiple
4 injection paths, and I'm not -- I'm not the systems
5 expert, but there are at least four to sometimes 12 of
6 these paths, depending on how many levels of pressure
7 systems that the plant has in their ECCS cooling.

8 So, I would say four is the minimum.
9 There are other plants that have fewer than that,
10 perhaps. There are plants that have as few as two
11 injection paths.

12 The purpose of these valves is twofold.
13 They are, basically, there to balance the flow into
14 the core, but also to throttle the high pressure
15 pumps, so that they don't experience a run-out
16 condition during the accident.

17 Just a few other background numbers, there
18 are no set specifications for what constitutes a
19 throttle valve. The designs and applications vary.
20 They are typically globe valve type of designs,
21 between one and four inches in diameter, with two
22 inches being the most common. So, you see a diversity
23 of industrial products that are applied for this
24 function.

25 And, that made it challenging for us, how

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1 to initiate this project. We had a couple of options.
2 We refer to the figures now.

3 Option number one was simply to procure
4 and test multiple industrial valves, but that's
5 problematic because it would require repeated
6 calibration of the system, and these valve bodies are
7 impossible to inspect. It would be very difficult.
8 It does have the advantage of exactly matching
9 inservice equipment.

10 We chose the second option, actually,
11 which was to fabricate a surrogate valve chamber with
12 a flexible geometry, where we could swap out the
13 internal details of the flow path and also give us a
14 chance to inspect and to clean the valve between
15 tests.

16 Our objective there was to match the
17 nominal dimensions of the valve, and the tolerance,
18 and also the flow path complexities, but not
19 necessarily to endorse any single industrial product.

20 The pump selection that we used for our
21 study was intended to have a HPSI-type design, and be
22 capable of matching the initial delta P and flow
23 conditions of the LOCA transient.

24 Obviously, at an academic setting, we are
25 not able to match the total delta P capacity of the

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1 HPSI, but we want to be on the initiation condition of
2 the transient. And, one of the objectives was to give
3 us some -- at least some margin for increasing
4 pressure and decreasing flow in the event of blockage.

5 If you think about what would happen in
6 the plant as the throttle valve would block, if it was
7 a very severe blockage the HPSI pumps would continue
8 to push up to the full system pressure.

9 DR. KRESS: Now, you are going to design
10 to match the flow in delta P.

11 MR. LETELLIER: Initial delta P.

12 DR. KRESS: Yes, but you are not going to
13 match the actual pressure.

14 MR. LETELLIER: That's correct, not the
15 absolute pressure.

16 DR. KRESS: Is that a problem or not?

17 MR. LETELLIER: I don't think so. We made
18 that judgment very early, that the driving force for
19 lodging, and clearing, and extruding debris would be
20 based on the differential pressure across the valve.

21 DR. KRESS: I was thinking that the
22 characteristics of the blockage may depend on the
23 pressure, if it blocks.

24 MR. LETELLIER: They may. We could
25 discuss that in detail.

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1 As we'll see, we were able to identify
2 some evidence of the onset of blockage and the
3 velocities with which it approaches the valve, and the
4 randomness of the orientation, its relative sizes are
5 all very important.

6 MR. TREGONING: Can you give an example of
7 where you think the absolute pressure might be
8 important with respect to the characteristics?

9 DR. KRESS: It might have something to do
10 with the nature of the debris. It may have different
11 characteristics.

12 MR. TREGONING: So, it might change the
13 morphology of the debris.

14 DR. KRESS: The morphology.

15 MR. TREGONING: Okay, understand.

16 MR. LETELLIER: The local forces on the
17 debris are only a function of its surrounding
18 differential, so that's the reason that we pursued the
19 path.

20 For debris types, we chose the three usual
21 suspects, our reflective metallic fragments,
22 fiberglass shreds, and calcium silicate.

23 The sizes that we tested in the surrogate
24 valve were those sizes proven to pass through
25 prototypical sump screen configurations, and that was

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1 Phase I of the project.

2 DR. BANERJEE: No NUKON?

3 MR. LETELLIER: That is the fiberglass.

4 DR. BANERJEE: Oh.

5 MR. LETELLIER: NUKON is a trade name,
6 common trade name, for fiber insulation.

7 The sizes, we did have some quantitative
8 information for, however, the quantities and the rates
9 could only be studied parametrically. That's some of
10 the issues regarding the current or future sump screen
11 designs, and what the fraction of debris that might
12 pass through.

13 And, it also -- it requires some estimate
14 of debris transport and generation in the vicinity of
15 the break.

16 So, we studied it parametrically. It was
17 very much an exploratory effort to look at what
18 phenomena might exist that leads to the onset of
19 blockage and, perhaps, accumulation.

20 DR. KRESS: So, when you say
21 parametrically, I would have envisioned that if you
22 keep increasing quantity and rate being produced in
23 blockage, and you say that's the -- you don't have
24 that -- is that the kind of thing you were thinking
25 of?

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1 MR. LETELLIER: Well, you'll see, we were
2 never actually successful at completely blocking the
3 valve. In fact, the limiting factor was the size of
4 our two-inch lines, and how much debris we could
5 physically pack into the introduction chamber. You'll
6 see a schematic in just a moment.

7 MR. TREGONING: But, you are correct, we
8 were looking for conditions that would lead to at
9 least partial blockage. So, the initial test plan,
10 the very few tests we did initially that looked at
11 very small quantities of RMI debris, we saw quickly
12 that we needed to up those quantities in order to get
13 blockage in many conditions, and we modified the test
14 matrix accordingly at that point.

15 MR. LETELLIER: Next slide, please.

16 I think you'll see that some of the debris
17 charges that we passed through the valve would not be
18 considered prototypical. They were very highly
19 concentrated slugs of material.

20 DR. KRESS: Did you introduce this mixture
21 of debris all at the same time?

22 MR. LETELLIER: We will talk about the
23 matrix, but the answer is yes, we studied various
24 combinations and various quantities of the three
25 debris types.

1 So, this next slide shows a schematic of
2 the apparatus. The business end is the high pressure
3 pump on the floor, down to the lower right. The
4 surrogate valve body is elevated about five feet off
5 the floor, and this debris insertion manifold is the
6 combination of valves that let's us introduce debris
7 under pressurized flow. So, there's a combination of
8 valves we'll look at in detail, so that we can switch
9 them over and add debris to the flowing system.

10 DR. KRESS: Is it a positive displacement
11 pump?

12 MR. LETELIER: It is actually an impeller
13 type pump, it's an eight-stage impeller. We could
14 look at the performance curves, but it basically has
15 a peak pressure of about 485 psi, and a --

16 DR. KRESS: I was wondering what that did
17 to the debris? You were introducing it --

18 MR. LETELIER: Downstream of the pump.

19 DR. KRESS: Downstream.

20 MR. LETELIER: At this point here.

21 DR. KRESS: Okay.

22 DR. BANERJEE: I guess there's a settling
23 tank, right?

24 MR. LETELIER: The large flow is a
25 reservoir of water, and you are correct, it provides

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1 an opportunity for settling. We have debris capture
2 at several points, at a trap in the flowing pipe,
3 there would typically be buckets with sieves.

4 We are trying to achieve a mass balance.
5 We know how much we put in, and we'd like to know
6 where the remainder resides.

7 There are also screens, mid-flow screens,
8 within the flume, and also a fine-mesh screen just
9 upstream of the pump.

10 DR. KRESS: So, you are not trying to
11 recirculate stuff that might get --

12 MR. LETELLIER: That's correct. We have
13 talked about looking at the effects of debris
14 ingestion on the test pump, but our immediate
15 objective was to allow it to survive the test
16 campaign.

17 DR. KRESS: Yes, that's a good idea.

18 MR. LETELLIER: That is, obviously, the
19 most expensive piece of the system.

20 Diagnostics, we included flow meters just
21 upstream of the pump at this point, thermocouples
22 upstream of the pump, and also downstream of the
23 valve, just to monitor -- well, the reason we have two
24 is to monitor the differential temperature across the
25 test apparatus, and, in fact, the pump does

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1 consistently heat the flow about ten degrees between
2 the inlet and the outlet, at flow rates of 75 gpm.

3 The primary measurement of interest are
4 the differential pressures across the valve body at
5 these locations.

6 So, let's look at a photograph.

7 MR. TREGONING: Do you want to mention the
8 downstream flow meter at all, just as a potential --
9 another potential trap?

10 MR. LETELLIER: The one we took out?

11 MR. TREGONING: Yes.

12 MR. LETELLIER: Initially, we actually had
13 our flow meter downstream of the valve in this long
14 section here. We were mostly concerned about the
15 hydraulic flow regime, so we could get a good
16 consistent measurement.

17 However, it would consistently foul with
18 the debris. These were impeller -- or turbine type
19 flow meters, with a triangular strut arrangement.

20 And again, the debris loadings are large
21 slugs of concentrated debris. Had we fed it in a more
22 dilute quantity, perhaps, it wouldn't have been an
23 issue, but we did have evidence of trapping on sharp-
24 edged obstructions.

25 So, the photograph makes this a little

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1 more realistic. The pump is again on the floor, with
2 the debris introduction manifold at this level, and
3 the valve body is the aluminum milled -- the insets
4 provide more detail of the valve body.

5 You can see the direction of the flow path
6 is an under/over type arrangement, it comes into the
7 lower cavity, passes through the throat, and out
8 through the outlet.

9 At this point, you can see the manifold
10 with the four separate valves that let us control --
11 isolate the flow, so that we could introduce debris to
12 the top, so all the pressurized flow continues in the
13 bottom. And, after we've introduced the desired
14 quantity and types, then we can valve it over and
15 flush the lines.

16 All of these tests were conducted when we
17 introduced the debris, both valves, 1, 3 and 4, were
18 completely open, so we had a parallel flow path during
19 the test, so there was no possibility to trap debris
20 in cavities.

21 The next slide shows the internal details
22 of the surrogate valve. Again, you can clearly see
23 the under/over flow path, with the lower chamber. The
24 valve seat, this valve is shown in the fully closed
25 position, so the points of contact are here at the

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1 ring and the stem.

2 We designed this valve body to be able to
3 put in different combinations of the ring and the
4 stem, and the three configurations we tested are shown
5 to the left. We have a shorthand nomenclature. At the
6 top is the five degree small, which describes the
7 contact angle of five degrees from the vertical and
8 the diameter, which is smaller than the large one.

9 MR. TREGONING: It's a complex
10 nomenclature system that was developed for this
11 testing.

12 MR. LETELLIER: I'm sorry, I'd have to
13 look in the report to say exactly what the diameter
14 is. We chose these configurations based on a survey
15 of commonly available industrial globe valves, and
16 again, because there's no set specification the plants
17 might employ any variety of these.

18 MR. CARUSO: Does the NUREG document
19 explain the basis for picking these particular ones?
20 I know it's based on the survey, but, I mean,
21 somewhere you looked at how many are of this type and
22 how many are this type, and said, well, because most
23 of them are this type this is what we are going to
24 test?

25 MR. LETELLIER: The explanation is very

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1 brief. At the onset of this study, we had informal
2 discussions with the industry at various workshop
3 settings. We asked for the staff's advice on specific
4 information. And, in the end we simply looked in the
5 catalogs. We looked at what was available for these
6 flow rates and delta P applications.

7 MR. CARUSO: And, some one person made a
8 decision that this is the typical -- typical
9 configuration?

10 MR. TREGONING: Well again, typical is
11 probably too strong a word. What we tried to do is
12 get something that was within the ballpark,
13 essentially, of the types of contact areas and stem
14 dimensions that would be --

15 MR. CARUSO: Who made that decision, was
16 that research or was that you guys?

17 MR. LETELLIER: It was primarily our
18 recommendation on the contractor, on LANL's side, and
19 it obviously has been reviewed by the staff.

20 We don't have any contradictory evidence
21 to cause us to change our choices at the moment.

22 As we get into the test metrics, you'll
23 see that our characterization of the valve will be
24 very familiar to the plan engineer, and they will be
25 able to look and see, what are my valve loss

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1 coefficients? Does this make sense to me?

2 DR. KRESS: When you change
3 configurations, you change both the stem and the seat,
4 is that correct?

5 MR. LETELLIER: That's right. They are
6 made in pairs.

7 DR. KRESS: Those are the only two things
8 you change.

9 MR. LETELLIER: That's right.

10 This configuration gives us a couple of
11 choices for inspection. You can take off the lower
12 plate, without removing the throat, to actually change
13 out the internals we take off the top head and remove
14 the flow path.

15 There is --

16 DR. SHACK: There was some discussion
17 yesterday that these valves are set to balance flow.
18 How did you choose your valve openings?

19 MR. LETELLIER: That is true, to my
20 present level of understanding, that some plants
21 balance and lock these valves in position. Other
22 plans can actually actuate them remotely, or manually,
23 during the accident sequence.

24 We chose our flow gaps, we chose a range
25 of flow gaps, in order to achieve the delta P and flow

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1 that we wanted to have.

2 DR. BANERJEE: Is this flow gap the
3 critical thing, or is it the whole combination of up
4 stream chamber, where you might get vertical motions
5 and things?

6 MR. LETELLIER: There is clear evidence in
7 the data that we look at that it is a combination.
8 It's an integrated system.

9 Obviously, the gap, as measured
10 perpendicularly to the ring in this manner, that
11 controls the flow path area, but the details of the
12 internal flow dictate how much the debris is entrained
13 and how much will reside in the cavity.

14 DR. BANERJEE: Good.

15 Now, those cavities are typical?

16 MR. LETELLIER: Yes, to the best of our
17 ability. We tried to match the adjacent volumes and
18 the flow path complexity.

19 There is a typographical error, you want
20 to change this annotation to 45 large at the bottom,
21 and it simply means that the diameter of the two large
22 stems are identical, but the angles are not.

23 DR. KRESS: Now the active -- through the
24 gap you go to was a -- and an annulus for going to the
25 outlet, and is the designs in the mentioned event

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1 critical?

2 MR. LETELLIER: On the outlet side?

3 DR. KRESS: Yes, on the outlet side, on
4 Figure 2, the annulus.

5 MR. LETELLIER: Through the upper chamber?

6 DR. KRESS: Yes.

7 MR. LETELLIER: One of the problems with
8 testing, studying this type of phenomena is, it's very
9 difficult to determine exactly where the debris may
10 have been lodged. We can test delta P flow across the
11 system, but once we take it apart it may have moved,
12 whether it was initially trapped in one location or
13 another.

14 To my knowledge, any of the debris that
15 was recovered was from the lower chamber, and once it
16 had passed through the gap it was easily flushed out.

17 There may have been small quantities
18 lodged in the upper cavity as well.

19 MR. CARUSO: Did you get any debris in
20 that upper balance chamber at all?

21 MR. LETELLIER: That was the question that
22 Dr. Kress was just asking.

23 MR. CARUSO: Oh, I'm sorry.

24 MR. LETELLIER: That's what he just asked.

25 MR. CARUSO: I thought he was talking

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1 about the outlet.

2 DR. BANERJEE: Do you do some calculations
3 of the streamlines and the fluid dynamics of this
4 valve before you happily put stuff into it?

5 MR. LETELLIER: No, we have not.

6 DR. BANERJEE: It seems an obvious thing
7 to start with.

8 MR. LETELLIER: We have offered to do
9 that, but instead chose to go to the data.

10 Now that we have evidence of loading in
11 the chamber and trapping in the throat, we could use
12 a CFD analysis to reduce that data and understand why
13 it happened.

14 DR. BANERJEE: Because otherwise you don't
15 know that you have anything similar between valves, or
16 what are the controlling phenomena, what's going on.

17 MR. LETELLIER: Part of the difficulty
18 with that is the diversity of designs in the industry.

19 DR. BANERJEE: Yeah, but it's cheap to run
20 a computer calculation, rather than doing an
21 experiment, if you can actually show that the two
22 correspond.

23 MR. LETELLIER: Yes, I agree, that that
24 cross comparison is useful.

25 DR. BANERJEE: Because this is a bit ad

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1 hoc.

2 MR. LETELLIER: I absolutely agree that
3 that calculation would be of benefit. But, on the
4 other hand we would have dozens of designs --

5 DR. BANERJEE: Sure, run them all, it
6 takes you what, an hour or two?

7 MR. LETELLIER: -- no.

8 DR. BANERJEE: I'll do it for you.

9 MR. LETELLIER: The run time is incidental
10 compared to the set up, having the geometries.

11 DR. BANERJEE: There are, of course, now
12 you can scan these in from SDL files and CAD files.
13 I don't think you should make a big issue of that, it
14 is really fairly easy to do nowadays.

15 MR. LETELLIER: I would love to do it if
16 we had a cooperative vendor to provide the geometry
17 files it would not be a huge effort.

18 DR. BANERJEE: Yes, if you have the CAD
19 files it's fairly trivial to set up the mesh.

20 MR. LETELLIER: That's true.

21 MR. TREGONING: But, I'd agree with Bruce,
22 I mean, we could have done it first, but it seemed
23 pointless if we were going to go through this
24 experimentation and even in the surrogate condition
25 when we are trying to create blockage, even if we

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1 couldn't create blockage in those conditions, you
2 know, it would have served very little purpose at that
3 point.

4 DR. BANERJEE: Yes, maybe, but this really
5 points to the point that Graham was making, that, you
6 know, it would be nice to do some pre-experiment
7 predictions and see how well you did, because
8 eventually the science, I mean, this is not all ad hoc
9 stuff that you are doing continuously.

10 MR. TREGONING: It is science. I would
11 say that blockages is prone to some of the same issues
12 that we've been dealing with over the last day, day
13 and a half, you are going to see that in the data.
14 It's a very stochastic, non-linear process to try to
15 predict.

16 DR. BANERJEE: But, even that was science.

17 MR. TREGONING: Yes, I would agree.

18 MR. CARUSO: What is the black pad on the
19 12 o'clock position on the picture of the ring?

20 MR. LETELLIER: I believe that this is
21 actually one of our shims, and I'll explain the test
22 matrix. We needed to calibrate the percentage of
23 blockage, and so we actually used epoxy to introduce
24 a rubber gasket, in essence, blocking part of the
25 flow.

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1 We did experience some technical
2 difficulties during the course of testing. We
3 occasionally would score the face and have to
4 remachine them. That was part of the benefit of this
5 design, is we could remanufacture the replacement
6 parts at minimal cost.

7 DR. SHACK: Did you actually try a hard
8 face, I mean, or is this just stainless steel?

9 MR. LETELLIER: These are -- these are
10 hardened stainless steel, but I'm not familiar with
11 the industrial quality that's used in the plant. It
12 was not our intention to study erosion, and, in fact,
13 our apparatus has only a few tens of hours of service
14 life, compared to a plant condition.

15 DR. SHACK: That's why I was surprised at
16 the wear in the title.

17 MR. TREGONING: Again, we were looking for
18 anecdotal evidence, again, just within these valves,
19 but you are right, they weren't hard faced in any way,
20 so we wouldn't claim that that had any particular
21 applicability.

22 MR. LETELLIER: This next slide itemizes
23 the measurements that were taken and what parameters
24 we were interested in. We were interested in a
25 spectrum of debris characteristics, the types, the

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1 three insulation products, their size, their shape
2 relative to the throat opening, how much mass we
3 introduced at one time, and at what rate we introduced
4 the debris.

5 DR. KRESS: When you say size, is that a
6 distribution?

7 MR. LETELLIER: Clearly, the one exception
8 is the RMI, as surrogate debris we actually had
9 regularly shaped square and rectangular strips of 1/8
10 and 1/4, and 1/4 by 1/2 inch aspect ratios.

11 The shredded insulation was blender
12 processed, as we've already discussed, and it was of
13 sizes representative of those that can pass, have been
14 shown to pass, through a sump screen.

15 And incidentally, when we talk about
16 penetration through a sump screen, it's very important
17 to distinguish between the clean configuration and the
18 partially-blocked configuration. All of our tests
19 were done with nominally clean sump screens.

20 We also looked at the shape of the debris,
21 the location, and the mass that was recovered at
22 various points. The RMI oils, for example, showed
23 clear signs of creasing and bending, as it was
24 extruded through the valve.

25 We changed out the stem geometries and a

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1 range of gap settings.

2 DR. SHACK: Bruce, you mentioned, you have
3 no sump screen in here, did you pre-filter the debris
4 through a sump screen, so that the stuff you had you
5 knew would pass through a sump screen, or is this just
6 blender processed?

7 MR. LETELLIER: It's simply blender
8 processed, and the -- the size distribution of what's
9 able to pass through the screen looks very much like
10 the debris that we introduce. However, the total
11 quantity that passes through is less.

12 DR. SHACK: Okay, and you know that from
13 the previous work.

14 MR. LETELLIER: That's right.

15 So, we were able to avoid that
16 complication of pre-sieving.

17 We conceived this design in exactly the
18 way you suggest, with debris introduced in the
19 flume, it would pass through a screen, through the
20 pump, and through the valve. And, our primary concern
21 was the pump.

22 MR. TREGONING: Well, and the other down
23 side of that, you can't -- it's harder to quantify
24 what gets through, so it's harder to make it a
25 systematic --

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1 MR. LETELLIER: Yes, you have to catch it
2 in order to quantify the penetration.

3 DR. SHACK: Right.

4 DR. BANERJEE: Your pump was not typical
5 of the ECCS pumps, right?

6 MR. LETELLIER: It was typical in its
7 design, but not in its capacity. It was able to -- it
8 was able to achieve the flow rates of 75 to 100
9 gallons per minute that you might expect in a HPSI
10 line, but the pressure was limited to about 485 psi.

11 Just for point of reference, in the clean
12 configuration the delta P across the HPSI valve in
13 service is between 20 and 200 psi, so we are easily
14 able to initiate the sequence, but not to achieve the
15 maximum delta P from the event of blockage.

16 To continue, we monitored the water
17 temperature upstream and downstream, the gauge
18 pressures across the valve, and the flow rates. Most
19 of the data were collected at 75 gpm.

20 DR. BANERJEE: Is there a way to
21 characterize what you are seeing, or are you going to
22 tell us about that.

23 MR. LETELLIER: That's the next bullet,
24 the key parameter was the valve loss coefficient. We
25 struggled initially to decide on a metric, minimal

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1 level of detectable pressure loss, minimum amount of
2 flow path area. In fact, there is no criteria in the
3 industry for degraded performance. They install, test
4 and operate these valves as if they are completely
5 clean, and in pristine condition.

6 So, the best we could do was characterize
7 the performance of our particular apparatus, and we
8 chose the valve-loss coefficient as a good indicator
9 that's proportional to blockage. It's a very simple
10 relationship from first law energy balance in the
11 lower left, that if the elevations are the same, and
12 the velocities are the same before and after the
13 valve, you can attribute any delta P to the body
14 itself, and that's the coefficient K.

15 In the appropriate units of gpm and psi,
16 it has a simplified expression that we use commonly.

17 Alternatively, a plant engineer may be
18 more familiar with the CV or the flow cap coefficient,
19 which is a reciprocal square root.

20 DR. KRESS: It's the same thing, just a
21 different --

22 MR. LETELIER: Exactly, and we prefer to
23 have something that was directly proportional to the
24 delta P.

25 We've discussed most of the debris

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1 characterization already. The NUKON was pre-shredded
2 as supplied by the vendor, and then blender processed
3 on site. The calcium silicate that we used was
4 coarsely crushed, I'm told, by a forklift at the
5 vendor.

6 DR. BANERJEE: It's not a lead shredder.

7 MR. LETELLIER: No, and we also sieved it
8 on site.

9 DR. SHACK: How big was the truck?

10 MR. LETELLIER: In order to improve the
11 consistency of our size distribution, we pre-sieved it
12 to a couple of size gradations.

13 Did we intentionally remove the fiber?

14 MR. TREGONING: Usually.

15 MR. LETELLIER: So, we took out the fiber
16 binder.

17 MR. TREGONING: Well, intentionally, is
18 too strong a word, quite often the fiber binder would
19 be in clumps and it would be removed by the sieves.

20 MR. LETELLIER: But, if there were any
21 remnants that got through, we didn't go through and
22 pick them out, certainly.

23 DR. SHACK: Right.

24 MR. LETELLIER: And, the debris loadings
25 were parametric, we'll look at those amounts as we go.

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1 The broad overview of our experimental
2 approach was first and foremost to establish the
3 baseline loss coefficient for our clean configuration
4 over the range of gap openings and flows that we're
5 interested in.

6 Our loss coefficients were then calibrated
7 to a known -- known obstruction, in terms of blockage
8 area, using simulated shims, and I'll show you the
9 calibration curve next.

10 So, eventually, we can relate a change in
11 K to some physical proportionality of blockage.

12 DR. KRESS: Just percent of the gap area
13 blockage, is that --

14 MR. LETELLIER: Essentially, yes, and we
15 recognize that there is internal structure to the
16 flow. We were not able to look at various locations,
17 it was a very difficult test to do, to epoxy the shims
18 in place and actually set the valve tightly against
19 it.

20 In most cases, our data are reported in
21 terms of the percent increase in the loss coefficient,
22 compared to the clean configuration. And,
23 occasionally, we do report them in terms of a
24 conversion to the equivalent blockage area.

25 So, in order to implement the experimental

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1 approach, the test metric included three components,
2 the baseline tests, the shim tests, and then a series
3 of debris introduction tests.

4 The debris effects were examined in three
5 series or three phases. Initially, we introduced them
6 one at a time, the so-called single debris test of
7 various quantities, and then next in combinations of
8 two component mixtures and then three component
9 mixtures, also in various orders of introduction. And
10 finally, we looked at the potential for gradual or
11 continuous accumulation in the third series.

12 The figure that illustrates the
13 quantitative data are for the shim test calibrations.
14 We tested -- one, two, three, four, five -- we tested
15 six discreet fractions of valve blockage, all at 75
16 gpm.

17 DR. BANERJEE: You mean valve openings.

18 MR. LETELLIER: No, actually, these were
19 all for constant volumetric flow of 75 gpm, and so
20 that predetermined the proportion of the valve that we
21 could block.

22 DR. BANERJEE: Well, I'm a little confused
23 by what you mean by block, that's all, is it the valve
24 opening which is changed?

25 MR. LETELLIER: If you imagine a fixed

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1 valve opening that we simply -- we glued or epoxy
2 adhered a rubber shim, so that it physically prevents
3 flow from passing through a portion of the annular
4 gap.

5 DR. BANERJEE: What was the reason for
6 doing that?

7 MR. LETELLIER: So that eventually we
8 could interpret our data, which are measured
9 conveniently in terms of a valve loss coefficient, we
10 could relate that to a physical configuration of
11 debris.

12 DR. BANERJEE: So, you are interpreting
13 that as some percent blockage looking at that line
14 there.

15 MR. LETELLIER: Yes, at least we've made
16 the connection. It's possible to interpret it that
17 way.

18 DR. BANERJEE: So, these shims were put
19 sort of uniformly, or were they just blocking one area
20 of the valve, or how did you place them?

21 MR. LETELLIER: I was about to mention
22 that we understand that there are complex internal
23 structures in the flow, but we didn't have the luxury
24 of randomizing the percent of blockage for the
25 calibration tests. They were all place contiguously on

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1 one side of the valve.

2 If we would go back to the --

3 DR. BANERJEE: Go back to that diagram.

4 MR. LETELLIER: The schematic?

5 DR. BANERJEE: Right.

6 MR. LETELLIER: If you'd jump back to
7 that.

8 So, we do have, obviously, eddies,
9 internal flow during this bend in the flow. And, at
10 the moment I'm not prepared to describe whether the
11 shims were placed on this side of the gap or this
12 side.

13 DR. BANERJEE: But, they were placed on
14 one side of the gap.

15 MR. LETELLIER: Yes, at about 90 degrees.

16 CHAIRMAN WALLIS: I'm sorry, I've been
17 out, are you just going to talk about valve blockage
18 today, that's all?

19 MR. LETELLIER: Yes.

20 CHAIRMAN WALLIS: Because the most
21 interesting part of your report, I found, was the
22 bypass of the screen. Aren't you going to talk about
23 that at all? Is anyone going to talk about that
24 today?

25 MR. TREGONING: We hadn't planned on it,

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1 just because that --

2 CHAIRMAN WALLIS: That's the more
3 interesting part.

4 MR. TREGONING: Apparently, we thought
5 this was the most interesting.

6 CHAIRMAN WALLIS: Can you bring that to
7 the full committee. I mean, you sent us the report,
8 we are very interested in it.

9 MR. TREGONING: Okay. If you have
10 questions, we'd be happy to answer them.

11 CHAIRMAN WALLIS: We're excited to hear
12 about it.

13 MR. TREGONING: No, and the reason we
14 didn't focus on it is because that work has been
15 completed for well over a year. I guess I assumed
16 that --

17 CHAIRMAN WALLIS: Well, we didn't know
18 about it.

19 MR. TREGONING: -- okay, I guess I had
20 assumed that there may have been a prior presentation.
21 We can certainly put together some of the salient
22 points for the --

23 CHAIRMAN WALLIS: I'm sorry to interrupt,
24 but I needed to know that.

25 MR. LETELLIER: Just a thumb nail sketch

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1 of the penetration study, I mentioned before you
2 returned that all of our penetration tests were
3 conducted in a clean configuration. So, if we
4 introduced a charge of debris, it did not have the
5 benefit of a previously established bend.

6 CHAIRMAN WALLIS: Yes.

7 MR. LETELLIER: The calcium silicate was
8 very difficult to retain any of that mass, 95 to 99
9 percent passes through easily in the sizes we tested.

10 The RMI is problematic. It's difficult to
11 introduce it against the debris without confounding
12 that with a transport -- transportability, and we
13 tried different mechanisms, resuspension from the
14 floor, dropping it directly in front of the screen,
15 but in general penetration fractions are very
16 sensitive to the relative size, and on the order of 30
17 to 40 percent --

18 MR. TREGONING: Tops.

19 MR. LETELLIER: -- maximum penetration.

20 CHAIRMAN WALLIS: It's not close to zero.

21 MR. LETELLIER: That's true.

22 MR. TREGONING: But again, these were
23 relatively elevated flow rates to remove some of the
24 difficulties with having debris either settling out or
25 accumulating at the bottom of the screen.

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1 We didn't want the debris to interact
2 during those tests, so the flow rates were higher than
3 might be expected in the modified designs.

4 CHAIRMAN WALLIS: And, what about
5 fiberglass?

6 MR. LETELLIER: I am thinking on the order
7 of 15 percent blockage, somewhat less.

8 MR. TREGONING: NUKON was very sensitive
9 to processing, that's where you saw quite a bit of
10 description between leaf shredding and blender
11 process. We had a much higher percentage of blender
12 process NUKON that would get through, it's finer,
13 obviously.

14 CHAIRMAN WALLIS: Right, do we know what
15 the sizes are in the LOCA?

16 MR. TREGONING: I'm sorry?

17 CHAIRMAN WALLIS: Do we know what the
18 sizes are from a LOCA?

19 MR. TREGONING: In terms of whether --

20 CHAIRMAN WALLIS: Whether it's a leaf
21 shredder or blender process.

22 MR. TREGONING: I'll let you take that
23 one.

24 CHAIRMAN WALLIS: There's probably some --

25 MR. TREGONING: Distribution, certainly.

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1 CHAIRMAN WALLIS: -- there's got to be
2 some standard size distribution from a large LOCA or
3 something. You didn't make any calculation.

4 MR. LETELLIER: Of course we do not have
5 calculations for that, we do have evidence from the
6 air jet tests that were done for the boiling water
7 reactor studies that show us a range of sizes between
8 individual fibers, to small clumps, up to shreds of
9 two inches and larger, to partial blankets.

10 For practical reasons, we've chosen the
11 leaf shredder approach as giving a visual
12 representation of the small shreds.

13 CHAIRMAN WALLIS: Yes, a guy off the
14 street could have told you you get something between
15 small fibers and large chunks, you have to get some
16 kind of a quantification, and the problem is, if you
17 are going to just have numbers like 30 percent,
18 something, transmission through the screen, someone
19 can just take that and use it, and it may be
20 completely inappropriate. You've got to have
21 something that's scaled or related to --

22 MR. LETELLIER: The distributions in size
23 from experiment, they are available, and we tend to
24 focus on the transportable sizes, at least under flow
25 velocities typical will fill up. The partial blankets

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1 are, perhaps, not as much a concern, unless they
2 degrade in turbulent flow.

3 Now, the other piece to your question was,
4 how representative is blender processed material, and,
5 in fact, during the integrated tank testing done at
6 UNM, where we had a 1/10th scale plant containment
7 sump, we have evidence that the debris -- piles of
8 debris in the leaf shredder configuration actually
9 degrade slowly over time. It's possible to build very
10 uniform mats out of individual fibers, and that's our
11 motivation for blender processing. The details will
12 vary, as we've learned.

13 DR. BANERJEE: You have no way, if I
14 remember the report, to characterize your vendor
15 process stuff, because if you drive the glomerate or
16 something, right? You didn't give any distribution of
17 sizes or anything.

18 MR. LETELLIER: That's correct, we have
19 not. Due to the difficulties of forming uniform beds
20 for the purpose of head loss testing, UNM and LANL
21 started implementing the blender.

22 When PNNL adopted that approach, they
23 recognized that they needed something that was much
24 better controlled, and they developed the R4 metric
25 for screen penetration, as something proportional to

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1 the degree of separation between fibers.

2 DR. BANERJEE: So then, it gives you a
3 measure, but it doesn't tell you what the physical
4 size of the things are.

5 MR. LETELLIER: That's correct.

6 DR. BANERJEE:

7 CHAIRMAN WALLIS: If you follow the
8 guidance that came out, I think that it's very crude.
9 I mean, it said that you assume half of it is shredded
10 and half of it is 4x4 clumps or something, it's
11 something very, very crude, if I remember from the
12 guidance that we looked at. That would, perhaps, lead
13 to very conservative predictions.

14 MR. LETELLIER: It does. the proportion
15 of fine material is intentionally over estimated, and
16 it's assumed to be 100 percent transportable.

17 CHAIRMAN WALLIS: Right.

18 MR. LETELLIER: And, in fact, the
19 degradation component of even the large has been --

20 CHAIRMAN WALLIS: This doesn't help you
21 very much, because it means that whatever they assume
22 is 40 to 50 percent if it gets to the sump anyway, and
23 gets to the screen anyway.

24 MR. LETELLIER: Right.

25 CHAIRMAN WALLIS: Which may turn out to be

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1 very conservative. I just don't know.

2 Okay, thank you. I've made you digress.

3 DR. BANERJEE: I just wanted to go back to
4 what you are doing with the shims. If I understand
5 the reason for doing that, it's to get a way to
6 interpret the data you get with blockage.

7 Now, let me ask you, in reducing the flow
8 area why did you choose shims rather than just opening
9 and closing the valve, change the flow that way?

10 MR. TREGONING: We did both, actually.
11 The baseline test did exactly that. We didn't show
12 that, because they are rather rote, but -- and if you
13 look at -- one of the concerns and one of the genesis
14 behind the shim test is, we had a question whether if
15 we had nine uniform flow through the valve if the
16 correlation between valve area and the K increase
17 would change.

18 Actually, we don't show the spot here, but
19 when we did the shim test and compared it with the
20 more uniform valve opening test, with respect to this
21 plot, you know, delta K increase versus low blockage,
22 they actually end up lying pretty close to one
23 another.

24 So, the shim test, at least as we've been
25 able to demonstrate, provided confirmation that the

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1 more simplistic test was not an unrealistic measure of
2 what the blockage was.

3 DR. BANERJEE: You looked at the effect of
4 non-uniform flow through the data.

5 MR. LETELLIER: Essentially, that's right.
6 Thank you, Ralph.

7 DR. KRESS: Those look like the same curve
8 to me.

9 MR. TREGONING: These are different
10 valves.

11 DR. KRESS: I know, but they look like I
12 would have drawn the same line to the data.

13 CHAIRMAN WALLIS: It's just area, isn't
14 it? I mean, this is --

15 MR. LETELLIER: Yes, they are pretty
16 consistent.

17 CHAIRMAN WALLIS: -- this one over here --

18 MR. LETELLIER: Yes, this was a
19 calibration where we intentionally introduced the non-
20 uniform blockage.

21 CHAIRMAN WALLIS: Reduced the area, all
22 right.

23 MR. TREGONING: Although, I will -- before
24 we get off of this, some of the apparent consistency
25 is due to scale as well. I think the biggest

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1 differences are down at the lower percentage increases
2 of K, the more lower valve blockages around 10 to 15
3 percent, where your K increases are on the order of 20
4 to 30 percent.

5 DR. KRESS: Yes, and that's the level that
6 we don't care much about, right?

7 MR. TREGONING: Well, but you are going to
8 see in the testing that that's the level that we tend
9 to be in for most of the test results.

10 CHAIRMAN WALLIS: Is this curve a theory?

11 MR. TREGONING: No.

12 CHAIRMAN WALLIS: It could be a theory
13 which simply says that the area is --

14 DR. KRESS: What's the form of the
15 equation?

16 DR. BANERJEE: I guess they were looking
17 at whether just changing the shape of the area --

18 CHAIRMAN WALLIS: That's the easiest
19 problem to solve, tell us what to do with the
20 difficult ones.

21 MR. LETELLIER: One other purpose for
22 conducting this test is to quantify our minimum level
23 of detection for this system. How sensitive are we in
24 terms of blockage effects, and through this and other
25 studies we'd like to say we have a detection threshold

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1 of about 5 percent blockage and no less.

2 As I said earlier, there is no performance
3 standard for degraded performance. These valves are
4 assumed to be clean when they are operable.

5 DR. KRESS: Do you have K values for real
6 valves out there, just to compare and see if you are
7 close?

8 MR. LETELLIER: I don't have them in front
9 of me. We did compare them in terms of the CV metric,
10 the reciprocal square root.

11 MR. TREGONING: Yes, that is information
12 we've tried to get, even getting the K information for
13 real valves is not -- you know, it's not an easy
14 exercise. You have to do a good bit of digging.

15 CHAIRMAN WALLIS: What about number two,
16 based on the propensity for NUKON to transport, I
17 thought you told me earlier when I asked you this, the
18 fiberglass -- lesser -- 95 percent of the CalSil one,
19 but sometimes most of the fiberglass was cored, and I
20 think you said --

21 MR. LETELLIER: The statement also --

22 CHAIRMAN WALLIS: -- 15 percent went
23 through or something, but you said it was sensitive to
24 processing, so if it was chopped up this propensity
25 for NUKON to transport is when it's really chopped up

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1 fine, is that it?

2 MR. TREGONING: Read the whole line.

3 CHAIRMAN WALLIS: Oh.

4 MR. TREGONING: This is combining the
5 screen penetration results with the propensity to
6 cause blockage.

7 CHAIRMAN WALLIS: No, it says based on the
8 propensity for NUKON to transport and penetrate the
9 screen.

10 MR. TREGONING: Right, keep going.

11 CHAIRMAN WALLIS: That's a statement in
12 its own right.

13 MR. TREGONING: Yes, but it's a
14 conditional clause of which --

15 CHAIRMAN WALLIS: Well, I don't know.

16 MR. TREGONING: -- you know, read what
17 follows.

18 CHAIRMAN WALLIS: No, but it says -- you
19 are saying already that it's highly likely the NUKON
20 will go through the screen. Therefore -- no, it
21 stands on its own, doesn't it?

22 MR. LETELIER: This is -- it is intended
23 to be a combined judgment, based on both its
24 penetration potential and its retention potential in
25 the valve.

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1 CHAIRMAN WALLIS: Yes.

2 MR. LETELLIER: And, you'll see that as we
3 look through the data, that NUKON does tend to
4 accumulate in the valves.

5 MR. TREGONING: And, just to explain it,
6 CalSil was certainly much more likely to penetrate.
7 However, CalSil by itself --

8 CHAIRMAN WALLIS: That is true, I don't
9 think the NUKON is flexible enough and there's enough
10 pressure.

11 DR. BANERJEE: And, the CalSil would
12 happily carry on into the reactor, right, block the
13 little holes there?

14 MR. LETELLIER: But, in combination with
15 other debris types the CalSil does become an important
16 contributor, and we'll see that.

17 MR. TREGONING: Right, you'll see that
18 later.

19 DR. BANERJEE: Well, eventually it will
20 catch on the NUKON, right?

21 MR. TREGONING: It could catch on other
22 seeds that might be there before it.

23 MR. LETELLIER: In general, and not
24 surprising, the higher the loading and the larger the
25 debris sizes resulted in a proportional increase in

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1 the valve loss coefficient. There were no surprises
2 there.

3 However, there is variability in the data.

4 For an equivalent mass loading, the valve
5 loss coefficients were typically higher for reflective
6 metallic chards than they were for an equivalent mass
7 of NUKON, I think simply because if you are able to
8 lodge a fragment of RMI that obstructs a very large
9 area immediately, and then the proportional mass of
10 NUKON is simply smaller.

11 CHAIRMAN WALLIS: I wasn't here earlier,
12 but it seems to me clear, you can put the valve in a
13 position where it is almost closed, where it is bound
14 to catch everything.

15 MR. LETELLIER: Yes.

16 CHAIRMAN WALLIS: Then you build up a huge
17 plug in the pipe. Is that not something that can ever
18 happen?

19 MR. TREGONING: Well, but again, normally
20 the way -- and again, my understanding of how these
21 valves are set, is they are normally set with a higher
22 gap than your screen penetration or mesh sizes, with
23 the idea that --

24 CHAIRMAN WALLIS: When they are open?

25 MR. TREGONING: -- yes, when they are open

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1 and operating.

2 CHAIRMAN WALLIS: My question is, if you
3 open and close them, and you've got some debris there
4 which doesn't open and close fully, then you have flow
5 through a very small aperture.

6 DR. BANERJEE: But, yesterday they told us
7 that there's some minimum.

8 CHAIRMAN WALLIS: Does that mean it can't
9 be closed completely?

10 DR. BANERJEE: No, apparently, that's not
11 the way they are operating.

12 CHAIRMAN WALLIS: It will be closed at
13 some point. Who told us that yesterday?

14 MR. LETELLIER: Typically, these are --
15 they are not intended to be actuated during the
16 accident sequence. Some plants are physically locked
17 in place and cannot be actuated, some plants can be
18 actuated if blockage is perceived, or if they need to
19 rebalance the flow injection paths.

20 CHAIRMAN WALLIS: If they are blocked, you
21 just open them wide and clear it out.

22 MR. LETELLIER: Perhaps.

23 MR. CARUSO: Are these manual valves
24 usually, or do they have motor operators on them?

25 MR. LETELLIER: My impression is that

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1 typically they are manual, and I have heard of some
2 pneumatic actuation.

3 MR. CARUSO: They are set and left. As
4 far as I know, they are usually set and left.

5 MR. TREGONING: Yes.

6 MR. LETELLIER: Yes, they serve two
7 primary functions, to balance the flow and also to
8 throttle the pump, to prevent run out.

9 If it were completely wide open, then the
10 pump would have no back pressure to work against.

11 The plants have -- anecdotally, they have
12 recognized the potential for -- first of all, I think
13 their primary concern is erosion and loss of function
14 for that valve, so they have started to -- I know of
15 plants that have introduced orifice plates downstream
16 of the valve to take -- to burn off some of the head,
17 so that they can relax the gap opening inside the
18 throttle valve.

19 CHAIRMAN WALLIS: What is the typical
20 velocity, just a number, through the gap opening?

21 MR. LETELLIER: I knew you would ask that.

22 CHAIRMAN WALLIS: Ten meters per second,
23 one meter per second.

24 MR. LETELLIER: We tend to think in terms
25 of the volumetric flow.

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1 CHAIRMAN WALLIS: All right.

2 MR. LETELLIER: The dimensions are
3 typical, the flow rates are set to be nominally 75 gpm
4 or less. The velocities are tens of feet per second.

5 CHAIRMAN WALLIS: What's the Reynolds
6 number in pipes?

7 MR. LETELLIER: I don't have that
8 information.

9 DR. KRESS: I was wondering if there was
10 a FROUDE number for debris that you change the nature
11 of the debris just to do the turbulence, before it
12 ever gets that.

13 CHAIRMAN WALLIS: FROUDE number is for a
14 different field altogether. You are talking about a
15 FROUDE number?

16 DR. BANERJEE: A fraud number.

17 CHAIRMAN WALLIS: That's for lawyers.

18 DR. KRESS: Any way, I was wondering if
19 the debris has the ability to change its nature before
20 it ever gets to that.

21 MR. LETELLIER: It is possible, and I
22 think in the power plant situation that's most likely
23 to occur within the pump itself, and those details we
24 are not able to reproduce, internal flow.

25 However, the FROUDE number, fraud number,

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1 is actually important for the blender processing,
2 where we are intentionally trying to separate the
3 debris from itself.

4 DR. BANERJEE: But, the velocity is pretty
5 high.

6 MR. LETELLIER: Yes.

7 DR. BANERJEE: That's the main thing.

8 MR. LETELLIER: As we said, for the size
9 of opening within the internal RCS this probably
10 experiences the highest velocities, which introduces
11 the possibility for self-scouring. If a blockage
12 starts to accumulate, the velocity will increase, and
13 we show evidence of that potential.

14 MR. TREGONING: In some of these tests you
15 see that happen.

16 MR. LETELLIER: Another aspect of the HPSI
17 system --

18 CHAIRMAN WALLIS: How abrasive is CalSil?
19 How abrasive is CalSil? It's pretty soft, isn't it?

20 MR. LETELLIER: Well, yes and no, it's a
21 calcium silicate. It could be considered --

22 CHAIRMAN WALLIS: So, it has some hard
23 edges too?

24 MR. LETELLIER: Yes.

25 DR. BANERJEE: But, it's not like sand.

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1 MR. LETELLIER: It is not a hard silica
2 type of sand.

3 Steve Unikewicz could probably help us
4 describe the metrics for how we would assess the
5 abrasive qualities of CalSil. It has not been tested
6 from that perspective.

7 Another aspect of the HPSI system
8 performance is the extremely high capacity for delta
9 P. If these valves were almost blocked, you could
10 experience 2,400 psi, which might have the potential
11 to extrude the debris simply, or, alternatively,
12 permanently compact it and press it in place.

13 We don't have that amount of margin. We
14 can test the initial conditions at about 350 psi, up
15 to a maximum of 485 to 500.

16 CHAIRMAN WALLIS: So, that was my concern,
17 if you had a valve that were closed, not quite closed,
18 if it ever go that, and they you said it would build
19 up this plug of debris, and then you tried to get flow
20 and you got 2,200 psi compressing the debris.

21 MR. LETELLIER: Right.

22 That's one of the phenomena we were aware
23 of, and we chose our pump to have some margin to
24 investigate that, within our safety limits.

25 The very last bullet describes some of the

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1 random variability that you are going to see in the
2 data points. First of all, we worked very hard to
3 minimize the electronic noise to less than 3 percent
4 of the mean signal, but the data jump around within
5 factors of two to five, and the very random nature of
6 the flow is my explanation for this. The self-
7 interaction of the debris, with the internal structure
8 of the flow, the debris size relative to those
9 internal eddies, the random orientation as it arrives
10 at the gap, for example, and simply the number of
11 debris elements in a unit mass. We are typically
12 testing ten grams, 25 grams, maybe 50 grams of
13 material, but that is a discreet number of RMI
14 fragments.

15 A couple of photographs to show you what
16 debris looks like when we open the chamber, and, Dr.
17 Wallis, you'll find the schematic on one of the
18 earlier pages, number seven, that shows you the lower
19 chamber. That's what we are looking at here, as we
20 pull out the internals. You can see 1/4 x 1/2 inch
21 strips of RMI. This test would have experienced an
22 increase in K value, but I cannot tell you whether the
23 fragments were lodged in the throat at under flow.

24 DR. BANERJEE: They probably have dropped
25 down when you took it out.

1 MR. LETELLIER: Yes.

2 MR. TREGONING: That's one possibility.

3 MR. LETELLIER: And, similarly, you can
4 see the yellow deposits of fiberglass that are in the
5 bottom cavity.

6 DR. BANERJEE: They are deposits?

7 MR. LETELLIER: The quality of this
8 photograph is not extremely good, but you can see the
9 granularity that represent the sort of largest flocs
10 or agglomerations here. These are composites of
11 multiple strands.

12 MR. CARUSO: Did you see any -- on the
13 seat, and on the disk, on the RMI testing, did you see
14 any impacts or evidence that the RMI, you know, had
15 gotten larger and deformed?

16 MR. LETELLIER: Scoring?

17 MR. CARUSO: Scoring at all?

18 MR. LETELLIER: Scratching?

19 I don't think that I could say we have
20 direct evidence of that. As I said, just the
21 manipulation of the valve in some cases led to
22 scoring. When we would tighten it down to the seat,
23 if we would go past that point, if there were any kind
24 of abrasive material like calcium residue we would
25 score the machined face.

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1 CHAIRMAN WALLIS: It's grinding in the
2 valve.

3 MR. LETELLIER: Yes, right.

4 We did experience that and we
5 intentionally took the opportunity to test or see if
6 we could determine the effect of K, because we had
7 good baseline information in the pristine condition,
8 and we were not able to discriminate those kind of
9 minor damage conditions.

10 The next slide begins our presentation of
11 data for the single debris series.

12 CHAIRMAN WALLIS: All right, so how did
13 these pieces get into the valve, you dropped them in
14 somewhere and flow them up to it, and some of them go
15 through?

16 MR. LETELLIER: On slide number six, it
17 will show you the manifold.

18 CHAIRMAN WALLIS: You drop them in, and
19 then -- I was just wondering, how many pieces could --
20 you go up to 60 here, under what conditions could you
21 get, say, 300 pieces in there, keep on dropping pieces
22 in, some of them get stuck.

23 MR. LETELLIER: Well, first of all, keep
24 in mind that the axis on the figure, that is the
25 number of pieces that were recovered from the chamber.

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1 We would typically introduce them in batches of 50 to
2 100 grams, which is a nice handful of RMI.

3 That was our metric for the debris
4 loading.

5 CHAIRMAN WALLIS: What happens in the
6 path, this thing is running for some time, maybe
7 thousands of pieces go through, I don't know.

8 MR. LETELLIER: Perhaps, that's true, but
9 distributed over time.

10 CHAIRMAN WALLIS: Right.

11 If there is some way for them to get
12 trapped in there, they can build up, I just don't
13 know.

14 MR. LETELLIER: We will look at that
15 question at the very last series, under the
16 accumulation potential.

17 CHAIRMAN WALLIS: Let me ask, the pieces
18 of RMI that are trapped, were they larger than the
19 gap, all of them, or were there some smaller ones?

20 MR. LETELLIER: That's a loaded question.
21 On edge, they are all smaller, but in aspect ratio
22 they are all bigger.

23 CHAIRMAN WALLIS: It depends which way
24 they try to get through the gap.

25 MR. LETELLIER: It just depends on which

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1 way they are oriented.

2 MR. TREGONING: Well, and again, most of
3 these things post test you saw a lot of crumpling of
4 the RMI debris, so there was some variability in terms
5 of how it would crumple that would affect the
6 dimensions as well.

7 CHAIRMAN WALLIS: Usually, once they get
8 held up against the gap, they stay there, because of
9 hydrostatic dynamic forces, then they maybe fall down
10 when you turn off the flow.

11 MR. TREGONING: Yes, right.

12 CHAIRMAN WALLIS: And, you can imagine
13 them sort of flying off, and some of them get stuck in
14 the position where they are held against the wall,
15 others go through.

16 DR. BANERJEE: Are these small pieces, or
17 they were all large pieces?

18 MR. LETELLIER: They were all uniform size
19 of either 1/4 inch square or 1/4 x 1/2 inch strips.

20 CHAIRMAN WALLIS: This is what you fed in.

21 MR. LETELLIER: This was our prototypical
22 chard or fragment of RMI.

23 MR. TREGONING: And again, those sizes
24 were picked based on the earlier screen penetration
25 work, where those were some of the biggest pieces of

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1 RMI that we could get through.

2 MR. CARUSO: How thick were they?

3 MR. LETELLIER: 15 mls, we can look in the
4 report for the exact number.

5 MR. CARUSO: Very flexible.

6 MR. LETELLIER: They are very thick, very
7 flexible. Our graduate student desperately hoped we
8 could reuse this material, just to avoid the tedium of
9 cutting more source material, but, in fact, most of
10 them were folded.

11 DR. BANERJEE: By the time they got
12 through they were crumpled.

13 MR. LETELLIER: That's correct.

14 CHAIRMAN WALLIS: But, you could do a
15 calculation of the pressure it would take to crumple
16 it enough to drive it through the gap.

17 MR. LETELLIER: We could have done that,
18 yes.

19 CHAIRMAN WALLIS: Take it as a beam that's
20 loaded in.

21 MR. LETELLIER: Yes.

22 So, the first data figure shows the
23 introduction of batches of RMI as a single debris
24 type. The plots are designated by symbol, designating
25 the different stem types, the 45 degree angle with the

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1 large diameter --

2 CHAIRMAN WALLIS: Go back to my previous
3 question. When you've got this 65 or whatever it is,
4 the point over there, what fraction is that of the
5 amount of stuff you put in? That's a handful, 65 must
6 be a pretty good handful. Do you put in a few
7 handfuls, it's a fairly large fraction of what you put
8 in?

9 MR. LETELIER: No, it's less -- easily
10 less than half, I'm going to guess 20 percent.

11 CHAIRMAN WALLIS: Half, that's a big
12 fraction, I would say 5 percent is a big fraction if
13 you are dealing with a lot of debris.

14 MR. LETELIER: Yes, that's true.

15 It is a surprisingly large number of
16 fragments.

17 CHAIRMAN WALLIS: But, if you are
18 comparing it with half, that tells me it's a lot.

19 MR. TREGONING: Again, of this size RMI
20 debris, which again, was the maximum size that we put
21 in.

22 CHAIRMAN WALLIS: If you put in three
23 handfuls, and one handful got stuck, that's a pretty
24 good measure, something like that, is that it? If you
25 put in five handfuls, and one handful got stuck.

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1 MR. LETELLIER: That's probably
2 reasonable.

3 DR. BANERJEE: SO, when you got a
4 percentage increase in K, did your flow stay the same,
5 too?

6 MR. LETELLIER: We did not control the
7 flow from that point of view. We preset the gap size
8 to achieve the initial condition, and we measured the
9 delta P, and we also measured the flow rate, which
10 would tend to decline.

11 DR. BANERJEE: Would decline.

12 MR. LETELLIER: Yes, with increased
13 blockage. So, we had both terms of the equation, we
14 had the flow rate and the delta P as the data point.

15 DR. BANERJEE: So, you only show the delta
16 P here, but the flow rate goes as the square root of
17 -- no, I guess it was proportional to the K.

18 MR. LETELLIER: We are presenting the K
19 factor, the loss coefficient, which has both. It's
20 the ratio.

21 MR. TREGONING: But, most of the time, not
22 all of the time, the delta P drop dominates, I think,
23 in many of these tests, because the blockage is in
24 many cases, were still partial, so you are still able
25 to get plenty of flow through the valve.

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1 MR. LETELLIER: As we speculated, the
2 velocities will increase to maintain a special plant
3 condition where the pumps have so much excess
4 capacity.

5 CHAIRMAN WALLIS: I would like to see
6 where we are with this presentation. We had some
7 extra presentations earlier, so that's the reason we
8 are behind.

9 MR. TREGONING: We have been going about
10 an hour, though, I think.

11 MR. LETELLIER: We are taking our share of
12 the time.

13 CHAIRMAN WALLIS: You are taking your fair
14 share, so if you finish by 10:30 or something, at that
15 time we could take a break, and we just set back the
16 other presentations?

17 MR. LETELLIER: Sure.

18 CHAIRMAN WALLIS: After the break.

19 MR. CARUSO: We have one more
20 presentation.

21 CHAIRMAN WALLIS: We have one more
22 presentation, then there's the sum up and so on.

23 It looks as if we are supposed to finish
24 by 11:00, maybe we'll finish by about 12:00.

25 Okay, sorry to interrupt you. Go ahead.

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1 MR. LETELLIER: That's not a problem to
2 finish within that time.

3 One trend of interest to note in this
4 figure, if you focus on the solid square symbols,
5 which represent the smaller diameter five degree stem,
6 they are all in the lower percentages of pipe loss
7 coefficients.

8 This goes back to the questions of
9 internal flow. For some reason, this configuration
10 performs much better in all cases as we go through,
11 you will see that the smaller diameter channels the
12 flow in some way that tends to clear the debris better
13 than the others.

14 That's not what I would have expected,
15 because there's more shoulder room in the cavity in
16 the dead eddies, but, nonetheless, the data are very
17 clear in that regard.

18 DR. BANERJEE: Just say it again, so that
19 I follow what you said.

20 MR. LETELLIER: The square solid symbols
21 represent the smaller diameter five degree, the
22 shallow angle stem, which has a smaller diameter so
23 the flow path is more tightly centered in the cavity,
24 in the chamber.

25 DR. BANERJEE: And, is the chamber smaller

1 too?

2 MR. LETELLIER: No.

3 DR. BANERJEE: No, the chamber is the same
4 size.

5 MR. LETELLIER: Same size, fixed
6 dimension, and yet we consistently show less debris
7 retention and a lower impact in terms of --

8 DR. BANERJEE: If there is a bigger
9 chamber and a smaller stem area, you get less debris
10 retention.

11 MR. LETELLIER: In our case, for --

12 MR. TREGONING: The interesting point is
13 that the blue square right around there where we found
14 40 some odd pieces of debris in the chamber after the
15 test, yet there was no increase in -- there was no
16 measurable degradation in the valve loss coefficient.

17 What could be happening with that big
18 shoulder, there could be eddies that are created, or
19 maybe the shoulder is even serving as a debris
20 blockage point.

21 CHAIRMAN WALLIS: It may be that it aligns
22 differently.

23 MR. TREGONING: It's causing it to trap in
24 the --

25 CHAIRMAN WALLIS: And, this is a little

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1 bit heavier, the heavier material gets thrown out of
2 the vortices, so if that's thrown out of the vortices
3 it could be that if you have large vorticle structures
4 it could be that they are oriented as they flow
5 towards the gap, if they are oriented more in the
6 direction of going through it than across it.

7 DR. DENNING: You didn't tell us how you
8 set the gap, though. There's a standard gap size that
9 you have for each of the three different
10 configurations? How did you do that?

11 MR. LETELLIER: During our initial
12 characterization of each pristine valve, we calibrated
13 the physical gap dimension to the flow rates and the
14 pressure drops. And so, when we are ready to
15 initialize a test we can return to that physical
16 setting, in terms of a thread count. There's actually
17 a fiducial measurement block where you can use a
18 micrometer to reproduce the valve setting.

19 DR. DENNING: But, the flow areas, what
20 are the relative flow areas for those different --

21 MR. CARUSO: What we are wondering is, for
22 each of these points, what's the geometry of the flow
23 path?

24 DR. DENNING: Yes.

25 CHAIRMAN WALLIS: Is it the same area?

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1 MR. LETELLIER: First of all, we have to
2 have a common understanding of flow area, and it's
3 always measured perpendicular to the flow across --

4 CHAIRMAN WALLIS: The narrowest part.

5 MR. LETELLIER: -- across the narrowest
6 aspect of the flow channel.

7 The gap settings, obviously, we --

8 CHAIRMAN WALLIS: Is that how you define
9 your K, or is the K based on something else? What
10 area is K based on?

11 DR. BANERJEE: Let's go to the next slide
12 defining the K.

13 CHAIRMAN WALLIS: It's based on Q?

14 MR. LETELLIER: K is simply delta P over
15 Q squared.

16 CHAIRMAN WALLIS: So, if you change the
17 area, the K changes.

18 MR. TREGONING: Yes, the baseline K can
19 certainly change.

20 CHAIRMAN WALLIS: My word, it's the sixth
21 significant figure.

22 MR. LETELLIER: Yes, very accurate.

23 CHAIRMAN WALLIS: That's amazing.

24 DR. BANERJEE: The smaller valve,
25 actually, the seat is shorter, that hole is smaller.

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1 MR. LETELLIER: Yes, both the ring, which
2 I'm showing here, and the stem, are both changed as a
3 mated pair.

4 DR. BANERJEE: You show the diagram there.

5 MR. CARUSO: Are you showing there -- that
6 diagram is a 45S -- 45L configuration.

7 MR. LETELLIER: Yes.

8 MR. CARUSO: And, the 5S and the 5L
9 configuration, is that the whole side of that stem
10 there, is that the entire seating surface, so it's got
11 a much larger seating surface?

12 MR. LETELLIER: It does, yes, it has a
13 much longer flow path.

14 MR. CARUSO: A longer flow path.

15 MR. LETELLIER: So, the geometry is very
16 different for these things. I don't know how the
17 changes with K -- the same K with a 45L has a
18 different flow length than a 5S and a 5L.

19 CHAIRMAN WALLIS: Sure.

20 MR. CARUSO: And, that would be
21 interesting to know, because that might tell you how
22 it is that some debris gets through and some doesn't.

23 CHAIRMAN WALLIS: Since nobody knows
24 what's happening, we can talk about this forever.

25 MR. LETELLIER: All of those aspects are

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1 quantified in the data report, as part of valve
2 characterization.

3 DR. BANERJEE: I think if we go back to
4 the data, it was quite interesting.

5 CHAIRMAN WALLIS: The data is interesting,
6 but the explanation is speculative.

7 MR. LETELLIER: Yes.

8 DR. BANERJEE: You have to start
9 somewhere.

10 CHAIRMAN WALLIS: It's very interesting
11 data to report on.

12 MR. LETELLIER: The next slide, Figure No.
13 16 --

14 DR. BANERJEE: One thing that you don't
15 show is the -- you had another S, there were two S's
16 in that diagram you showed us, there was a 45S.

17 MR. TREGONING: That was a typographical
18 error, as Bruce mentioned earlier, it should have been
19 a 45L. The seat area is the same size.

20 DR. BANERJEE: So, you had only one S.

21 MR. LETELLIER: Large and small, two
22 diameters, two different contact angles.

23 This next figure, perhaps, answers the
24 question -- your original, most recent question. It
25 presents the RMI single debris data in terms of the

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1 gap size, and here we've done the geometry to convert
2 the stem setting to the cross sectional flow area, and
3 they are in the range of 1/16 to 1/8 inch in gap cross
4 section, and you can convert that to an annular area
5 to compute volumetric flows.

6 DR. BANERJEE: So, you show similar
7 trends.

8 MR. LETELLIER: It does. This is simply
9 an alternative presentation of the same data. We are
10 now --

11 DR. BANERJEE: Oh, okay.

12 MR. LETELLIER: -- we are converting this
13 to be explicit in terms of the gap size.

14 CHAIRMAN WALLIS: Once you are above one,
15 it's not clear it's statistically significant.

16 MR. LETELLIER: Above one?

17 CHAIRMAN WALLIS: Once you are above one,
18 it looks as if below one it's less likely to block,
19 but, you know, four, and eight, and ten, are not
20 statistically different.

21 MR. LETELLIER: Keep in mind that the
22 symbols represent different quantities of debris in
23 combination with each stem.

24 CHAIRMAN WALLIS: So, some of the points
25 shouldn't be compared with some of the other points.

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1 MR. LETELLIER: That's right.

2 You need to focus your eyes on a single
3 group of symbols.

4 DR. BANERJEE: So, all the S's still lie
5 below, right?

6 MR. LETELLIER: Yes.

7 DR. BANERJEE: The 5S group.

8 MR. LETELLIER: Yes, all the 5S's are
9 below the threshold of detection.

10 This presentation also gives you an
11 impression of the relative size of the debris
12 fragment. Remember, the RMI are discreet dimensions,
13 and the gap can be a range, a continuous range. And
14 so, we are increasing the -- actually, as we proceed
15 across the figure to larger ratios, we are physically
16 reducing the gap. We are closing the valve.

17 CHAIRMAN WALLIS: 10g means gallons per
18 minute or something?

19 MR. LETELLIER: No, the units are gap
20 size.

21 CHAIRMAN WALLIS: In grams, or what's 10g?

22 MR. TREGONING: 10g is the mass of loading
23 of the RMI, so that was 10 grams.

24 CHAIRMAN WALLIS: But, the flow rates are
25 different for all of these experiments? I don't know

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1 what to say then.

2 MR. TREGONING: No, they are all
3 nominally.

4 CHAIRMAN WALLIS: They are all the same
5 flow rate.

6 MR. TREGONING: 75 gpm.

7 CHAIRMAN WALLIS: Nominally, but they
8 change slightly as you go up in K, right, but that's
9 not the first order of it.

10 MR. TREGONING: Pressure is certainly much
11 more sensitive.

12 CHAIRMAN WALLIS: So, this could be
13 presenting increase in pressure drop.

14 MR. TREGONING: Yes. In many cases there's
15 a direct correlation.

16 CHAIRMAN WALLIS: Well, it's the same flow
17 rate, that's what it is. We are talking about a
18 difference between five and 50. Okay.

19 MR. LETELLIER: You are exactly right, the
20 previous figure is more --

21 MR. TREGONING: Let's not go backwards.

22 MR. LETELLIER: Let's move ahead to the
23 single debris NUKON tests, which we have more limited
24 data. It shows a positive correlation, as we
25 increased the mass of the loading in a charge, a slug

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1 of debris, we tend to have higher amount of retention,
2 a higher percent increase in K.

3 DR. DENNING: But now, the 5S valve still
4 is by far the best.

5 MR. LETELLIER: Now shown as diamonds,
6 it's by far the best.

7 There's actually --

8 DR. DENNING: There's something weird
9 going on.

10 MR. LETELLIER: I agree, I'm not prepared
11 to say that it's anomalous, but I think it is
12 interesting, and it's worthy of -- it's worthy of
13 comparison now to the actual plant configurations,
14 what do the valves look like, why could this be
15 atypical compared to plant performance.

16 Although the data are sparse, these are
17 reasonably well behaved trends. The X is for the 45
18 large stem show a nice proportionality, as do the 45
19 large and the 5 large.

20 CHAIRMAN WALLIS: This mass of NUKON, is
21 that the amount that gets stuck in the valve now?

22 MR. TREGONING: No, that was the amount
23 that was introduced at the beginning of the test, that
24 was the charge.

25 MR. LETELLIER: Yes, these are the amounts

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1 introduced.

2 DR. BANERJEE: But, you do have a measure
3 of how much was stuck, from a post test exam, right?

4 MR. LETELLIER: Yes.

5 The RMI pieces are easy to count.

6 CHAIRMAN WALLIS: The other graphs were
7 for -- based on the amount that got stuck.

8 MR. LETELLIER: That was for RMI, which is
9 easy to count.

10 CHAIRMAN WALLIS: Right.

11 MR. LETELLIER: For the NUKON, it's much
12 harder to recover all of the residue, but we do save
13 and dry that. It's reported.

14 MR. TREGONING: The mass loadings, and
15 there's legends where the amounts was the mass
16 introduced.

17 CHAIRMAN WALLIS: Yes, those are the ones,
18 I can see that.

19 MR. TREGONING: Yes.

20 MR. LETELLIER: Moving on to the two
21 component mixtures, just some overview observations.

22 CHAIRMAN WALLIS: I don't know how to
23 translate RMI pieces to grams.

24 MR. LETELLIER: Yes.

25 CHAIRMAN WALLIS: Okay, sorry.

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1 MR. LETELLIER: 50 grams is a handful.

2 CHAIRMAN WALLIS: 50 grams is a handful?

3 Okay, 50 grams is a handful.

4 MR. TREGONING: I don't think that
5 conversion factor is going to be sufficient for Dr.
6 Wallis. That is in the report. We do -- I just can't
7 pull the number off the top of my head.

8 CHAIRMAN WALLIS: No, you don't have this.

9 MR. TREGONING: No, like I said, we'll be
10 submitting the report shortly.

11 MR. LETELLIER: Some overview observations
12 of two component mixtures. Compared to single test --
13 single debris tests, the CalSil-RMI mixtures were the
14 only combination that exhibited a clear increase in K,
15 compared to introducing them by themselves.

16 The other pair-wise combinations were not
17 as evident.

18 DR. BANERJEE: CalSil-RMI, that's a weird
19 one.

20 MR. LETELLIER: Given that you have RMI
21 lodged in the valve, it was effective that
22 accumulating CalSil --

23 DR. BANERJEE: But, the CalSil is so
24 small.

25 MR. LETELLIER: But again, this RMI is

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1 bent, so there's plenty of trapping pockets, you know,

2 DR. KRESS: Yes, but I would have thought
3 NUKON combination with CalSil would have been a bad
4 combination.

5 CHAIRMAN WALLIS: Yes, you would have
6 thought.

7 DR. BANERJEE: That's the danger of
8 engineering judgment.

9 MR. LETELLIER: We would have thought as
10 well. The data are admittedly sparse in that regard.
11 It deserves further comparison, but it's clearly
12 evident in the information that we do have.

13 The mixtures of fiberglass and RMI, and in
14 the CalSil-NUKON, they did not differ significantly
15 from the analogous separate tests, except for one
16 exploratory case where we've literally packed the
17 chamber with CalSil-NUKON to what you might consider
18 to be an unrealistically high -- we physically could
19 not fit anymore into the chamber, and in that case --

20 MR. TREGONING: It was unsieved, though,
21 I think that was the other key component. So, it
22 still had binder in the CalSil, as well as there was
23 some initial clumping.

24 MR. LETELLIER: So, page 19 shows mixed
25 RMI-NUKON.

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1 CHAIRMAN WALLIS: Where's the one that
2 showed the clear increase in K? That's a single test.

3 MR. TREGONING: Yes, there was only a test
4 or two of that RMI-Calsil mixture, so that --

5 CHAIRMAN WALLIS: With this kind of stuff
6 it's difficult to conclude anything from one test,
7 right?

8 MR. LETELLIER: We would agree. That's
9 why we noted that as an exception and have not
10 presented it.

11 CHAIRMAN WALLIS: You presented your test
12 on this figure here, conclude what you want to
13 conclude, if you are basing it all on one test.

14 DR. BANERJEE: But, you don't show the
15 small stem.

16 MR. LETELLIER: On the previous slide for
17 the small stem?

18 DR. BANERJEE: No, I mean --

19 DR. SHACK: On the mixed debris test, you
20 don't seem to have tested the small stem, or at least
21 it's not on this graph.

22 CHAIRMAN WALLIS: It's not on this graph.
23 This is a funny trend, because if the valve opening is
24 zero you'd expect a percent increase in K to be
25 infinite, or huge.

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1 MR. LETELLIER: No, it's a percent
2 increase.

3 CHAIRMAN WALLIS: A very tiny opening
4 would get blocked up.

5 MR. LETELLIER: No, this is a
6 differential, it's a comparison of the clean
7 configuration, you essentially have a ratio of zero
8 over zero.

9 CHAIRMAN WALLIS: That's what I mean,
10 that's what I mean, though, a very small gap, which
11 has trapped all the debris, would surely give you a
12 figured percent increase.

13 MR. LETELLIER: No, because that graph --

14 MR. TREGONING: But, that gap in the clean
15 condition would have had high K initially.

16 CHAIRMAN WALLIS: You are talking about
17 percent increase.

18 MR. TREGONING: Right, compared to the
19 baseline of the clean condition.

20 CHAIRMAN WALLIS: If it traps all the
21 debris, a percent increase you'd think would be --

22 DR. BANERJEE: Yes, that's why engineering
23 judgment is bad, that's what you would have been
24 thinking, and I would have thought.

25 CHAIRMAN WALLIS: I'm still thinking. It

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1 depends, I think, on the experiment, and how much
2 stuff you put it, for how long, it's a very small gap.
3 If you put in enough stuff for long enough it's going
4 to fill the pipe and everything else, and it won't let
5 anything through, and that's sort of the limiting
6 case.

7 MR. TREGONING: Potentially.

8 CHAIRMAN WALLIS: And, then, it's going --
9 then you are going to apply your 2,200 pair size,
10 squash all that stuff.

11 Well, that's my engineering judgment.

12 DR. BANERJEE: How long were these tests
13 run for?

14 MR. LETELLIER: These tests, from the time
15 the debris are introduced to the time it passes
16 through, is only a few seconds. It literally is
17 flushed through the valve.

18 DR. BANERJEE: It's introduced as a pulse.

19 MR. LETELLIER: It's introduced as a
20 pulse.

21 DR. BANERJEE: And, when you have the very
22 small gap openings, do you, basically, capture all the
23 RMI there that goes through?

24 MR. LETELLIER: No.

25 MR. TREGONING: We had question earlier

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1 for Dr. Wallis, 10 to 30 percent, less than 50 percent
2 certainly, even in the most cases with the highest
3 amount of capture.

4 CHAIRMAN WALLIS: I think actually that
5 what I said was probably reasonable, because I can
6 take your black diamonds and extrapolate, and it's
7 increasing, it's increasing K going up, as you go down
8 in the valve opening. The points that are .05 are all
9 for different kinds of valves from the other ones, so
10 you can't extrapolate anything based on just looking
11 at the data here, because different valves are the
12 different flow rates.

13 MR. LETELLIER: It's critical to keep in
14 mind what configuration you are looking at.

15 CHAIRMAN WALLIS: Why did you do that?
16 Why didn't you test the same valve at three flow
17 rates?

18 MR. TREGONING: There's a range of
19 settings -- there's a range of settings and gap sizes
20 out in the plants, we wanted to at least look at that
21 range.

22 CHAIRMAN WALLIS: But, you are doing
23 science here as well, you are trying to understand.

24 DR. BANERJEE: They are not.

25 MR. TREGONING: The initial objective was

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1 just to determine if we could get blockage in these
2 configurations.

3 MR. LETELLIER: Under representative plant
4 configurations.

5 Now that we --

6 CHAIRMAN WALLIS: Well, I guess if someone
7 else brings in a different valve then you have to test
8 it. There's no theory of anything, no predictive
9 capability. If someone changes the opening in the
10 valve then they have to do an experiment.

11 MR. LETELLIER: No, let me say first that
12 now that we have evidence of potential blockage, this
13 is the time to understand it to drive the system.

14 CHAIRMAN WALLIS: This is like the ICET
15 test, you are just trying to see if something happens,
16 and then you are going to go and make it quantitative
17 later.

18 MR. LETELLIER: That was our initial
19 objective, to see if it was possible --

20 CHAIRMAN WALLIS: Right.

21 MR. LETELLIER: -- to block.

22 DR. BANERJEE: Now, coming back to this
23 question of the valve opening, when you have very
24 small valve openings, you have a much higher velocity
25 through there, right?

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1 MR. LETELLIER: Yes.

2 CHAIRMAN WALLIS: You have the same
3 pressure, you have the same velocity.

4 MR. TREGONING: For a given flow rate.

5 CHAIRMAN WALLIS: Ah.

6 DR. BANERJEE: Given the flow rate is
7 constant.

8 MR. LETELLIER: That's what's critical to
9 the plant, is to maintain flow.

10 DR. BANERJEE: So then, if you have a
11 piece of RMI or something, potentially, you could
12 deform it because of the higher forces due to the
13 velocity head, and, perhaps, that's the effect,
14 speculating. You see what I mean, let's say you get
15 a piece that comes up against that gap, and you have
16 over five velocities, so, potentially, it could
17 deform, whereas at a low velocity just sit there and
18 sort of hang out.

19 CHAIRMAN WALLIS: So, what controls the
20 flow rate in this then, you say it's all the same
21 flow, in the plant what controls the flow rate? You
22 run the pump, and doesn't this control the flow rate,
23 this valve?

24 MR. LETELLIER: It does, the power plant
25 actually has an enormous capacity for delta P, for

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1 driving the system --

2 CHAIRMAN WALLIS: But, that would mean you
3 would have to run the pump at a different speed or
4 something? You've got a pump curve, the flow rate you
5 get depends on the setting of the valve, doesn't it?
6 These are independent variables, you can't say we are
7 going to keep the valve opening -- the flow rate
8 constant to vary the valve opening.

9 MR. LETELLIER: These are typically
10 constant speed pumps that rely on the valve throttle.

11 CHAIRMAN WALLIS: So, you have a pump
12 curve, so as you change the valve opening you change
13 the flow, which is the problem with the low flow rate,
14 the small clearance, you also get a low flow rate.

15 DR. BANERJEE: Well, your pump cover is
16 like this, right, so here --

17 CHAIRMAN WALLIS: I don't know what my
18 pump cover is like.

19 DR. BANERJEE: -- well, let's assume it
20 looks like a normal pump, okay, it's kind of flattish
21 and it falls off. If you are in the flat portion --

22 CHAIRMAN WALLIS: Then you've got a
23 constant flow rate?

24 DR. BANERJEE: -- more or less.

25 CHAIRMAN WALLIS: But, when you throttle

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1 down you are in the other part.

2 DR. BANERJEE: I don't know where they
3 are.

4 CHAIRMAN WALLIS: Anyway, that's another -
5 - that's the engineering study of this.

6 We don't want to interrupt you anymore.
7 We've made the point, I think.

8 MR. LETELIER: Let's move on to the
9 overview for three component mixtures, slide 20. In
10 this case we are introducing all three of our debris
11 types in different sequences, in order of
12 introduction, and find that in this case there are
13 apparent increases in valve blockage compared to the
14 analogous single debris tests by themselves. But, no
15 particular order of introduction seems to give us
16 marked differences.

17 CHAIRMAN WALLIS: I'm sorry, I want to go
18 back to this. You did all these tests at constant
19 flow rate?

20 MR. LETELIER: They were initialized at
21 the same flow rate, and then they were measured.

22 CHAIRMAN WALLIS: I would want to go back
23 to NRR and say, in the plant how does the flow change
24 as you change the valve opening. Then you could
25 figure out, perhaps, something a bit more realistic in

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1 relation to the real problem?

2 MR. LETELLIER: We have been asking and
3 searching for those reality checks, if you will.

4 CHAIRMAN WALLIS: You were aware of this
5 then.

6 MR. LETELLIER: I wouldn't say that,
7 actually. We have not gotten all of the information
8 that we needed to make the best possible choice of
9 flow conditions and valve geometries.

10 CHAIRMAN WALLIS: This seems to be a
11 problem then, getting them -- you guys are doing
12 research, you need to have access right away to the
13 necessary information.

14 MR. LETELLIER: It's not that we haven't
15 tried, the staff has pursued all avenues to obtain
16 more quantitative information. Largely, it comes from
17 anecdotal discussions with the industry reps.

18 CHAIRMAN WALLIS: But, the rule of thumb
19 is that half of what you hear anecdotally is wrong.

20 MR. LETELLIER: And, half right.

21 DR. BANERJEE: But, don't they have specs,
22 tech specs, and things which give this stuff?

23 MR. LETELLIER: Flow rate is a technical
24 specification, but the particular valve design is not
25 specified uniquely.

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1 DR. BANERJEE: Right, but they provided
2 whatever it is, it's documented, enormous piles of
3 stuff of there's.

4 MR. TREGONING: I think we've reached a
5 clear limitation if we -- you know, and especially
6 given the time constraints that we've got, you know,
7 if we want to have a more in-depth presentation on
8 throttle valve performance how the specs, what
9 information we have, versus we don't have, I suggest
10 we either defer that either to the next May committee
11 meeting or set up a separate subcommittee meeting.

12 CHAIRMAN WALLIS: Well, we are going to
13 probably have a meeting on downstream effects anyway,
14 correct?

15 MR. TREGONING: It sounds like that was
16 potential.

17 MR. CARUSO: We are scheduled to have
18 another meeting like this in June, so that might be a
19 good time to --

20 MR. TREGONING: Potentially, I mean, so if
21 that's a topic that we want to pursue, we could -- I
22 would offer --

23 CHAIRMAN WALLIS: I'd like to see the NRR
24 timeline that says by a certain time we will have
25 resolved this issue, by a certain time we will have

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1 resolved that issue, and this issue, and depending on
2 what happens in these tests we are going to have
3 various piles, we are going to go on.

4 At the moment, it seems higgledy,
5 biggledy, I mean, they are going to present something
6 to us in June, maybe something in September, maybe we
7 are going to say it's not good enough.

8 DR. BANERJEE: I think maybe the
9 downstream effects meeting should be earlier than
10 June.

11 CHAIRMAN WALLIS: As soon as possible, as
12 soon as possible.

13 MR. LETELLIER: Moving quickly through the
14 accumulation test, which was one of the more
15 interesting studies, it addressed a lot of the
16 questions you've raised about long-term accumulation
17 in a plant environment. This plant -- this test was
18 conducted over a period of three hours, with
19 sequential introductions of debris, at 15 minute
20 intervals, and the trace of data on slide 23 you can
21 see how the system responds to that in terms of delta
22 K.

23 We did see a steady increase, or rather,
24 a loss of performance over time, but each sequence or
25 each addition of debris did not necessarily give you

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1 a measurable effect. So, in the broad picture,
2 there's evidence of accumulation, but it's not
3 deterministic in terms of the next incremental
4 quantity.

5 CHAIRMAN WALLIS: It seems to clear itself
6 to some extent.

7 MR. TREGONING: In some cases you saw
8 that.

9 MR. LETELLIER: It does.

10 MR. TREGONING: Yes.

11 CHAIRMAN WALLIS: From like a screen,
12 where it typically goes up and keeps on going up.

13 MR. LETELLIER: In this case, if we had
14 time to examine the pump curve you would see that the
15 differential pressures are increasing, and our pump
16 does have some capacity for that.

17 Also, the velocities are increasing, so it
18 self-scours, it tends to weaken any kind of mechanical
19 debris lodging and --

20 CHAIRMAN WALLIS: Do you see evidence of
21 self-scarring at the end of the test?

22 MR. LETELLIER: What I'm saying is, the
23 velocities increase, so that there's the potential for
24 that explanation for this behavior.

25 CHAIRMAN WALLIS: Oh, that's a hypothesis.

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1 MR. LETELLIER: Yes.

2 DR. DENNING: Well, is it hypothesis or is
3 it pretty much clear that somehow the blockage must be
4 reduced? I mean, isn't it clear the blockage --

5 MR. LETELLIER: It is clear that the
6 blockage was reduced, and it is a fact that both the
7 delta P and the velocities are increasing. So, if you
8 can speculate about the physical mechanics of what
9 occurs.

10 And finally, just the overview summary.
11 Just to recap, the screen -- the penetration rates and
12 the quantities were parameterized in this test for
13 various reasons. We did want to challenge the system
14 to the point of blockage. We were never able to do
15 that because of the limited volume of the chamber, the
16 debris chamber.

17 We had to do this because presently and
18 possibly there never will be a predictive capability
19 for debris generation transport and arrival times.

20 Also, there are sump screen and LOCA
21 specific dependencies that led us to choose a
22 parametric approach.

23 Our choice of a surrogate throttle valve
24 chamber proved to be effective for investigating these
25 phenomena. There's clearly room for improvement. For

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1 example, once the debris blockage occurred, I could
2 not tell you if it was physically trapped in the
3 throat or lodged in the chamber. But, we did achieve
4 a minimum blockage detection of about 5 percent of the
5 flow area, and again, there is no performance
6 standard, no standard for degraded performance. The
7 plant engineer will not tell you, is this acceptable.
8 We were simply characterizing the sensitivity of our
9 system.

10 DR. BANERJEE: But, if you get a 200
11 percent change in K, it goes as a square root with K,
12 the flow rate, so it's roughly --

13 CHAIRMAN WALLIS: That's not so bad.

14 DR. BANERJEE: -- yes, who cares.

15 MR. LETELLIER: But again, that represents
16 a degraded flow condition, and the plant will not tell
17 you, the vendors will not tell you, am I safe, is this
18 acceptable.

19 DR. BANERJEE: That's a separate issue,
20 but your flow is going to drop by -- I mean, if you
21 change this by 200 percent, your flow will go with the
22 square root.

23 CHAIRMAN WALLIS: Depending upon your pump
24 cover.

25 DR. BANERJEE: Yes, if your pump cover is

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1 on the flat part.

2 MR. LETELLIER: That's correct.

3 DR. BANERJEE: So, it's not a big deal.

4 DR. DENNING: No, but what I think that
5 potentially is a big deal, I mean, we size the system
6 to -- you know, obviously, there's redundancy in this
7 kind of stuff, but, you know, I mean, I was asking
8 myself, you know, is it a big deal or isn't it a big
9 deal to see this, and I think that these are big
10 enough that one worries.

11 DR. BANERJEE: But, they should be
12 evaluated.

13 CHAIRMAN WALLIS: But you might fail to
14 meet some success criteria.

15 DR. DENNING: You might fail to meet a
16 success criteria.

17 DR. BANERJEE: On the surface the flow
18 will drop by --

19 CHAIRMAN WALLIS: I'm trying to remember
20 what you said about the first bullet, there's no
21 predictive capability. Do you remember what you said?

22 MR. LETELLIER: No, sir.

23 CHAIRMAN WALLIS: I thought you said there
24 never will be. Did you say there never will be?

25 MR. TREGONING: I don't think he said

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1 never will be. We'd have to go back and look at the
2 transcript, but I think he said --

3 CHAIRMAN WALLIS: I don't need to look at
4 the transcript.

5 MR. TREGONING: -- not likely.

6 MR. LETELLIER: I did say perhaps.

7 CHAIRMAN WALLIS: So, what you meant to
8 say, if you said it never will be, was that it's
9 unlikely there will be?

10 MR. LETELLIER: I said perhaps there never
11 will be a truly predictive --

12 CHAIRMAN WALLIS: No, I missed the --

13 MR. LETELLIER: -- capability.

14 CHAIRMAN WALLIS: -- perhaps, okay.

15 MR. TREGONING: It's an important
16 omission, though.

17 MR. LETELLIER: But, there are obvious
18 reasons why we had to parameterize it in this study.

19 To conclude, all debris combinations
20 except CalSil alone showed evidence of a blockage
21 potential. We are not judging severity, but we have
22 demonstrated that the phenomena exists, it can't
23 happen.

24 There is clear evidence of accumulation
25 over longer-term tests, and also corresponding

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1 evidence of self-cleaning by whatever physical
2 mechanism.

3 Our test blockage regimes did not exercise
4 the full range of our test pump, and, obviously, they
5 could not exercise the full range of the HPSI system.

6 DR. BANERJEE: I think you don't mention
7 one interesting thing you found, which was that the
8 upstream chamber to the stem configuration has an
9 effect on the results, and that seems to also hold for
10 CalSil, if I remember by just looking at the curves.

11 CHAIRMAN WALLIS: Now, if these things are
12 blocking the flow area, and if you go to higher
13 pressures than you have, and that distorts this
14 material and jams it into the gap, then we might
15 speculate that it would be difficult to close the
16 valve if you wanted to.

17 DR. DENNING: I don't think you want to
18 close the valve.

19 MR. LETELLIER: We have never intended --

20 CHAIRMAN WALLIS: You never want to close
21 the valve?

22 DR. DENNING: Then you have total flow
23 blockage.

24 CHAIRMAN WALLIS: I don't know.

25 DR. DENNING: It would just exacerbate the

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1 problem.

2 CHAIRMAN WALLIS: You never want to close
3 the valve.

4 DR. DENNING: This particular valve, I
5 don't think you do.

6 DR. BANERJEE: Aren't there any blocked
7 valves after this is captured? There must be some
8 blocked valves or something, somewhere.

9 CHAIRMAN WALLIS: Some other valve in
10 series with this one, the shut-off valves.

11 DR. BANERJEE: Yes, but even if you look
12 at NUKON, the 5F series show a much lower percentage
13 increase in K. So, what you saw with RMI you see with
14 NUKON as well. So, it seems that there's something
15 interesting if you look at those diamonds and those
16 triangles.

17 DR. DENNING: It is dramatic.

18 DR. BANERJEE: What?

19 DR. DENNING: It is dramatic.

20 DR. BANERJEE: It's pretty dramatic, yes.

21 DR. DENNING: Particularly, since it's
22 kind of counter intuitive to me.

23 DR. BANERJEE: Yes, in fact --

24 DR. SHACK: Big shoulders give you a place
25 to trap stuff.

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1 DR. BANERJEE: Yes, but --

2 DR. SHACK: Instead of the valve itself.

3 DR. BANERJEE: Until you saw the results,
4 maybe, as I said, in a pre-experiment CFD calculation
5 you are a part of that, but without that I wouldn't --

6 CHAIRMAN WALLIS: I'm not sure that CFD
7 can predict the orientation of these particles.

8 DR. BANERJEE: No, but it can get the
9 vortice.

10 CHAIRMAN WALLIS: But, it treats them as
11 spheres or something, which is completely wrong.

12 DR. BANERJEE: Whatever, but it doesn't
13 matter, it gives you the qualitative picture, and what
14 we look at is --

15 CHAIRMAN WALLIS: Well, if you accelerate
16 an object, and acceleration is the only thing
17 happening, it tends to orient itself so the entire
18 mass is maximum. In other words, they will cross the
19 flow.

20 So, if you accelerate it very rapidly,
21 it's trying to turn across the flow, that may have
22 something to do with it.

23 DR. BANERJEE: But, what you see is,
24 generally, even in turbulence, that particles get
25 thrown out of vortices, which is why you get these

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1 streaky structures. Turbulence doesn't actually mix,
2 it's acting as a very good separator, and that's
3 probably what you are seeing, is some segregation in
4 the vortices.

5 DR. DENNING: I think now the \$64 question
6 is, I think this was exploratory, now there are
7 results in, and so there's a question to research, and
8 then there may be questions to NRR, you know, what
9 does it mean, where do we go from here, do we now have
10 to have a predictive capability here to analyze this.
11 Does it mean more? So I guess I'd ask Ralph, I mean,
12 what's your interpretation, where do we go from here,
13 is there more research that's required now because
14 things have come up, or this is kind of what you
15 expected anyway.

16 MR. TREGONING: Yes, I think, you know,
17 the next step is clearly to -- again, this was a
18 surrogate generic study that was meant as a scoping
19 study. The next step clearly is to look at these
20 results and try to see how applicable they are, with
21 consideration of plant specific or actual valve
22 designs.

23 So, that's clearly the next step, and
24 that's something that we'll be certainly looking at
25 with interfacing or interacting with the industry

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1 about.

2 DR. BANERJEE: And, whether these types of
3 pressure loss -- I mean, flow losses --

4 CHAIRMAN WALLIS: I'm trying to think of
5 what it is --

6 DR. BANERJEE: -- can be lived with or
7 not.

8 CHAIRMAN WALLIS: -- what it is you folks
9 would -- we have three hours of the full committee
10 meeting on these topics.

11 MR. TREGONING: Is that how long we are
12 scheduled for?

13 CHAIRMAN WALLIS: Three hours.

14 MR. TREGONING: Okay.

15 DR. KRESS: Total.

16 CHAIRMAN WALLIS: And, that means that
17 there may be up to two hours for presentation of these
18 research results, and I think it's important that you
19 present the committee sort of the results, not a lot
20 of -- not a lot of spending time describing the
21 history or how you shred it and all that, that might
22 come up. The thing is, what's the message, yes, we
23 have found something, we found an effect, we've got
24 some idea of what causes it, but, you know, here are
25 the gaps in our knowledge or something like that, so

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1 we can see where you are and, perhaps, give some
2 advice about what needs to be done.

3 MR. TREGONING: For the main committee, we
4 would certainly focus on significant findings and
5 results, and some of the main themes. We could do
6 this globally for every research program, or we could
7 try to focus on --

8 CHAIRMAN WALLIS: I would like you to do
9 it for the one that we didn't get to talk about today,
10 the bypass and the screen, give us an overview of that
11 one.

12 MR. TREGONING: So, for main committee, a
13 little bit more detailed overview with respect to the
14 bypass study, but --

15 CHAIRMAN WALLIS: And, more concentration
16 on results and implications, and where do we go from
17 here.

18 MR. TREGONING: Do you want us to cover
19 all of the research areas in main committee or focus
20 on chemical effects?

21 CHAIRMAN WALLIS: Well, I think everything
22 we heard at this subcommittee from my point of view
23 was interesting, and the one that probably, from my
24 point of view, needs not quite so long attention is
25 the ability to predict the chemistry, but even that's

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1 very interesting, the fact that you can predict the
2 chemistry, it's all important.

3 MR. TREGONING: Okay. We'll certainly
4 take that under consideration -- that's what we'll
5 plan to do then for main committee.

6 CHAIRMAN WALLIS: The fact that you can
7 predict the chemistry is maybe the most optimistic of
8 all the stories we've heard, so that's a good one to
9 put forward.

10 DR. SHACK: The other thing that seems
11 strange here is, the 45L, where you have the most
12 tests, seems to give you the most scatter. I mean,
13 I'm not sure that if we just ran more tests everything
14 would have an order of magnitude variation. That was
15 particularly more scattered for some reason.

16 MR. LETELLIER: The 45L has a much shorter
17 flow path length. As you raise it above the ring,
18 then the flow geometry changes much more rapidly than
19 in the shallow angles. It's a much longer valve
20 contact surface, actually.

21 MR. TREGONING: But, if you look at the
22 data, a lot of times we saw this with 45L, it's almost
23 like a bifurcation occurs, where --

24 DR. SHACK: Well, I'm looking at the mixed
25 RMI-NUKON one, where I go from 5 percent to 55

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1 percent, and, you know, it's just stacked up.

2 MR. TREGONING: Even there, I mean --

3 DR. SHACK: Well, there's those two, and
4 then there's the two up there.

5 MR. TREGONING: Right, so in many cases
6 with the 45L we saw, again, almost a bimodal or
7 bifurcation type of behavior.

8 DR. SHACK: Oh, I see, you are saying it
9 either does or doesn't.

10 MR. TREGONING: You reach these
11 configurations where you start to get accumulation,
12 and then they become just very efficient catchers at
13 that point. In some ways it's analogous to what you
14 see across -- or it may be analogous to what you see
15 with respect to head loss through a bed, where you --

16 DR. SHACK: Well, of course now, with the
17 mixture one you've got three points spread.

18 MR. TREGONING: Yes, the mixture one is
19 spread --

20 CHAIRMAN WALLIS: Yes, be careful about
21 going bimodal and getting anything into that.

22 MR. TREGONING: Well again, I don't want
23 to over sell it, but it is interesting that not only
24 for these -- for at least these tests, but you see it
25 in a lot of the -- debris tests --

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1 CHAIRMAN WALLIS: We can take bets on when
2 you do the next black diamond test, where it's going
3 to be.

4 MR. TREGONING: We've got a pretty good
5 range here.

6 CHAIRMAN WALLIS: I think we should stop
7 and have a break. I was hoping we could take a break
8 earlier, but we'll take a break until 11:05, and then
9 we will hear the next presentation, which is due to
10 take about an hour. We hope to finish by noon. I
11 think some committee members have to leave. We are
12 taking a break now, 15 minutes, 11:05.

13 (Whereupon, at 10:50 a.m., a recess until
14 11:04 a.m.)

15 CHAIRMAN WALLIS: The last, but not least,
16 is a discussion of the transportability of coatings
17 debris.

18 MR. GEIGER: Yes, thank you, sir.

19 CHAIRMAN WALLIS: Please, go ahead.

20 MR. GEIGER: Good morning. My name is
21 Ervin Geiger. I'm with the Office of Nuclear
22 Regulatory Research, Division of Engineering
23 Technology, until the 19th of this month anyway when
24 the name changes.

25 I'm new to the NRC, this is the first time

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1 I've had the opportunity of speaking to this group.
2 I'm the Project Manager, I'm the NRC's eye for this
3 transport research.

4 My previous experience has been 30 years
5 in the nuclear industry working for Bechtel Power, and
6 I'm a Mechanical Engineer by training. I've been
7 involved in a number of initial plant designs back in
8 the '70s, I started in '75, so '75 through '85 I did
9 a number of nuclear plant designs. And after that,
10 when the construction sort of went into maintenance
11 work, primarily in steam generator replacements on
12 PWRs, and as part of that we did a lot of studies on
13 some blockage, where we'd replace the insulation on
14 the primary piping, the mainstream piping, and steam
15 generators, we did a lot of evaluations on transport
16 to the sumps, and that's how we selected the types of
17 insulation. A lot of times we selected the RMI
18 because that wouldn't transport to the -- as much as
19 the blanket, where we felt there was plenty of margin
20 in the sumps we chose blanket, because of its thermal
21 efficiency, and also ease of installation and
22 maintenance.

23 With me is Anne Fullerton, from the Naval
24 Surface Warfare Center in Carderock, Maryland, and
25 they are -- that's the lab that's actually doing the

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1 -- conducting the testing for us. I'll let Anne say
2 a few things about her experience.

3 MS. FULLERTON: Thanks, Ervin.

4 Like Ervin said, I'm from the Naval
5 Surface Warfare Center, Carderock Division. I work in
6 the Special Projects Group of the Maneuvering and
7 Control Division, and somebody said yesterday, what do
8 like these projects here have to do with the Naval
9 Surface Warfare Center, how is that like a ship?
10 That's a very good question. But to us --

11 CHAIRMAN WALLIS: Well, if a ship ever
12 turns into a lot of debris it might --

13 MS. FULLERTON: That's about it, which is
14 an even bigger problem.

15 So, to us, it's just another hydrodynamics
16 problems, and in the Special Projects Group we tend to
17 do a lot of different kinds of research, mostly in
18 support of ship design, but some things that are more
19 of just the hydrodynamics problems. So, to us, this
20 was interesting. It was something we could do, and we
21 were happy to help out.

22 I've been at the Naval Surface Warfare
23 Center for about a year. Previous to that I was at
24 Stevens Institute of Technology. I was a graduate
25 student there, so I have a Ph.D. in Ocean Engineering,

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1 where I did other problems related to hydrodynamics.
2 So, that's a little bit about my background.

3 MR. GEIGER: Okay, thank you.

4 The purpose of the study was just to study
5 the behavior of debris -- coatings debris in water,
6 whether it was stagnant water or moving water, as it
7 would be in a containment or in a LOCA.

8 CHAIRMAN WALLIS: Do you worry about how
9 they react when they come near objects? I mean, if
10 they are flowing in the containment building, they go
11 down staircases, and around walls and all kinds of
12 things.

13 MR. GEIGER: This study involved primarily
14 how it behaves in still water, in other words, when it
15 landed on the surface how quickly it --

16 CHAIRMAN WALLIS: So, how they behave in
17 a pool maybe.

18 MR. GEIGER: How they behave in a pool,
19 and then also under flow conditions, actually, with a
20 steady stream flow, we didn't look at turbulences or
21 anything, we just looked at flow rates, so one
22 direction was flow.

23 CHAIRMAN WALLIS: Some of these flows on
24 floors may be fairly shallow streams.

25 DR. BANERJEE: How fast were the flows,

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1 were they turbulent? I mean, were they --

2 MS. FULLERTON: No, they weren't that
3 fast.

4 MR. GEIGER: They were not that fast, no.

5 CHAIRMAN WALLIS: What was their Reynolds
6 number?

7 MS. FULLERTON: We didn't calculate the
8 Reynolds number. The tank was about 30 feet long,
9 with a three foot by three foot cross section, and the
10 fastest we went was about one foot per second.

11 CHAIRMAN WALLIS: So, it's a high Reynolds
12 then.

13 DR. BANERJEE: Very high Reynolds.

14 MS. FULLERTON: Yes.

15 DR. BANERJEE: Very turbulent.

16 CHAIRMAN WALLIS: Unless you smooth it
17 very carefully at the inlet, in which case it might
18 not develop.

19 MS. FULLERTON: Yes.

20 DR. BANERJEE: Most likely it was very
21 turbulent.

22 MR. GEIGER: Most likely further down,
23 yes.

24 DR. BANERJEE: No, one foot high --

25 MS. FULLERTON: Three feet high.

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1 DR. BANERJEE: -- three feet high.

2 CHAIRMAN WALLIS: It's a really high
3 Reynolds number.

4 DR. BANERJEE: It's a very high Reynolds
5 number.

6 MR. GEIGER: Actually, when we get into it
7 we'll show you some diagrams of what it looks like.
8 It's kind of a unique setup that we had because of the
9 facilities they had. It was rather interesting.

10 DR. BANERJEE: The reason we ask is
11 settling --

12 MR. GEIGER: Settling, yes.

13 DR. BANERJEE: -- is very dependent on the
14 turbulence.

15 MR. GEIGER: Yes, I understand.

16 And again, you know, we had discussed a
17 number of times what the reasons for these studies
18 are, and this is, again, a safety evaluation, it
19 considers all of the unqualified coatings in a
20 containment, plus the qualified failed coatings in the
21 containment to transport to the sump during a loss of
22 coolant accident.

23 So, what we are trying to do is to see how
24 conservative this assumption is, and historically a
25 number of nuclear plants have not experienced failures

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1 in the coatings. Initially, the plants had what we
2 considered qualified coatings. They did a DBA test,
3 temperature, radiation, and pressure, but those were
4 all the initial tests, and they verified that over
5 those conditions the coating will stay on the wall.
6 Of course, these days there have been plants where the
7 coating is actually failing prematurely, and there's
8 a lot of studies to look into why this is happening.
9 Of course, this was not part of this study. What we
10 were looking at is what happens to these coatings when
11 they actually end up on the containment floor, and
12 then how are they transported, if they are
13 transported.

14 The information gathered from these tests
15 will aid in assessment of the response to GL 2004-02,
16 and further, some of this information we gathered can
17 actually be used to look at the sump screens, and come
18 up with parameters for seeing how the flows will
19 affect or maybe affect the design of the sump screen,
20 so it could be used for that.

21 CHAIRMAN WALLIS: So, are you going to --
22 I don't think you are going to show us how it can be
23 actually used to make plant-specific predictions.

24 MR. GEIGER: Well, the data we gathered is
25 very generic in nature, as to how -- so, what we did

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1 was, we studied -- if a coating landed on a surface,
2 and the different types of coatings, what would
3 happen, how long would they stay on the surface, would
4 they sink, and if they sink while the stream is
5 moving, how long it took them to actually reach the
6 bottom, and then what would happen when they did that.

7 So, that was all --

8 CHAIRMAN WALLIS: So, you think all this
9 could somehow be put together to provide a method for
10 predicting what happens in a containment?

11 MR. GEIGER: Yes. These could all be, you
12 know, contribute to that sort of an evaluation.

13 The testing is complete in the lab, and
14 the data is now being analyzed and evaluated. We took
15 an awful lot of data, so it's taking quite a while to
16 put it all in a format that we are sure we can present
17 it.

18 The NUREG is scheduled to be published
19 some time this fall, fall of 2006, so we are moving
20 pretty well along with it.

21 DR. BANERJEE: You looked at qualified and
22 unqualified.

23 MR. GEIGER: Yes, we did.

24 CHAIRMAN WALLIS: But, your sizes, they
25 are like flakes, they are not the tiny little

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1 particles that we heard about yesterday.

2 MR. GEIGER: Well, they range, yes, and I
3 will pass -- we tested -- what we did, the concept for
4 the testing was, it's a not plant-specific test. We
5 are looking at gathering, you know, just establishing
6 certain parameters on behavior of these coatings, that
7 then could be applied in a number of ways. Okay, it's
8 just basically a study of what happens to coating
9 chips -- different types of coating chips, sizes, and
10 densities. So, we looked at -- we studied --

11 DR. BANERJEE: Inside the ZOI or outside
12 the ZOI?

13 MR. GEIGER: Anywhere.

14 DR. BANERJEE: Anywhere.

15 MR. TREGONING: Primarily, outside the
16 ZOI, I mean, within the ZOI assumptions are made that
17 it's particulate.

18 MR. GEIGER: Yes, what we studied is, we
19 did the -- the assumption is that in the ZOI, the
20 paint is basically small, micron size, right, okay, so
21 we didn't study those because when we did this
22 facility we didn't have the capability anyway, it
23 really wasn't the intent to study that, because all
24 those particles are assumed to go to the sump, it
25 would be entrained, so what we are looking at is

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1 larger particles that were outside the ZOI but maybe
2 on the floor from previous failures, or could be
3 washed off the walls and structures by spray. So,
4 that was really the intent of this study.

5 MR. TREGONING: And, the concern now is
6 with ECCS, there's a very conservative assumption that
7 says any unqualified coatings, or previously qualified
8 coatings that have visual evidence of degradation, are
9 assumed to fail. So, that can be a very large coating
10 loading potentially that needs to be designed around.
11 So, transportability was obviously an obvious question
12 for these, and those failures are expected to be
13 larger size than just particulate.

14 DR. BANERJEE: Yesterday we heard from the
15 industry, right, about the experiments they've been
16 doing.

17 MR. TREGONING: Well, yes.

18 DR. BANERJEE: So --

19 MR. TREGONING: Initiating. These are
20 complimentary, because they are looking at more
21 failure mechanisms and failure amounts. These are
22 looking at transportability.

23 Did you want to say something, Matt?

24 MR. YODER: Yes. As I said yesterday,
25 this testing is confirmatory testing.

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1 CHAIRMAN WALLIS: You have to identify
2 yourself for the record.

3 MR. YODER: I'm sorry, Matt Yoder, from
4 NRR.

5 This is confirmatory testing, so as I said
6 yesterday, if the licensee were to take exception to
7 the position the staff has and they were to try to
8 assume some debris characteristic size of a chip, and
9 then try to save it, that would not transport, or
10 would only transport X distance in their containment.

11 This is the testing that the staff would
12 use to inform our evaluation of that.

13 DR. BANERJEE: And, in fact, in this pre-
14 testing, if I recall, it didn't measure the particle
15 size.

16 MR. YODER: Again, the testing you are
17 referencing was just of unqualified coatings.

18 DR. BANERJEE: Yes.

19 MR. GEIGER: And, that wasn't transport
20 testing, that was just to see if it failed.

21 DR. BANERJEE: Yes, I realize what it was,
22 so this is complimentary.

23 MR. GEIGER: Yes, this is complimenting
24 that, yes.

25 MR. TREGONING: But again, Matt had a good

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1 clarification. This is intended, primarily, for
2 informing the staff on the evaluations.

3 MR. GEIGER: So to continue, we studied
4 five different coating systems, and I will discuss
5 them in the next few slides, and we brought some
6 samples we'll pass around to show you what we did.

7 We studied the three sizes ranging from
8 two inch down to 1/64 inch in size, and the debris
9 shapes were random. We had randomly generated the
10 shapes in a commercial blender, and we tested curled
11 chips, flat chips, and some we did temperature curing
12 to --

13 CHAIRMAN WALLIS: So, you chopped up these
14 sheets of paint and then you somehow segregated them
15 into the different groups by -- not by picking out
16 each one.

17 MR. GEIGER: By chipping and sieving.

18 MS. FULLERTON: No, we used sieves.

19 MR. GEIGER: So, the samples were
20 manufactured by applying the coatings to a
21 polyethylene sheet, and letting it cure, and then it
22 was peeled off, and then broken into sections and
23 shipped to us.

24 DR. BANERJEE: So, this was almost like a
25 parametric study, not necessarily what you expected

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1 would happen in the steam environment at LOCA
2 conditions.

3 MR. TREGONING: Yes, this is totally
4 parametric. All the testing was not -- was done at
5 room temperature water, so it was not done at LOCA,
6 under LOCA pool conditions.

7 DR. BANERJEE: But we haven't seen a
8 report on this yet.

9 MR. TREGONING: You are not even going to
10 see data on this.

11 MS. FULLERTON: No, we just finished this
12 at the end of January.

13 MR. GEIGER: We just finished the testing.

14 MR. TREGONING: This is as fresh as fresh
15 can be.

16 MR. GEIGER: We are anxious to see, you
17 know, we are anxious to get it out to everybody, so we
18 are working diligently on it.

19 The chips, as they were applied, there's
20 a range of specific gravities, and they range from one
21 for the alkyd to about 2.6 for zinc epoxy system, and
22 we studied different thicknesses, these were applied,
23 we have a one coating system for 1 to 3 mls, and then
24 we also have a six-coat epoxy which we studied, which
25 is a much thicker chip, and then we studied it in

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1 water velocities where we had stagnant water in a
2 stagnant pool, and then we had velocities up to one
3 feet per second.

4 So, Anne is going to pass around the
5 samples.

6 DR. BANERJEE: There are all sorts of
7 alkyds, right?

8 MR. GEIGER: Oh, yes, there are.

9 DR. BANERJEE: Each manufacturer does a
10 different one, correct?

11 MR. GEIGER: There's many formulations, so
12 we couldn't really -- and that's why this is
13 parametric, because there's so many formulations of
14 epoxy, the alkyds, the zincs, so that it would be
15 pretty much impossible to study them all. So, what we
16 did was, I mean I think the primary mechanism that's
17 involved is the specific gravities, as to how readily,
18 you know, it sinks, and then the shape factor, and
19 just the thickness, which is part of shape factor, so
20 those will contribute quite a bit to the
21 characteristics of how it will flow.

22 MR. TREGONING: And the size, those were
23 the principal variables.

24 MR. GEIGER: And the size, thank you.

25 MR. TREGONING: So, yes, we couldn't test

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1 everything, so we tried to span the range of --

2 DR. BANERJEE: So, you took some
3 representative alkyd and --

4 MR. TREGONING: -- yes, it was certainly
5 representative, and again, it would have had a density
6 similar to most, or specific gravity similar to most
7 other alkyds.

8 MR. GEIGER: And, we picked the
9 manufacturer that we found was used quite a bit in the
10 plant, and this was all unqualified. The alkyd was an
11 unqualified coating.

12 DR. BANERJEE: So, let me try to
13 understand this, because if I was in industry, I would
14 try to take my piece of alkyd or something, do a
15 little test on it, see how much came off, and then
16 have some characterization of particle size.

17 MR. GEIGER: Correct.

18 DR. BANERJEE: And then, you would have
19 some sort of relationship that I could use to find out
20 how much would get to my screen. Is that the whole --
21 because they don't seem to be doing that part of the
22 testing, they are only doing --

23 MR. GEIGER: No.

24 DR. BANERJEE: -- how much falls off,
25 right?

1 MR. GEIGER: Right.

2 DR. BANERJEE: At the moment, that's what
3 they seem to be doing, unless they are doing also some
4 transport stuff, I don't know.

5 MR. YODER: Matt Yoder, let me -- I think
6 what you see is for a study like what you've been
7 referencing for the past couple days, the EPRI report,
8 where they have some rough idea of the particle size
9 you expect, to make some kind of analysis, and that
10 may or may not include testing to say that those
11 particles will transport or not. And, the staff would
12 use this testing to say whether we found that credible
13 or not.

14 DR. BANERJEE: All right.

15 MR. TREGONING: There has been prior
16 transport testing of coatings that have been done
17 historically, so this isn't the only study of its
18 kind, by any stretch of the imagination. And, I think
19 a lot of the plants, as Matt said, once they get their
20 loading they would use CFD with some assumptions to
21 determine really what transports or not.

22 MR. CARUSO: Quick question. Which one of
23 these samples is the highest density?

24 MS. FULLERTON: That's the zinc.

25 MR. GEIGER: The zinc, it has a silver

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1 packing.

2 MS. FULLERTON: Yes, that one.

3 MR. GEIGER: Yes, that's it, yes.

4 MR. CARUSO: This is the highest density?

5 MR. GEIGER: Yes.

6 MR. CARUSO: And the stuff that --

7 MS. FULLERTON: That's the alkyd.

8 MR. GEIGER: I was going to label them,
9 I'm sorry, I didn't have a marker.

10 And, let me just clarify, as to exactly
11 how this information will be used is up to NRR. Okay,
12 we are presenting some data and NRR is going to use
13 that to evaluate the submittals.

14 CHAIRMAN WALLIS: You could have a contest
15 for designing the chip which will go the furthest,
16 like a paper airplane, because some of these might, if
17 launched the right way, go quite a way.

18 MR. GEIGER: Potentially, yes.

19 So, we tested an alkyd, and zinc primer,
20 and then with an epoxy -- two epoxy topcoats, the
21 nomenclature, ALK is the alkyd, the zinc primer has
22 the ZE, then we had an epoxy primer, and the epoxy
23 topcoat, which is the E2, and we had an epoxy that was
24 six coats, now that's not a qualified coating system,
25 but we were trying to replicate the maintenance in the

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1 plant where they applied a lot of coats.

2 DR. BANERJEE: So, do these float like
3 leaves, do they get wet?

4 MS. FULLERTON: The latest one does, the
5 one that looks like a garbage bag when you see it, the
6 other ones mostly sink.

7 DR. BANERJEE: They sink.

8 MS. FULLERTON: Yes.

9 DR. BANERJEE: So, you gently put them on
10 the surface.

11 MS. FULLERTON: Yes, we did -- yes, a
12 couple different tests, but yes.

13 MR. GEIGER: Okay.

14 Then we tested an epoxy sealer with a
15 surfacer and two epoxy topcoats, which is typically
16 used on a concrete surface, so there's five coating
17 systems we used.

18 And, the specific gravities ranged from
19 about 1.0 to, like I said, 1.58 for the zinc epoxy
20 system. So, I mean, and those are a combination, you
21 know, we checked the entire volume to see the weight,
22 it wasn't the individual components.

23 CHAIRMAN WALLIS: So, what you passed
24 around is one inch to two inch, is that right?

25 MR. GEIGER: Yes -- well, those are

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1 actually --

2 CHAIRMAN WALLIS: Bigger.

3 MS. FULLERTON: One to two inch.

4 DR. BANERJEE: What is this ultra think
5 stuff?

6 MR. GEIGER: That's the alkyd.

7 MS. FULLERTON: Alkyd.

8 MR. GEIGER: That's the alkyd, and that
9 typically comes from, it's equipment furnished by
10 manufacturers.

11 We tested one inch to two inch size chips,
12 and then we tested one sample of 1/8 and 1/4 size
13 chips.

14 CHAIRMAN WALLIS: What is typical of the
15 containment?

16 MR. GEIGER: The containment, well, as you
17 can see, some of these are pretty brittle, and if you
18 look at the pictures of the containment, they tend to
19 come off in sheets, but I think --

20 CHAIRMAN WALLIS: Those are the thick ones
21 in there, in the containment?

22 MR. GEIGER: Yes, the two coat --
23 typically, the zinc and the epoxy, the two-coat epoxy
24 was typical in the picture.

25 CHAIRMAN WALLIS: So, they might come off

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1 in sheets, as you say.

2 MR. GEIGER: They may come off -- not in
3 large sheets, but from photographs I have seen, you
4 know, they start to curl and peel, but they are rather
5 brittle, so if they would fall I imagine they would
6 break into different types of shapes.

7 MR. CARUSO: All these tests were done at
8 room temperature, right?

9 MR. GEIGER: Yes.

10 MR. CARUSO: You didn't do any tests at
11 higher temperatures?

12 MR. GEIGER: No, we didn't, no. We did
13 presoak some at 140 degrees, so we did that. We took
14 some samples, before we put them in the water, we
15 presoaked them at 140 to see if they would change
16 their shapes or anything like that.

17 DR. BANERJEE: I have a question.
18 Obviously, for the lighter things, if you put them on
19 the surface, surface tension will have a very
20 important effect on the wetting characteristics. And,
21 obviously, if you have surfactants and things in the
22 water, this will start to effect things.

23 So, did you look at, at least in broad
24 terms, whether the wetting characteristics might
25 change with containment-like water, compared to just

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1 normal water? Whether it floats or not really will
2 depend on how it is wetted in the early stages.

3 MR. TREGONING: Yes, there's a lot of
4 conditions that will determine whether --

5 DR. BANERJEE: Yes.

6 MR. TREGONING: -- it floats or not,
7 including how agitated the surface of the pool is.

8 DR. BANERJEE: Sure.

9 MR. TREGONING: As it fills up, or even as
10 something is traveling over the surface of pool, so we
11 didn't look specifically -- there were no measurements
12 of surface tension, for instance, done on these tests,
13 and there were no --

14 MS. FULLERTON: Actually, there were.

15 MR. TREGONING: Oh, I'm sorry, I'll just
16 be quiet then.

17 MS. FULLERTON: That's okay.

18 MR. GEIGER: We measured surface tension
19 in the tank, and, of course, we didn't mix any
20 chemicals, there was just tap water, it was tap water.

21 DR. BANERJEE: So, at least you knew
22 whether there were surfactants, whether there were
23 monolayers, and that sort of stuff.

24 MS. FULLERTON: That's correct, and there
25 are a few different tests done. We did a time to sink

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1 test, and Erv will talk about it a little bit more,
2 but we did some tests where we placed the paint chips
3 on the surface and saw how long it took for them to
4 sink. And, we also did some tests where they were
5 placed just under the surface, and we measured the
6 terminal velocity of the chips. So, there are
7 different, a few different measurements, so that there
8 would be something, you know, including the effects of
9 surface tension.

10 MR. GEIGER: We did some pre-wetted.

11 DR. BANERJEE: Well, the Navy should know
12 about surface tension.

13 MS. FULLERTON: That's right, we do a lot
14 of other things with surface tension.

15 MR. GEIGER: We did the mixture, and the
16 mixture was -- the definition was, basically, it had
17 to be between 10 percent and 25 percent chips smaller
18 than a 1/4 inch, and that was the ranges, and the rest
19 would be larger chips.

20 We did two types of testing. We did what
21 I said, I mentioned, about quiescent zinc testing,
22 where we had a vertical acrylic tank, and I said we
23 measured the surface tension, and then what we did
24 was, the test, we did a time to sink test and a
25 terminal velocity test. The time to sink test was, it

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1 consisted of dropping the coating chips from a
2 distance of one foot above the surface onto the
3 surface, and then timing how long it would take for it
4 initially to sink, and then for the remainder to sink
5 to the bottom.

6 CHAIRMAN WALLIS: You must have had a lot
7 of orientation with the chip?

8 MR. GEIGER: Yes, but it was random.

9 MS. FULLERTON: We had to make it random,
10 because it definitely did make a difference how it
11 fell.

12 CHAIRMAN WALLIS: The terminal velocity,
13 these things don't fall just like a sphere, I mean,
14 they --

15 MS. FULLERTON: They have no sideways
16 component, right.

17 CHAIRMAN WALLIS: Do they hit the wall of
18 the tank, it looks like a pretty small tank.

19 MS. FULLERTON: No, no, we would put them
20 in the middle of the tank, and if they did hit --

21 DR. BANERJEE: It's a flume.

22 MS. FULLERTON: No, that's in the second
23 one.

24 MR. GEIGER: We did a quiescent --

25 MS. FULLERTON: It's lab space, and

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1 there's the --

2 DR. BANERJEE: This was a stirred tank or
3 a quiescent?

4 MR. GEIGER: This is quiescent, this is
5 totally still, yes.

6 And then, we did the transport test, which
7 was in a flume, where we measured the tumbling
8 velocity which consisted of initially placing the
9 chips on the bottom and then increasing the flow rate
10 until the chips initially started moving, we called
11 that the incipient tumbling velocity, and then we
12 cranked it up to see 80 percent of bulk tumbling
13 velocity.

14 DR. BANERJEE: Did you put any on the
15 surface of the flume, like the water surface?

16 MR. GEIGER: We initially were going to do
17 that, but from the quiescent testing we saw how they
18 behaved, so we knew that, you know, if you put them on
19 -- like the alkyd, if you put it on the surface, it
20 all went to the end.

21 MS. FULLERTON: It would just all go to
22 the end.

23 DR. BANERJEE: It would what?

24 MS. FULLERTON: It would just stay on the
25 surface.

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1 MR. GEIGER: It would stay on the surface
2 and transport.

3 MS. FULLERTON: So, we knew what would
4 happen.

5 MR. GEIGER: The heavier chips, most of
6 them, even on the quiescent test, we put them on the
7 surface, they very quickly broke the surface and sank.
8 There were some, occasionally one would remain.

9 DR. BANERJEE: But, the reason is in a
10 quiescent tank they would sink a lot faster than in a
11 turbulent flow.

12 MR. GEIGER: Sure.

13 MS. FULLERTON: Right.

14 DR. BANERJEE: So, did you do some
15 experiments in the flume where you put --

16 MR. GEIGER: Yes, we put them right on the
17 surface, yes.

18 MS. FULLERTON: They were --

19 MR. GEIGER: That's the other one, that's
20 the steady state transport test, where we took --
21 where we came up with the tumbling velocity, and then
22 we used that as a factor for selecting a -- well, we
23 tested it at the tumbling velocity and a lower
24 velocity, right?

25 MS. FULLERTON: Lower velocity, yes.

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1 MR. GEIGER: So, we tested what the
2 transport was at those, at the tumbling velocity. We
3 put them in just -- introduced them just below the
4 surface, and studied the way it went.

5 DR. BANERJEE: All right.

6 MR. GEIGER: Okay.

7 And then --

8 MS. FULLERTON: So, they still had about
9 three feet to fall, maybe a little less, 2-1/2 feet.

10 MR. GEIGER: And, we selected 0.2 feet per
11 second, because actually we got very encouraging
12 results from the tumbling velocity test as to what it
13 really took to move these, so we initially were going
14 to do it at 0.1 feet per second, but then, you know,
15 we felt pretty comfortable using that higher, to try
16 to get an upper range.

17 So, that's the quiescent test.

18 So, that, basically, is the facility.

19 MS. FULLERTON: There's a camera over here
20 that was used to record the images, this is a
21 tensiometer up here to measure the surface tension.

22 CHAIRMAN WALLIS: Surface tension doesn't
23 change much, does it?

24 MS. FULLERTON: Yes, this is a pipe that
25 was one foot, we dropped the chip one foot from above

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1 the surface, so that we were consistent in putting the
2 paint chips in.

3 DR. BANERJEE: Okay.

4 MR. GEIGER: Transport testing, and we can
5 go to the next slide and she can explain it.

6 DR. BANERJEE: You didn't use your model
7 basin, huh?

8 MR. GEIGER: Part of it.

9 MS. FULLERTON: We considered a lot of
10 options, because this is something a little different
11 than we do. You know, we needed a smooth bottom. We
12 needed it to be very clean, and we needed to be able
13 to see in from the sides so that we could take the
14 images to track the particles.

15 CHAIRMAN WALLIS: So, you dropped a dry
16 chip in from one foot?

17 MS. FULLERTON: Yes.

18 CHAIRMAN WALLIS: There's almost no place
19 in a containment where a dry chip is going to fall
20 from one foot.

21 MS. FULLERTON: Presoaked, right, they
22 were presoaked chips.

23 CHAIRMAN WALLIS: It was presoaked.

24 MS. FULLERTON: Right. The time to sink
25 test, I believe, were all presoaked.

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1 CHAIRMAN WALLIS: Presumably, in reality
2 they'd fall from 30 feet or something.

3 MR. GEIGER: Well, that's true.

4 MR. TREGONING: But then, they'd end up --

5 MR. GEIGER: -- terminal velocity.

6 CHAIRMAN WALLIS: I mean, with water, yes.

7 DR. BANERJEE: You never know.

8 MR. GEIGER: Okay. This is the transport
9 tests. This is the diagram. So, we had a 30 foot
10 long flume, and we had a filtering system and
11 segregation system at the end, so that we could see
12 what portion of the fragments actually floated to the
13 end and what entrained in the middle, and then what
14 transported along the bottom.

15 And, these are two views of the flume
16 itself. Actually, one of the water tanks that they
17 have out there is circulated water, channels with --
18 and the technician could go out on that platform and
19 actually place the chips in the bottom or drop them at
20 the top. And, this is an end view so you can see.

21 Do you want to explain a little bit about
22 this?

23 MS. FULLERTON: Sure, just a little bit
24 more.

25 What we did have was, we had ordered a 30-

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1 foot long acrylic tank, so that we would have access
2 to the side, and originally we were planning on making
3 more of a stand-alone apparatus that we would just
4 have piping and a pump that we'd be able to set up the
5 currents that we would need inside the tank. And
6 then, we decided we already had a circulating water
7 channel that was capable of this feed range that we
8 were looking for, so we took the acrylic, the smallest
9 tank in this schematic here, and we actually suspended
10 it in the circulating water channel, so we could
11 control the velocity from the channel, but we were
12 able to put our cameras under water to look along the
13 side. And, we had access to the top part, we were
14 able to keep it clean and smooth and recover the paint
15 chips from it.

16 So, that was how we set it up.

17 DR. BANERJEE: You just put it into one of
18 your basins.

19 MS. FULLERTON: Yes.

20 MR. GEIGER: How accurate was your flow
21 control inside?

22 MS. FULLERTON: I think it was -- it's
23 within a tenth of a foot per second.

24 CHAIRMAN WALLIS: You tested all these
25 different things.

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1 MR. GEIGER: Yes, the next three slides I
2 just put in here to give a feeling for how many
3 different tests we actually ran, because you see all
4 the chip sizes we ran, and we ran five different
5 samples, dry and presoaked, we did a terminal velocity
6 test, and also for the large epoxy-based systems we
7 did -- we tested an oven cure, where we oven cured it
8 for 48 hours at 120 degrees and --

9 CHAIRMAN WALLIS: These velocities are all
10 one particle at a time?

11 MR. GEIGER: Yes. Well, one -- a batch.

12 MS. FULLERTON: We would track one
13 particle at a time.

14 CHAIRMAN WALLIS: Throw in a batch of
15 chips to measure the velocity, or just one?

16 MS. FULLERTON: Into the transport flume,
17 we would put in --

18 CHAIRMAN WALLIS: Into the plexiglas tank.

19 MS. FULLERTON: -- oh, we would put not
20 just one at a time. The time to sink we would drop
21 one at a time.

22 CHAIRMAN WALLIS: One at a time.

23 MS. FULLERTON: The other, the terminal
24 velocity, we would put as many as we could without
25 having them touch each other.

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1 CHAIRMAN WALLIS: So, there's a group of
2 them.

3 MS. FULLERTON: There's a group of them,
4 yes, but we were able to --

5 CHAIRMAN WALLIS: Were you able to relate
6 that to how one falls?

7 MS. FULLERTON: We were able to track them
8 separately.

9 CHAIRMAN WALLIS: Did you relate that to
10 how one falls?

11 MR. GEIGER: There was only a group --

12 CHAIRMAN WALLIS: Did they touch each
13 other?

14 MS. FULLERTON: No, well, and if they did
15 we would ignore it, because the point of the testing
16 was just to see if the behavior of one individual
17 chip, and not how it interacted with other chips. So,
18 we were always careful to try to make sure that they
19 wouldn't interfere with each other.

20 MR. GEIGER: So, this is like for the
21 quiescent test, the different tests we ran, and then
22 the tumbling velocity test, and again, we ran the
23 incipient and the bulk.

24 For the steady state again --

25 CHAIRMAN WALLIS: If you dropped two

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1 chips, one behind the other, one is in the wake of the
2 other one, they do interfere with each other.

3 DR. DENNING: You are sure that they
4 weren't close enough that -- I mean, you dumped them
5 together, I mean, you would expect bubbles.

6 MS. FULLERTON: Well, for the time to sink
7 test, they are all on the surface, so I suppose if one
8 moved over and was close to the other one, but they
9 were varied apart. With the time to sink, we did try
10 to wait a long enough time that it wouldn't be in the
11 wake of another chip.

12 CHAIRMAN WALLIS: Yes, I can see that.

13 MS. FULLERTON: But, I suppose it's
14 possible, yes.

15 CHAIRMAN WALLIS: When they are falling.

16 MS. FULLERTON: Right.

17 CHAIRMAN WALLIS: Terminal velocity test,
18 were groups of them or one at a time?

19 MS. FULLERTON: Well, it would be one
20 group at a time. I guess to clarify, so you would put
21 like say five large chips on the surface and let them
22 fall. And, if it moved over, you know, presumably,
23 they are all separated.

24 CHAIRMAN WALLIS: So, there are very few
25 chips.

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1 MS. FULLERTON: There are very few chips,
2 right.

3 MR. TREGONING: And, the tumbling velocity
4 test, obviously, all the chips were introduced on the
5 floor before flow was started.

6 CHAIRMAN WALLIS: Okay.

7 MR. GEIGER: Okay. Now, Anne will
8 describe how the software they used, and the
9 methodology they used, to actually run the tests.

10 CHAIRMAN WALLIS: Do you have any results
11 to show us?

12 MS. FULLERTON: No, not at this time.

13 MR. GEIGER: We do have some --

14 MR. TREGONING: Just observations.

15 MR. GEIGER: -- we have some observations.

16 MR. TREGONING: Again, these tests were
17 just completed, you know, a week or so ago.

18 CHAIRMAN WALLIS: So, we don't know if
19 they made any sense in terms of interpretation yet?

20 MR. TREGONING: We are still making sure
21 that we understand that as well.

22 MS. FULLERTON: Okay.

23 So, as Erv said before, we used a blender
24 to get the size chips that we were looking for. Then
25 we used sieves to segregate them into size classes.

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1 Then we would also -- before each test we would take
2 an image of the sample on a contrasting sheet of paper
3 underneath, and we used some chip sizing software to
4 get the average chip area, the major and minor axis,
5 and a few other characteristics about the chips.

6 Then, when we actually --

7 DR. BANERJEE: So, how did you
8 characterize it? I mean, you have an area and the
9 perimeter, is that what you did?

10 MS. FULLERTON: We have an area and a
11 major and minor axis, so the smallest axis and the
12 largest axis.

13 DR. BANERJEE: So, you didn't measure a
14 perimeter, because in --

15 MS. FULLERTON: But, we could, we have the
16 images.

17 DR. BANERJEE: -- in a regularly-shaped
18 device --

19 MS. FULLERTON: Right.

20 DR. BANERJEE: -- there's an issue as to
21 how you characterize it.

22 MS. FULLERTON: Right.

23 DR. BANERJEE: So, if you got the
24 perimeter and the area you'd get a fractal dimension
25 for it.

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1 MS. FULLERTON: Right.

2 DR. BANERJEE: Maybe you can use that.

3 MS. FULLERTON: We could use that.

4 DR. BANERJEE: Yes.

5 MS. FULLERTON: And, we have the images,
6 so we could, you know, go back and get the perimeter
7 from those images.

8 DR. BANERJEE: Yes.

9 MS. FULLERTON: Basically, the point of
10 the sizing software was to make sure that what we had
11 in the sieves was what we thought we had, you know,
12 that would make sure that we had what we were looking
13 for.

14 Slide 17 has a histogram, just a
15 characteristic histogram for 100 chips for an E3C time
16 to sink test. That was the one that has the white one
17 with the ridges on it, so it's just an area histogram,
18 and major axis histogram.

19 We also used some different --

20 CHAIRMAN WALLIS: So, the one which is
21 2600 square millimeters is a pretty big chip.

22 MS. FULLERTON: Right, and there's only a
23 few of those, so there were some larger.

24 CHAIRMAN WALLIS: So, when you say you got
25 them in the range of one to two inches, this is really

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1 a five-inch chip or something, isn't it?

2 MS. FULLERTON: It could be, I don't think
3 so. I mean, it had to pass --

4 CHAIRMAN WALLIS: Maybe I'm wrong.

5 MS. FULLERTON: -- it had to pass through
6 the sieve.

7 CHAIRMAN WALLIS: Okay, okay.

8 MS. FULLERTON: One axis of it has to be
9 one or two inches. It's possible the other axis was
10 bigger.

11 CHAIRMAN WALLIS: All right.

12 MR. GEIGER: It does represent the random
13 size in the plant.

14 MS. FULLERTON: Right, and, you know, we
15 could have made them all squares, but we were trying
16 to make them as irregular and random as possible.

17 We also used some software to track the
18 chips, so during the transport testing we had four
19 cameras, two looking above, two looking from the side,
20 and we also actually had an extra camera at the end,
21 which was looking at the capturing device at the end
22 of the filtration system.

23 DR. BANERJEE: They have to be in your
24 field of you, were you moving the whole group of
25 cameras with the chips?

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1 MS. FULLERTON: No, the cameras were
2 fixed, but looking at different places within the
3 tank, so that we would be able to capture them.

4 And, we had two cameras right at the
5 starting line, or whatever you want to call it, and
6 making sure that when we would introduce the chips
7 that they were always in that -- we had marked off a
8 certain area.

9 CHAIRMAN WALLIS: It's just like a ski
10 race, isn't it, you start them --

11 DR. BANERJEE: You have your basin
12 structure, you move the cameras, you know --

13 MS. FULLERTON: With a carriage, right.

14 DR. BANERJEE: Yes.

15 MS. FULLERTON: But, in the actual basin
16 that we used, the circulating water channel, the whole
17 point is to keep the model fixed and move the water
18 past it, so there's not that kind of a thing there.

19 DR. BANERJEE: Okay.

20 MS. FULLERTON: If we wanted to use one of
21 the bigger basins --

22 DR. BANERJEE: Yes.

23 MS. FULLERTON: -- it's not really good
24 for this kind of test.

25 MR. TREGONING: It would have been over

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1 kill for this test.

2 MS. FULLERTON: Yes.

3 So, we would take these images of the
4 chips and use this chip tracking software, which would
5 calculate the area of each chip.

6 So, what we would do is, find the center
7 of each chip and track every frame. We would use a
8 camera that took 30 frames per second, and from that
9 we are able to get the velocity of each chip.

10 So, we'll go on to the movie now. This is
11 from the quiescent tank. Now, we can track both
12 components of that velocity, too.

13 DR. BANERJEE: It's falling leaves.

14 MS. FULLERTON: Right, and you definitely
15 see a lot more of that in the larger chips than you do
16 with the smaller chips.

17 CHAIRMAN WALLIS: But, they are in a tank,
18 so it doesn't affect the wall repelling them that
19 would keep them from going off on a long trajectory
20 sideways, which they might do in a big tank. I don't
21 know.

22 MR. GEIGER: They are sort of coming down
23 in the middle.

24 CHAIRMAN WALLIS: I know they are, but
25 that's because they are -- it could be because they

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1 are in the tank.

2 MR. TREGONING: If there directional flow
3 and other things associated with your actual
4 conditions, yes, that could dramatically affect how
5 far they transport.

6 CHAIRMAN WALLIS: No, I mean if there's no
7 flow at all, and if there's something, a wall effect
8 which repels them, I'm just hypothesizing that.

9 DR. BANERJEE: Well, there will be a wall
10 effect. Were these all in the center, more or less?

11 MS. FULLERTON: Pretty much, yes, they
12 didn't get very close to the wall.

13 MR. TREGONING: Can you characterize that,
14 what was --

15 MS. FULLERTON: Measurement?

16 MR. TREGONING: What is the frame to view
17 of the -- this is a one to two inch chip, so it looks
18 like --

19 MS. FULLERTON: Yes.

20 MR. TREGONING: -- you've got about, what,
21 a six inch --

22 MS. FULLERTON: It's about -- it's
23 probably not even that, it's probably more like four
24 inches.

25 MR. TREGONING: And, what was the

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1 dimension of your tank again?

2 MS. FULLERTON: It's about one foot by one
3 foot.

4 DR. BANERJEE: Yes, so if it's toward the
5 center it will be minimized.

6 MS. FULLERTON: Right.

7 DR. BANERJEE: But, if it gets near the
8 wall, obviously, there will be an effect.

9 MS. FULLERTON: Right, but then it would
10 be out of the camera view, so we wouldn't be able to
11 track it.

12 MR. TREGONING: Did you notice that during
13 any of the time to sink test?

14 MS. FULLERTON: Most of them, because we
15 were dropping them in the center, so --

16 CHAIRMAN WALLIS: These are ones going
17 down one after the other, so they are falling through
18 the wake of the other one, which is sharing vortices.

19 MR. TREGONING: No, this is a repetitive
20 loop.

21 MR. GEIGER: There's two different chips
22 here, I think.

23 CHAIRMAN WALLIS: You watch the same one
24 time, after time, after time?

25 MS. FULLERTON: There are two chips, two

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1 different chips, but it's --

2 CHAIRMAN WALLIS: There are two that look
3 different. But, it just keeps on repeating and
4 repeating?

5 DR. BANERJEE: It is two chips following
6 each other.

7 MR. TREGONING: We can't lock up the ACRS
8 computer with ABI files, so that's why it's relatively
9 small.

10 CHAIRMAN WALLIS: But, you see what we are
11 getting at, is that if there are two, then one is in
12 the wake of the other one.

13 MS. FULLERTON: Right. Yes, this is
14 played at half speed.

15 MR. TREGONING: So, they are actually
16 coming faster than this. You can see the smaller ones
17 are --

18 CHAIRMAN WALLIS: So, it's interesting,
19 they do want the fall flat, they don't want to go, you
20 know, sideways.

21 MS. FULLERTON: Sideways, right, unless
22 they hit the surface sideways, then they'll go
23 straight down.

24 DR. BANERJEE: But, that's a very unstable
25 configuration to actually go straight down.

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1 MS. FULLERTON: Right.

2 DR. BANERJEE: A small perturbation will
3 take --

4 CHAIRMAN WALLIS: They will move across
5 the flow.

6 MS. FULLERTON: Well, these are also the
7 E3C, which has the ridges.

8 CHAIRMAN WALLIS: Those were accelerated
9 through a valve, that's different.

10 MR. TREGONING: Oh, okay, apparently.

11 MS. FULLERTON: So, Ervin, I don't know if
12 Ervin mentioned it or not, but for the quiescent
13 testing we also did an experiment with thermal cure on
14 some of the chips, to see if that would change any of
15 the characteristics.

16 So, for all except the alkyd sample we
17 heated them in an oven, one for two weeks at 150
18 degrees, and one for two days at 120 degrees, to see
19 if there were any effects. There were no significant
20 effects, all the effects were within the standard
21 deviation of all of the other testing. So, that was
22 the only information we collected with that thermal
23 cure was for the quiescent testing.

24 DR. BANERJEE: What happens if you wet the
25 alkyd, would it sink?

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1 MS. FULLERTON: Yes.

2 MR. GEIGER: No, no.

3 DR. BANERJEE: Like sometimes leaves, they
4 will sink.

5 MS. FULLERTON: No, when they were dropped
6 onto the surface they were not, yes.

7 MR. GEIGER: We also did like on the
8 epoxies, some of them we did a curl -- we heat curled
9 them and put them on a drum or something to get them
10 to -- to try to get them so we could study the shape
11 effects.

12 CHAIRMAN WALLIS: They were dry when they
13 landed, wouldn't they, or were they not dry when they
14 landed?

15 MS. FULLERTON: They are dry when they --
16 when we introduce them.

17 MR. GEIGER: They don't soak up water.

18 MS. FULLERTON: No.

19 So, we would take the water out and
20 separate them, and then put them in. So, there would
21 be some water on them, but not -- it wasn't like they
22 were in a water mix.

23 DR. BANERJEE: Is the alkyd's true density
24 higher than water?

25 MS. FULLERTON: It's just about the same.

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1 MR. GEIGER: The manufacturer says 1.15
2 specific gravity, we measured about one.

3 DR. BANERJEE: Okay, so that explains
4 that.

5 MS. FULLERTON: So --

6 CHAIRMAN WALLIS: Heavier samples fall
7 faster is not being contentious, is it?

8 MS. FULLERTON: No, stating the obvious.

9 MR. TREGONING: We have general agreement
10 with that.

11 MS. FULLERTON: And, the alkyd didn't sink
12 when we dropped it on the water. We covered that.

13 So, we have another movie of the tumbling
14 velocity tests, these were when we would replace the
15 chips along the bottom of the tank and then slowly
16 increase the speed of the flow.

17 CHAIRMAN WALLIS: Are they being picked
18 up?

19 MS. FULLERTON: To see what velocity --

20 MR. TREGONING: You see them lifting.

21 MR. GEIGER: These are two views, from the
22 top --

23 MS. FULLERTON: And from the bottom.

24 CHAIRMAN WALLIS: Now, once they are
25 picked up and get oriented around, then they could

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1 shoot up to the surface, couldn't they?

2 MR. GEIGER: Well, I don't think --

3 MS. FULLERTON: That didn't --

4 CHAIRMAN WALLIS: You never saw that?

5 MS. FULLERTON: Not to the surface, some
6 would get --

7 CHAIRMAN WALLIS: But, they do shoot up
8 some ways.

9 MS. FULLERTON: -- some would get
10 suspended, especially the lighter ones, the alkyds.

11 MR. GEIGER: If you look at it this way to
12 see how some of them lift up, they just kind of go
13 along the top.

14 DR. BANERJEE: It depends on the specific
15 gravity and the size. What's happening is that the
16 turbulence, which is catching it in an ejection --

17 CHAIRMAN WALLIS: They seem to get their
18 back end picked up, so the lift that picks them up,
19 and then now you see it on the right there.

20 MR. CARUSO: What samples are these?

21 MS. FULLERTON: These are the E6, which is
22 an epoxy.

23 CHAIRMAN WALLIS: Once it gets lifted up -

24 -

25 MR. CARUSO: What specific gravity?

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1 MS. FULLERTON: I think it was 1.75.

2 DR. BANERJEE: Pretty dense.

3 MS. FULLERTON: Yes.

4 DR. BANERJEE: So, the smaller -- if you
5 made them smaller, did they get entrained up further?

6 MS. FULLERTON: The smaller ones, yes,
7 would get entrained, more than the larger ones.

8 CHAIRMAN WALLIS: Did it come back down
9 again, I think that the condition for one lying on the
10 ground to be picked up is a rather different condition
11 for one in the flow to land, because I noticed that
12 once they get off the bottom they get across the flow,
13 and the force on them goes up tremendously.

14 MS. FULLERTON: Sure, they orient
15 themselves.

16 CHAIRMAN WALLIS: So, whether or not they
17 will come down and settle is quite different.

18 MS. FULLERTON: Getting picked up, and
19 also --

20 DR. BANERJEE: The wall structures, you
21 know, the ejections will take them off, and what
22 brings them down are the sweeps.

23 MS. FULLERTON: Yes.

24 DR. BANERJEE: So, what you see, the
25 lighter particles will get -- I mean, not lighter, but

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1 the smaller --

2 MS. FULLERTON: Smaller, right.

3 DR. BANERJEE: -- they will go higher, and
4 then if they come down they'll come down with a sweep.

5 MS. FULLERTON: Right.

6 DR. BANERJEE: Real fast. So, you know,
7 the wall structures --

8 CHAIRMAN WALLIS: This is a turbulent
9 flow.

10 DR. BANERJEE: There are periodic
11 ejections scaled with the wall shear, so you can
12 probably find the frequency with which this would
13 happen.

14 CHAIRMAN WALLIS: I think they are very
15 unlikely to come down just so that they land and stay
16 in sort of a protected little boundary there.

17 MS. FULLERTON: Some of them would.

18 DR. BANERJEE: It will, because --

19 CHAIRMAN WALLIS: Well, they have to land
20 just right. If they land on the tip, then the force
21 is going to blow them away.

22 MR. CARUSO: And, the surface has to be
23 relatively flat.

24 CHAIRMAN WALLIS: Right.

25 MR. TREGONING: But, this is very smooth.

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1 MS. FULLERTON: Yes, it was very smooth.

2 DR. BANERJEE: In reply to Graham's
3 question, if you -- depending on the level of
4 turbulence you have, these can actually -- the sweeps
5 can go right to the surface -- I mean, the ejection,
6 so you could take them almost up to the surface,
7 depending on how turbulent the flow was.

8 MS. FULLERTON: It would be very rare to
9 see any of that, that went up to the surface.

10 DR. BANERJEE: You had --

11 MS. FULLERTON: No, that was the highest,
12 some of them are much lower. The alkyds were much
13 lower, more like .3 feet per second, the curl chips
14 were lower, it was easier to pick up a curl chip
15 because you already have some of the area in some
16 cases oriented in the direction of the flow. So, it's
17 easier to pick them up.

18 MR. CARUSO: What velocity is this?

19 MS. FULLERTON: This I think is about one
20 foot per second.

21 MR. CARUSO: One foot.

22 MS. FULLERTON: Yes.

23 CHAIRMAN WALLIS: And, is it changing, or
24 there will be just different ones picked up because of
25 the turbulence?

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1 MS. FULLERTON: It is changing very
2 slowly, so we would start out at a lower speed and
3 slowly increase, and we are measuring velocity at the
4 same time, water velocity.

5 CHAIRMAN WALLIS: Why did you call this
6 pick-up velocity or entrainment velocity?

7 MR. TREGONING: It's just an historical
8 term.

9 CHAIRMAN WALLIS: It's misleading.

10 MR. TREGONING: It is, it's a bit
11 misleading, but it's an historical term.

12 DR. BANERJEE: There's a huge literature
13 on this area.

14 CHAIRMAN WALLIS: I would want to know
15 what happens to them after they are picked up, do they
16 ever -- if they are picked up at one foot per second,
17 do they ever land again?

18 MS. FULLERTON: Yes.

19 CHAIRMAN WALLIS: They do, do they land
20 and stay?

21 MS. FULLERTON: They do -- well, very --
22 not very many of them, most of them would get
23 transported to the end, and end up on the screen once
24 they get picked up.

25 MR. GEIGER: At this velocity.

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1 MS. FULLERTON: At this velocity, right.

2 CHAIRMAN WALLIS: Okay.

3 Well, you are going to sort all that out.

4 MS. FULLERTON: Right. We have to -- we
5 have a lot of data to go through.

6 MR. TREGONING: Again, there were other
7 tests where they injected paint into the flow with a
8 certain velocity, and those test are more illustrative
9 in terms of what the transport distances are like
10 before settling occurs, or I'll say should be more
11 illustrative.

12 CHAIRMAN WALLIS: I guess most of the
13 literature with regard to rods and spheres, and it's
14 flat shapes are not that often studied, it's sort of
15 interesting.

16 MS. FULLERTON: Yes, it is. I did a
17 little bit with sediment transport, and this is a lot
18 -- definitely much bigger than I had ever dealt with
19 before. But, not quite a ship.

20 CHAIRMAN WALLIS: So, you did do sediment
21 transport?

22 MS. FULLERTON: No, it was on -- just on
23 estuarine circulation.

24 Some preliminary observations, again, very
25 preliminary. The flat ALK debris had the lowest

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1 tumbling velocity, so that was about .3 feet per
2 second. The E6 and the zinc had larger tumbling
3 velocities. Again, these are the heavier chips, so
4 that's pretty obvious. In general, the curled chips
5 had lower tumbling velocities than the same debris
6 flat chips, because they are having more of their area
7 into the flow, and very little transport at the .2
8 feet per second, which was the lower velocity that we
9 tested. Most chips did not make it all the way to the
10 end, except for the ALK, more of that transported in
11 general.

12 SO, in summary, the testing is complete.
13 We just finished it about two weeks ago. We are in
14 progress for data analysis, and the report will be
15 available from NRC in fall, 2006.

16 CHAIRMAN WALLIS: So, you are doing the
17 usual thing, doing the tests and then trying to figure
18 out what it means.

19 MS. FULLERTON: That's right.

20 MR. GEIGER: Mostly to make sure we have
21 all our data, you know.

22 CHAIRMAN WALLIS: Well, for the report you
23 want to have it right, and I would hope that you were
24 actually trying to plug some data and think about it
25 while you are doing the testing.

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1 MR. TREGONING: No, we did, of course we
2 did that.

3 MS. FULLERTON: Right, we had to do that
4 for -- especially for the tumbling velocity, because
5 that's what we tested at the following week.

6 MR. TREGONING: We modified the matrix
7 fairly significantly, based on some of the initial
8 results from both the time to sink and the settling
9 velocity.

10 DR. BANERJEE: Typically, what was the --
11 I mean, just -- is there a correlation between --
12 let's say in the quiescent tank, between the area of
13 your flake and the settling velocity, in rough terms?
14 Can you give us some preview of this? Say the same
15 material, the same --

16 MS. FULLERTON: So you are asking, the
17 smaller chips are sinking quicker or slower?

18 CHAIRMAN WALLIS: I would think it's about
19 the same.

20 MS. FULLERTON: It's about the same, but
21 there is the sideways component.

22 CHAIRMAN WALLIS: Mass goes as area, and
23 drag goes as area, so you don't think it's the same.

24 DR. DENNING: The sideways components are
25 the bigger.

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1 MS. FULLERTON: The bigger chips, the
2 sideways component is bigger, which gives us --

3 CHAIRMAN WALLIS: It's like going down a
4 half pipe.

5 MS. FULLERTON: Right.

6 MR. GEIGER: The smaller chips we are
7 doing that a lot faster.

8 CHAIRMAN WALLIS: Yes, well you may want
9 to correlate the frequency.

10 DR. BANERJEE: Well, the drag goes with
11 the area, right?

12 CHAIRMAN WALLIS: And the weight goes with
13 the area too.

14 DR. BANERJEE: But then, the sideways
15 motion.

16 CHAIRMAN WALLIS: It might make a
17 difference.

18 DR. BANERJEE: It's worth understanding
19 that.

20 CHAIRMAN WALLIS: So, this is very
21 fundamental stuff, and we have to -- somebody has to
22 figure out how to apply it.

23 MS. FULLERTON: Right.

24 DR. BANERJEE: One thing that you can do
25 relatively easy is to put a little turbulence into

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1 your quiescent tank with a moving grid.

2 MS. FULLERTON: Yes.

3 DR. BANERJEE: There's a huge and
4 beautiful set of experiments done by Faeth and --
5 General Fluid Mechanics, where they look at the effect
6 of turbulence on settling velocity. It's homogenous
7 turbulence, and I think that would be interesting for
8 you to read.

9 MS. FULLERTON: Okay, sounds good.

10 DR. BANERJEE: There's two papers, that's
11 F-A-E-T-H.

12 MS. FULLERTON: F-A-E-T-H.

13 CHAIRMAN WALLIS: How much spread is there
14 in the results? Is there a lot of statistical
15 variation if you take, say, 100 flakes that look
16 similar and do a test of terminal velocity, is it a
17 pretty narrow distribution?

18 MS. FULLERTON: For the tumbling velocity?

19 CHAIRMAN WALLIS: Right, or for anything.

20 MS. FULLERTON: Well, and we did about, I
21 think, 50 chips for each for the tumbling velocity.

22 The quiescent testing, there was more --
23 I think a higher deviation from the average for the
24 larger chips than for the smaller chips, and we
25 thought that maybe that had something to do with that

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1 sideways component that was a little bit different.
2 But, we got pretty consistent results for -- we had
3 good repeatability. We tested many, many chips.

4 CHAIRMAN WALLIS: Any other questions?

5 Thank you very much.

6 MS. FULLERTON: Thank you.

7 CHAIRMAN WALLIS: Do we have a wrap up now
8 from the RES?

9 MR. TREGONING: Quick wrap up.

10 CHAIRMAN WALLIS: Then we go for lunch.

11 MS. EVANS: Okay. My name is Michelle
12 Evans. I'm from the Office of Research. I'm a Branch
13 Chief in the Division of Engineering Technology.

14 I just want to summarize what you heard
15 with regard to the research in the last day and a
16 half, talk a little bit about where we are headed, and
17 maybe how the committee could help us.

18 First of all, I'd like to thank the
19 committee for the opportunity to present our research
20 over the last day and a half. We appreciate the
21 opportunity for your dialogue, and incites, and
22 questions.

23 Research invested a significant amount of
24 resources in this research over the past year.
25 Several of the things that you heard about yesterday

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1 were just implemented, or initiated, in the last year.
2 the ICET testing yesterday, and also the downstream
3 effects throttle valve work that you heard about
4 today, those tests were -- that research has been
5 going on for a few years. However, the rest of this
6 research was initiated about a year ago.

7 At that time, management had made
8 decisions about the scope of the research that we
9 would move forward with, and the basis for the scope
10 was a balancing of the need to move forward on the
11 designs by the industry, how research could best
12 support NRR in their review of licensee submittals,
13 what the NRC's role is in the research versus what
14 industry's role is in conducting related research,
15 also balancing the resources and the timing of
16 everything.

17 So, about a year ago there was a decision
18 made to fund this research, and to move forward with
19 the idea that it would be completed in the spring of
20 this year, but that decision was revisited in the fall
21 of 2005, and again additional resources were made
22 available to complete the scope of the testing that
23 you've heard about in the last day and a half here, to
24 complete it by April.

25 CHAIRMAN WALLIS: You wanted to finish

1 this work by now.

2 MS. EVANS: We want to finish what you've
3 heard about.

4 CHAIRMAN WALLIS: And, it looks as if
5 quite a bit of the work is, in fact, raising more
6 questions, rather --

7 MS. EVANS: True.

8 CHAIRMAN WALLIS: -- than resolving
9 issues.

10 So, is it finished?

11 MS. EVANS: Is it finished? This scope
12 will end --

13 CHAIRMAN WALLIS: Are you going to cut it
14 off before you've really solved the problem?

15 MS. EVANS: No. The scope of work we've
16 laid out, we still intend to finish what we had laid
17 out in April.

18 CHAIRMAN WALLIS: Yes.

19 MS. EVANS: And, I understand additional
20 questions may have been raised.

21 Our intent is to be done with this current
22 research and to allow the industry to move forward
23 with what they are doing, come forward with their
24 submittals, and once we see those and NRR has had the
25 opportunity to review what comes forward, there may be

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1 a need to do additional research, but we are not at a
2 point right now where we are committing to do that.

3 We have looked internally in the Office of
4 Research and NRR staff-wise at, you know, potentially,
5 we've got a wish list on additional research that
6 could be useful, but there are no commitments at this
7 point that we would do any of that until, you know --
8 the need may arise, but at this point we are not
9 moving forward with any additional research.

10 I think we've got commitment to meet again
11 with the committee to talk more about the results of
12 the research. I believe we've got a June subcommittee
13 meeting. We'll come forward then with any additional
14 significant findings and results over the next couple
15 months.

16 There's also a Chemical Effects Peer
17 Review, which we will be wrapping up in the next month
18 or so, so we'll be at a point to present that to you
19 in June.

20 CHAIRMAN WALLIS: Can I ask you something
21 now?

22 MS. EVANS: Yes.

23 CHAIRMAN WALLIS: We heard this morning
24 about the flow paths through the core.

25 MS. EVANS: Right.

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1 CHAIRMAN WALLIS: Are you doing any
2 research, have you done any research on what would
3 happen if you got debris in the core?

4 MS. EVANS: No, we haven't.

5 CHAIRMAN WALLIS: Do you plan to do any?

6 MS. EVANS: We've looked at the need to,
7 you know, and the thought of doing that has entered
8 into discussion, yes.

9 We have a budget process where we look at
10 what may be on the horizon in '07-'08, and, yes, that
11 is definitely an area that may need additional
12 research. But, no, we haven't committed to do that at
13 this point.

14 As you heard, the WOG and industry,
15 they've got their approach that they are working
16 through, and NRR staff is working with them to
17 understand that.

18 So, at this point is there a clear need?
19 No, but is there potential? Yes.

20 CHAIRMAN WALLIS: Do you get involved in
21 reviewing the WOG guidance, or work, whatever we call
22 it, the WOG work that we saw on what to do with the
23 debris in the core, did you folks review that at all,
24 or it just went to NRR? Did you review it from the
25 point of view of saying, when they say calculate this,

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1 did you review it from the point of view of what's to
2 say you ought to be able to calculate what they
3 suggest you calculate?

4 MR. TREGONING: Shanlai Lu is going to
5 elaborate a little bit on that.

6 CHAIRMAN WALLIS: This is an NRR problem,
7 it's not an RES problem, so it's not something that
8 RES has been doing, reviewing the WOG.

9 MR. LU: The WOG is planning to submit a
10 report to us, that's not here yet.

11 CHAIRMAN WALLIS: What you've seen is a
12 draft.

13 MR. LU: Yes, what we saw was just draft,
14 and it's coming in.

15 MR. SCOTT: It's coming in this month,
16 right, I think by the end of February.

17 MR. LU: Yes, by the end of February they
18 are going to have us our review from the NRR side.
19 So, I think we probably will talk to Rob and Michelle,
20 once we have more questions about that.

21 MS. EVANS: At this point, as far as the
22 committee goes, and what we've presented, you know,
23 information on our research, we are looking for the
24 committee to give your view on the credibility of what
25 we did and told you about over the last day and a

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1 half.

2 We do understand that there --

3 CHAIRMAN WALLIS: Do you want a grade on
4 credibility? That's a dangerous thing to ask for.

5 MS. EVANS: Well, we are very interested
6 in the incites that the committee has to offer, so,
7 yes, we would accept a review on credibility. We also
8 would --

9 CHAIRMAN WALLIS: I think more the issue
10 is adequacy.

11 MS. EVANS: Okay.

12 We also understand that things may be
13 missing, there may be areas we haven't touched on, and
14 like I said, we also internally have identified
15 potential future research also. But, at this point in
16 time the decisions were made to, you know, allow the
17 industry to proceed down the path that they are
18 heading with the submittals, and additional decision
19 on additional research be made at a later time.

20 MR. SCOTT: At the appropriate time, I'd
21 like to present a few closing remarks.

22 CHAIRMAN WALLIS: Sure, maybe now is the
23 time.

24 MR. SCOTT: Okay.

25 We also would like to thank you all for

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1 the opportunity to present our views and what's going
2 on with the issue, and to hear your views and
3 perspectives on GSI-191.

4 We would like to, and are happy to,
5 facilitate your continued review. We are ready and
6 willing to meet with you at an appropriate time to
7 discuss follow-on issues, including the downstream
8 effects. As Michelle mentioned, and as was discussed,
9 we are expecting a WOG report on downstream effects,
10 and we'd be happy to discuss the staff's review of
11 that at an appropriate future time.

12 You asked, Dr. Wallis, a couple days ago,
13 how you can help in this area, and we've kicked that
14 around a little bit. We have some thoughts.

15 First of all, as I think Michelle referred
16 to also, we would greatly appreciate the committee's
17 perspectives on the chemical effects issues, as
18 clearly was brought out again and again this week,
19 these are very complex issues, and we would appreciate
20 your input on those.

21 Would like to address one remark that you
22 made a little earlier today, regarding the NRR dates
23 for issue resolution. Please remember that the
24 process that we've presented to you is a process that
25 involves, rather than research providing sufficient

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1 information by itself to resolve the issue by a date
2 certain, research has provided perspective, and is
3 providing perspective for the staff. The staff also
4 expects that the industry will provide the information
5 in addition to what research has provided sufficient
6 to resolve the issue.

7 So, when the industry submits its
8 responses to the requests for additional information
9 that we are sending out to them regarding the generic
10 letter, we will have that information from research in
11 hand to provide additional perspective and
12 confirmation for the staff's review.

13 We did not expect, and this process has
14 not been developed to have research take the whole
15 burden on.

16 CHAIRMAN WALLIS: You folks have sketched
17 out all the strategy. I'm just thinking about
18 history. Does history show that given a complex issue
19 like this, with a whole lot of interacting, not very
20 well understood phenomena, does history show that
21 relying on industry to solve it works?

22 I remember when we were dealing with
23 LOCAs, the Agency actually made a commitment to do the
24 fundamental work so that we understood what was going
25 on and could make the right decision, and there have

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1 been other examples where the Agency has said, we've
2 got to take the lead because it's too disbursed to go
3 out to the industry and so on.

4 But, in this case you seem to be always
5 saying, well, it's up to industry to solve it, come
6 back, and we're going to somehow judge it. Does
7 history show that that approach works?

8 MR. SCOTT: I'm going to dodge that issue
9 a little bit, but I would say that if industry --

10 CHAIRMAN WALLIS: I'm thinking of the
11 record, because someone might read the transcript to
12 get the answer to this.

13 MR. SCOTT: I don't have the answer to it.

14 CHAIRMAN WALLIS: No.

15 MR. SCOTT: But, I would add the
16 following, and I think Michelle referred to it as
17 well. If the industry submittals come in, and we
18 identify in our review of those submittals that there
19 is an issue with the way that we've gone through this,
20 then that may need to necessitate a change in course.

21 So, we are not going to be, you know,
22 fixed on this to the end, unless the approach works,
23 clearly.

24 One more point I'd like to make is, we
25 would appreciate the committee's support for what the

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1 staff believes to be a prudent course of action
2 regarding enlarging the strainers. We recognize that
3 these are very complex issues that are going to take
4 a long time to resolve, and the uncertainties are
5 large and are likely to remain so for some time. The
6 staff believes that the enlargement of the strainers
7 at this time in parallel with the continued
8 development of information by research and by the
9 industry that this is a prudent activity to undertake.

10 We expect, and have communicated to the
11 licensees, that as they make modifications to their
12 strainers that they will fully assess downstream
13 effects, such that the installation of larger
14 strainers does not inadvertently cause a problem with
15 downstream effects.

16 And, that concludes my remarks, subject to
17 your questions.

18 CHAIRMAN WALLIS: Well, the issue of
19 enlarging strainers, the prudent course of action,
20 presumably, has to be taken in the framework of
21 understanding of the NRC's philosophy and methods for
22 ensuring public safety, not just within the sort of
23 technical judgment of people like the ACRS.

24 So, it seems to me that we can certainly
25 tell you something about what's involved with

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1 enlarging strainers, but in terms of what's the
2 prudent course of action we may be getting outside the
3 terrain in which we are comfortable and confident to
4 maneuver.

5 MR. SCOTT: I understand that. Some of
6 the remarks that were made earlier today and yesterday
7 led us to believe there were some concerns in that
8 area, and we're trying to address those.

9 DR. DENNING: Well, I think that the
10 concern is -- relates to downstream effects, and what
11 we've heard today, or the last few days, indicates
12 that there really has not been enough research
13 examination of downstream effects at this time. We
14 haven't seen the evidence, and we hear things like,
15 well, there are going to be plant-specific, and we'll
16 review what the industry provides, and this type of
17 stuff, I don't think that that is a prudent way to go
18 forward.

19 I think that you ought to be looking at
20 some examples today to see if we really understand
21 what the implications are of potentially large
22 loadings of material passing through the screens with
23 larger screen areas. That seems -- I mean, and I
24 don't speak for the Advisory Committee clearly here,
25 but it certainly seems like enlarging the screens is

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1 a very good idea, relative to many of the other
2 concerns that we have, but the one area that hasn't
3 been, I don't think, adequately looked at before one
4 could answer that question is the downstream effects.

5 MR. SCOTT: One point I didn't make, but
6 should, is that the staff's technical adequacy audits
7 that we will be doing on the industry's work will
8 provide an opportunity to focus on just the same thing
9 you talked about.

10 CHAIRMAN WALLIS: I think there's going to
11 be a tradeoff, that you have too big a strainer it's
12 probably bad for downstream effects, and if you have
13 too small a strainer it's bad for NPSH. How do you
14 make the decision, it has to be based on some kind of
15 a measure of success, or some measure of risk, or
16 something, where you see one going down, one going up,
17 and somewhere there's a minimum of some kind of value
18 of something.

19 MR. SCOTT: Yes.

20 CHAIRMAN WALLIS: Now, has the Agency ever
21 tried to address it that way, I don't think you have,
22 I haven't seen any kind of a prospective on what's the
23 increased risk of this versus the decreased risk of
24 that, and how does it all balance, and this is how we
25 are going to make a decision.

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1 MR. TREGONING: But, wait a minute, I
2 mean, that's one way to solve it, is trying to
3 optimize it, and there may be an optimal screen size.

4 CHAIRMAN WALLIS: How else would you do
5 it, when you've got to trade off things against one
6 another?

7 MR. TREGONING: Well, you can have a non-
8 optimized design that still may satisfy the regulatory
9 requirements that are -- again, there's quite a --

10 CHAIRMAN WALLIS: So, how are you going to
11 decide what those requirements should be then?

12 MR. TREGONING: Well, we are not changing
13 the requirements to meet 5046 as part of this
14 exercise.

15 CHAIRMAN WALLIS: The core remains --

16 MR. SCOTT: That's the whole basis for the
17 success criteria for this entire exercise that we're
18 undertaking.

19 CHAIRMAN WALLIS: -- well I think --

20 MR. TREGONING: To ensure that we can meet
21 5046.

22 CHAIRMAN WALLIS: -- you may be trading
23 off uncertainties, too, in which case it is a
24 tradeoff.

25 DR. DENNING: Should we do some summary?

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1 I mean, there are some summary statements I'd
2 certainly like to make.

3 CHAIRMAN WALLIS: I think we can have some
4 summary statements now. What I would really like from
5 you and Sandra, I've got some from Tom, maybe I'll get
6 some more, is some written stuff, which I can -- which
7 will help me to write a report or a position of at
8 least the subcommittee. I guess it would be very
9 appropriate to give some final remarks now.

10 DR. DENNING: Okay.

11 Well, let me say that with regards to
12 things we heard on the first day, I have serious
13 concerns, and I'll talk about those a little bit more,
14 in terms of the regulatory approach, not because -- I
15 think it's being driven by an industrial approach that
16 I don't think is the right way to go forward, and so
17 I'll comment a little bit more on that later.

18 With regards to the last day and a half,
19 I have been very impressed by the research that is
20 going on. I think that almost uniformly the things
21 that I heard are important things and the quality of
22 the research is excellent, but it is done, and to
23 think that we are bringing it to a conclusion in April
24 to me just seems premature.

25 One of the reasons that I think that it

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1 isn't done is that, I think that my greatest concern
2 about the approach that I see to closure, as it now
3 exists in the industry's mind, and I think in NRR's
4 mind, is one in which there's a lot of post testing,
5 as we get down to this last stage of the overall
6 analysis, and you look at what happens at the screen,
7 what I heard was an integral post test approach idea
8 as to how to do that, and I think that that integral
9 proof test, without a real understanding of
10 phenomenology and without models is very difficult to
11 support technically. And, I think that the importance
12 of the research that we have going on is that it does
13 give NRR the ability to make -- to ask the right
14 questions of industry.

15 I think at the moment, because we haven't
16 really brought the research together, we don't really
17 have models, and when I say models I don't want to
18 imply that I think that we can have first principle
19 models for all of these things, but I do think that we
20 have to take the results that we are getting and
21 develop models of some degree, because without those
22 I don't think you have an understanding, or we can't -
23 - we don't really have a technical understanding of
24 what's going on.

25 So, the value of the research, obviously,

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1 is to provide tools to NRR. I don't think that those
2 tools have been really drawn together. I think that
3 we are on our way to doing that, but I don't think we
4 are there, and I don't think we are going to be there
5 for another nine months from what I'm hearing. So, I
6 think there's a lot of analysis of the experimental
7 work that's been done, a lot of putting it together
8 with interpretive tools, so that NRR has the right
9 tools to challenge what is presented to them by
10 industry.

11 That includes on the chemical effects side
12 the difficult problem of bringing that into the
13 pressure drop. Now again, I don't really believe that
14 we are going to have a correlation where you are going
15 to dump in some chemical effects and come up with a
16 modification to a head loss correlation, but you are
17 going to have to have some quantitative understanding
18 of its impact, so that you can get -- can develop
19 alternatives, technical alternatives, like the removal
20 of TSP, perhaps, control of amount of aluminum, those
21 types of things. But, in order to be able to develop
22 those as technical alternatives you are going to have
23 to have some quantitative drawing together of these
24 results on the chemical side.

25 And again, I heard things that I thought

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1 were definitely headed in the right direction, but the
2 thought that one could -- that we are ready by April
3 to do that, we definitely didn't hear that.

4 I guess the final thing I would say is,
5 and maybe I am repeating myself, and that is that we
6 need some perspective on these downstream effects, and
7 I think that just taking some cases and having either
8 research or NRR personnel run through some cases, and
9 see how much debris are we really talking about
10 downstream in the screens, and where does it wind up,
11 and what happens in cold leg breaks versus hot leg
12 breaks, that we've got to do some of that thinking in
13 advance and not waiting for an audit of an industry
14 analysis.

15 CHAIRMAN WALLIS: Thank you.

16 Sanjoy, would you like to give some
17 closing remarks?

18 DR. BANERJEE: Sure.

19 Just a few things. First, I think that we
20 should divide the problem into before the strainers
21 and after the strainers, and my impression is, we know
22 quite a bit about what happens before the strainers
23 and, perhaps, even when they get on the strainers, but
24 not that much after the strainers. And, both are
25 important problems.

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1 I feel a little uncomfortable with letting
2 industry come and do their testing, and then we
3 examine these tests and say are they good enough or
4 not good enough.

5 I think we should sort of interact with
6 them, even at this stage, to give them some feedback
7 as to whether it's likely to be adequate or not,
8 because if they have done all these tests with all
9 these screens, what they are really doing is they are
10 taking pieces of screen, taking a particular
11 situation, a particular flume, looking at the dropout,
12 perhaps, trying to get some benefit for the near field
13 effect, whatever it is, it's a pretty ad hoc approach,
14 and it could be that when we examine these later down
15 the line we'll find it's not adequate, in which case
16 they've spent a lot of money doing plant-specific
17 work, even making modifications to plants, which may
18 turn out to be inadequate, or to lead to another set
19 of problems.

20 So, I do think that they have been doing -
21 - they have been going this course for 30 years now,
22 or whatever, some period of time, the issue is, is it
23 such a big problem that they need to immediately
24 increase these areas? Is it such a big safety issue?
25 And, I can't judge that. If that's felt that it is

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1 such a big safety issue, then, of course, we should do
2 whatever we can based on our judgment today to take
3 care of this.

4 But then the understanding should be clear
5 that this may not be the answer, you know, that
6 eventually they make these MODs, they increase the
7 area, but that may lead to a whole new set of
8 problems, which we need to take care of in the future.

9 So, I would just feel a little more
10 comfortable if there was some more time, I don't think
11 the problem is going to be solved completely, but it
12 could be that there are some innovative ways to take
13 care of this. I imagine you can think of several,
14 which is other than just increasing the screen area.
15 It might be able to take care of both problems, and it
16 might be a design solution, rather than a solution
17 which is based on analysis.

18 So, my sense of this problem is that we
19 are still some ways from resolving it. I do feel
20 there is need for more research, particularly, after
21 the screens, if you like. I do feel that you made
22 very good progress on some areas of research, which
23 can support NRR.

24 I'm particularly happy with what I saw on
25 the chemical analysis part, the modeling there, and a

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1 little bit more work there I think would be very
2 helpful to just close that out in a nice way.

3 I think you are making very good progress
4 on the studies you are doing on blockage, probably the
5 answer you will get is one that nobody will like, that
6 there's no way to actually handle the chemical effect
7 without having a very high pressure loss, however big
8 the screen is, if it covers the whole screen,
9 unfortunately, I think it's going to be clogged. So,
10 one will need to take care of the chemical effects in
11 some other way.

12 But, you know, without saying there's any
13 guidance, one way might be to remove the aluminum
14 ladders, or scaffolding, or whatever. The other way
15 might be to find a new buffer, other than
16 trisodiumphosphate. Who knows, I don't know the
17 answers, I'm just throwing these out.

18 So, there may be innovative ways to take
19 care of these problems, so that -- and you've
20 identified this very nicely I think. So, I'm just --
21 I feel a little bit uncertain about going ahead and
22 just examining what industry submits, and saying is it
23 good enough or not to meet the safety goals that we
24 have, because first I don't think we have enough
25 information to make that judgment very well right now,

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1 second I think getting that information isn't a long
2 way off, and we could probably get a better, more safe
3 design eventually, and NRR might have an easier job in
4 handling this in the future if we just were a little
5 bit more cautious on this, and took a little more
6 time.

7 So, that's my view.

8 CHAIRMAN WALLIS: Thank you.

9 Well, I don't think I'm going to give you
10 a definitive judgment. I agree in many ways with what
11 my colleagues have said, and I have spoken out during
12 the meeting here. You can read the transcript.

13 It would appear that we have a long way to
14 go in terms of a technical understanding, an ability
15 to predict things, quite a few things associated with
16 this problem.

17 We are continually finding new
18 information, which indicates that we didn't have it
19 before, therefore, we would previously be making
20 decisions based on something other than information,
21 and some of this new information includes significant
22 surprises, which indicates that we are not towards the
23 end of a research program.

24 I feel that the downstream effects,
25 particularly, what happens in the core, are an

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1 important issue. I'm surprised it hasn't been
2 addressed with the same kind of vigor and questioning
3 that the sump screen blockage is being addressed with.

4 I suspect that when we do begin to
5 investigate downstream effects, we may find the same
6 kind of lack of information, and the same kind of
7 unexpected results in some areas, that we've been
8 finding with the screens.

9 And so, if I were making a decision on
10 this matter, I'd be very nervous about making any
11 decision at the moment, and what I would look for, I
12 think I've said this at times in the proceedings here,
13 is what I would try to look for would be a way around
14 the problem which was less subject to uncertainty,
15 where I could be clear that I knew what I was doing.

16 Now, I'd invite my colleagues to send me
17 written statements, which I can use helping guide the
18 full committee. The full committee is going to, I
19 understand, give you a letter, and then we'll be
20 responding to what we see as the stated things. It
21 won't be a prescription for what you ought to do, or
22 a decision on the size of strainers or something like
23 that. It's going to be a much more preliminary type
24 of judgment, I think, saying this is where you are,
25 clarifying the situation, rather than saying it's

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1 clear to us what you ought to do or where you ought to
2 go, because I don't think it is clear just what he
3 path should be, and there seems to be a hope that
4 giving it to industry, and having 69 plants all submit
5 different ad hoc experiments and calculations, is the
6 right way, and that seems to me a very big risky thing
7 to attempt to do.

8 Now, maybe if industry can get together as
9 a group and solve some of these problems, that would
10 be a step forward. But, I would be very nervous to
11 have an individual plant, with the resources they
12 have, come up with a really convincing answer to the
13 question, what should we do.

14 MR. SCOTT: Can I make a couple of
15 clarifying remarks, Dr. Wallis, or a couple of points?

16 One, regarding the point you just made, of
17 course, the individual plants are not 69 of them
18 contracting people to do testing. They settled on
19 five vendors, and the vendors are doing the testing,
20 so it's not like there are 69 different sets of tests
21 involved.

22 CHAIRMAN WALLIS: But, by the time that
23 they -- they are going to interpret those for their
24 plants.

25 MR. SCOTT: Correct.

1 CHAIRMAN WALLIS: So, I guess, there are
2 different tests, but there may be some things which
3 are so plant specific that they will actually require
4 plant-specific tests.

5 MR. SCOTT: Yes.

6 CHAIRMAN WALLIS: I mean, the plant that
7 has acres of aluminum is going to be very different
8 from all the other plants, if it has that. I expect
9 by now they don't have it anymore, but there may be
10 some plants which, because of the way the architect
11 engineer has arranged things, that you just cannot do
12 something with what's in the sump, for instance. There
13 may be some solutions which are not available to some
14 plants, and by the time you put together all these
15 things you may end up with a lot of -- quite a few
16 rather unique situations.

17 MR. SCOTT: Well, maybe tech staff can
18 correct me if I state this wrong, but I would say that
19 we're going to have 69 plant-specific solutions based
20 on five basic approaches provided by the vendors.

21 CHAIRMAN WALLIS: And, I think that's part
22 of my colleagues nervousness, is whether those basic
23 tests are going to be general enough and have -- so
24 that they can be used for different -- somewhat
25 different situations from the tests.

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1 MR. SCOTT: Which brings me to another
2 clarifying remark Dr. Banerjee made regarding
3 observation or, let's say, waiting on the industry to
4 come forth with test results. The staff is not doing
5 that. The staff is out while the industry is doing
6 the testing observing the tests. We have a number of
7 trips that have happened in the past several weeks,
8 and a number more on the horizon. So, we are not just
9 waiting for them to send something in, just to clarify
10 that.

11 DR. BANERJEE: Yes, I know that you are
12 watching these tests, I'm more concerned that
13 implicitly almost agrees with this approach, because
14 part of it, you see, at least in my view, is that
15 approach is fraught with a great deal of difficulty in
16 terms of acceptability, because they are taking little
17 pieces of the screen, or whatever, putting it in the
18 flume, and then putting some stuff, which is
19 depositing out, hopefully they don't ask for too much
20 near field effect credit, but that, when you take it
21 to a real situation, imagine the top hat strainers
22 now, there are a whole area of these, so you've taken
23 a little piece of screen and you've tested it, but
24 there are all sorts of potential blocking effects
25 which occur.

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1 To give you an example, when you stack the
2 strainers in the design that went into Vermont Yankee,
3 they did testing of one clean strainer. Okay. When
4 you stack them the stuff gets in between, and it
5 builds up a bed. So, they used the approach velocity
6 for a clean strainer to get the pressure velocity.

7 As you build up the bed, your approach
8 velocity completely changes. So, they submitted the
9 calculations based on the approach velocity for a
10 clean strainer, but in reality it was the
11 circumference and the approach velocity was up by a
12 factor of ten. So, when you actually take the real
13 configuration it's very different from doing a little
14 test on this sort of thing, and they have no way to go
15 from that test to the full scale system. So, where is
16 the bridge, you know, and the way they do it, if you
17 look at their -- you have to actually read their
18 reports to understand what they have done.

19 So, for Vermont Yankee we did that, we
20 went back to every report and we read it. Otherwise,
21 it's very difficult to understand what they are doing,
22 and it's a very dangerous thing to say even implicitly
23 that these tests actually are going to be even
24 relevant.

25 You almost are saying, okay, if you do

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1 these tests, we are observing them, it's going to be
2 okay.

3 You know, maybe I'm interpreting it wrong,
4 but there is a whole lot more than testing a little
5 piece of thing and saying this is the pressure
6 velocity.

7 MR. SCOTT: You are probably not going to
8 find this a highly satisfying answer, but we don't --
9 I mean, I agree with what you just said, however, we
10 expect the industry to provide that bridge, and we
11 will look at it and see if we agree that it is
12 adequate.

13 DR. BANERJEE: And, there will be 69
14 different bridges for 69 different plants.

15 MR. SCOTT: Five different bridges with
16 variations.

17 DR. BANERJEE: No, there will be pretty
18 big variations, because the way they put those top
19 hats, and if you take a top hat it will make a big
20 difference, and each plant will have a different way
21 of doing it, of course.

22 So, I think this is a very, very dangerous
23 approach.

24 MR. LU: Well, in terms of scaling, I
25 think you have a very valid point, I agree 100 percent

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1 with your point there. That's the reason we raised
2 the issue last March when we first saw the test, and
3 at my recommendation the staff started to have tours
4 to look at the vendors testing as early as we can, and
5 actually that's what we have been doing during the
6 past year, to make sure that all five vendors are
7 doing the right tests and following the right
8 procedures.

9 In terms of scaling, you have a valid
10 point, that's exactly what we have been after the
11 industry to provide that bridge, and what we are
12 looking for is that five vendors, now it all depends,
13 if you want to take the credit from the near field
14 sediment, most of them -- actually, some of them are
15 dumping out all the debris on the strainer surface.
16 So, if those are scaling issues, some plants have to
17 address that. And, they are looking for answers from
18 the five vendors to address those issues

19 CHAIRMAN WALLIS: I think we are going to
20 have to stop. We are not as a subcommittee now trying
21 to solve the problem for you by discussing it with
22 you, but --

23 MR. SCOTT: May I make one more clarifying
24 remark, please?

25 CHAIRMAN WALLIS: Yes. You can make

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1 another clarifying remark.

2 MR. SCOTT: Okay. Final one, I promise.

3 What I wanted to emphasize here, the
4 remark was made, or there was a statement regarding
5 whether the staff believes that the enlargement of the
6 strainers is the final answer to the problem.

7 We certainly do not at this point take
8 that position. We fully recognize that as we get
9 smarter and as the industry gets smarter on this
10 issue, that there may need to be additional changes.
11 So, we are not by any means at this point saying that
12 the installation of larger strainers is the end of the
13 problem.

14 CHAIRMAN WALLIS: I am trying to think of
15 what letter the committee will write. What I'm
16 anticipating is that we will write a letter which is
17 not wordy, and it will have some very crisp statements
18 about how we think you are going in various areas, and
19 there may be just three or four sentences, and those
20 that will be memorable, and recognizable by the
21 reader, rather than having our usual letter where we
22 have a couple of crisp sentences and a lot of
23 explanation.

24 That's my anticipation at the moment, and
25 i may be completely wrong.

1 Thank you all very much, it's been a very
2 interesting and useful meeting on a very important
3 problem. Thank you. We'll now close.

4 (Whereupon, the above-entitled matter was
5 concluded at 12:35 p.m.)

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CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on
Reactor Safeguards
Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.


John Mongoven
Official Reporter
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Transportability of Coatings Debris

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ACRS Subcommittee on Thermal-Hydraulic Phenomena
February 14 - 16, 2006



Transportability of Coatings Debris

Objective

Characterize the transport behavior of coatings debris in water under stagnant and flow conditions.

Motivation

Current Safety Evaluation places conservative assumptions on ECCS sump screen design by assuming that all unqualified and qualified loose/delaminated coatings transport to the ECCS sumps during a LOCA.

Background

Nuclear power plants have experienced loose or delaminated Category 1 coatings. These loose/delaminated coatings may be transported to the ECCS sump during recirculation phase of ECCS operation.

Transportability of Coatings Debris

Intended Regulatory Use

- Provide information to aid staffs assessment of licensees' responses to GL 2004-02.
- Data can be used to generate plant-specific analyses of coatings debris transport.

Status

- Testing is complete.
- Data is being analyzed/evaluated.

Schedule

NUREG/CR report publication: **Fall 2006.**

Concept

- ◆ Characterization of transportability of coatings debris. In particular, study the effects of:
 - Coating System Variation
 - Debris Size
 - Debris Shape
 - Debris Density
 - Debris Thickness
 - Water Velocity

Coatings Tested

- ◆ Alkyd topcoat (ALK)
- ◆ Zn Primer with two Epoxy topcoats (ZE)
- ◆ Epoxy Primer and topcoat (E2)
- ◆ Epoxy, six coats (E6)
- ◆ Epoxy sealer, Epoxy surfacer with two Epoxy topcoats (E3C)

Debris Sizes Tested

- ◆ 1 inch to 2 inch
- ◆ 1/8 inch to 1/4 inch
- ◆ 1/32 inch to 1/64 inch
- ◆ Mixture of above sizes

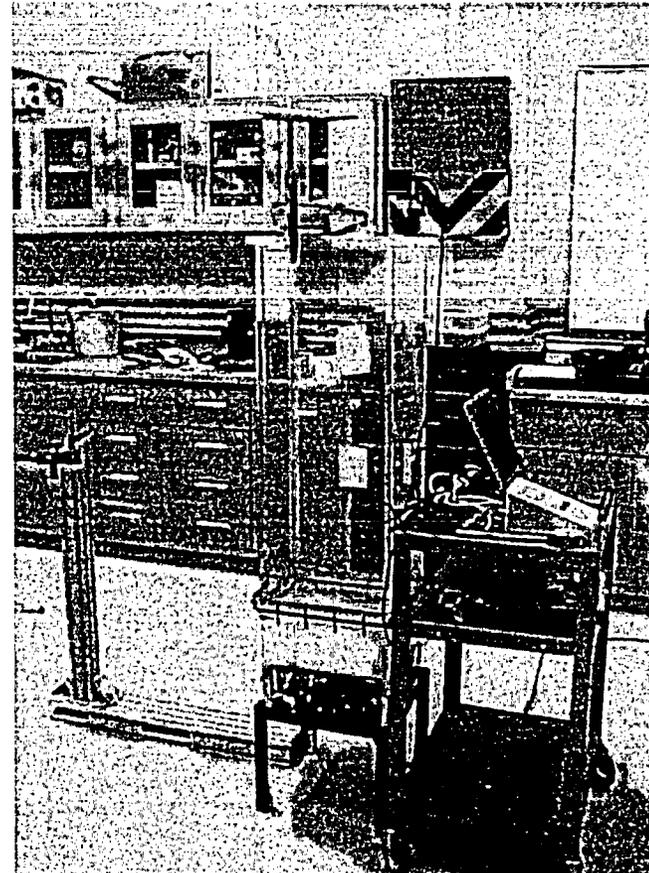
Test Facility

- ◆ Two types of testing
 - Quiescent testing
 - ◆ Time-to-sink
 - ◆ Terminal velocity
 - Transport tests
 - ◆ Tumbling velocity
 - ◆ Steady-state velocity

Quiescent Testing

◆ Test Apparatus

- Vertical Plexiglas tank with camera access on all sides
- Test water is free of movement or flow
- Capable of conducting both terminal velocity and time-to-sink tests

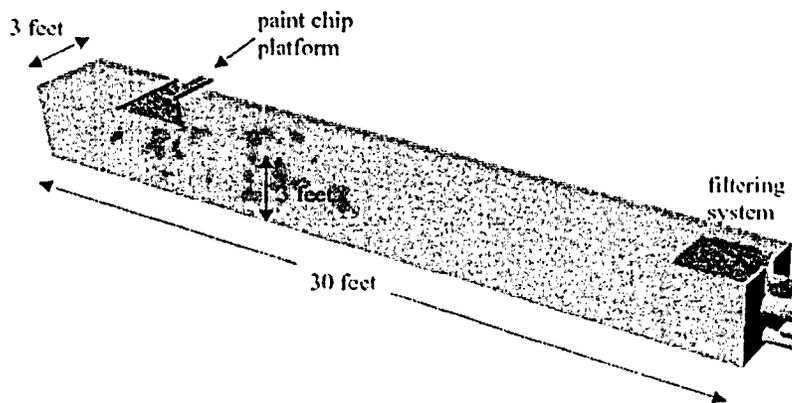
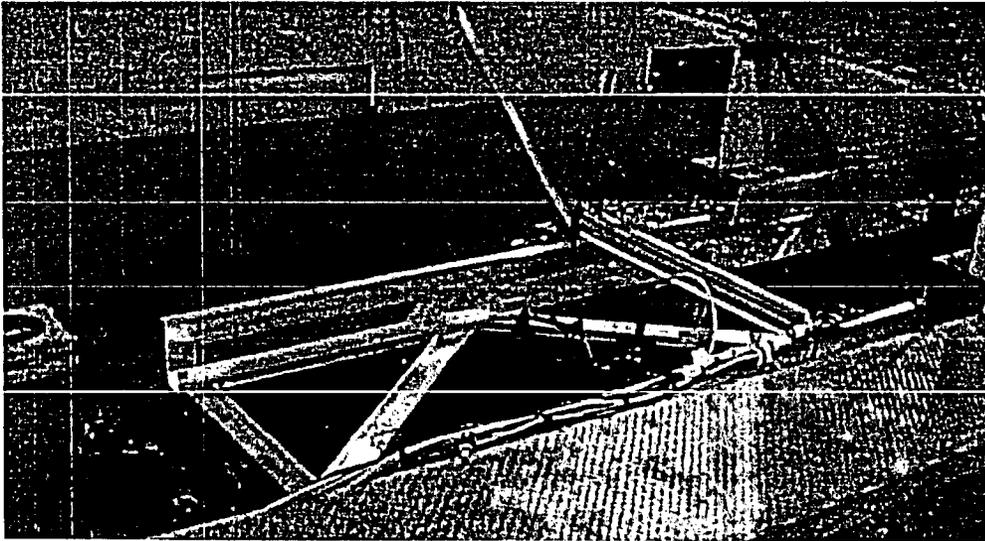


Transport Testing

◆ Test Apparatus

- 30' long acrylic tank (flume) , 3' by 3' cross section, with smooth sides and floor.
- Flume suspended in the Circulating Water Channel (CWC) to create uniform currents
- Clear sides and bottom provide necessary camera access
- Cameras located at 4 points along the length of the flume
- Filtering system to provide collection of debris at the surface, in suspension, and along the bottom

Transport Test Apparatus



February 16, 2006

Transportability of Debris Coatings

10

Test Matrix-Quiescent Tests

Size/Shape	Coating	Initial, Bulk, and Final Time to Sink	Terminal Velocity
1"-2" flat	ALK, ZE, E2, E6, E3C	dry & presoaked	presoaked
1"-2" curled	ALK, ZE, E2, E6, E3C	dry & presoaked	presoaked
1/8" – 1/4"	ALK, ZE, E2, E6, E3C	dry & presoaked	presoaked
1/32" – 1/64"	ALK, ZE, E2, E6, E3C	dry & presoaked	presoaked
Distribution	ALK, ZE, E2, E6, E3C	dry & presoaked	presoaked

Note: ZE, E2, E6, E3C also underwent thermal curing process of 120°/2 days and 150°/2 weeks

Test Matrix-Tumbling Velocity Tests

Size/Shape	Coating	Tumbling Velocity
1"-2" flat	ALK, ZE, E2, E6, E3C	incipient, bulk
1"-2" curled	ALK, ZE, E2, E6, E3C	incipient, bulk
1/8" – 1/4"	ALK, ZE, E2, E6, E3C	incipient, bulk
1/32" – 1/64"	ALK, ZE, E2, E6, E3C	incipient, bulk
Distribution	ALK, ZE, E2, E6, E3C	incipient, bulk

Test Matrix-Steady State Transport Tests

Size/Shape	Coating	Velocity
1"-2" flat	ALK, ZE, E2, E6, E3C	0.2 ft/s, tumbling
1"-2" curled	ALK, ZE, E2, E6, E3C	0.2 ft/s, tumbling
1/8" – 1/4"	ALK, ZE, E2, E6, E3C	0.2 ft/s, tumbling
1/32" – 1/64"	ALK, ZE, E2, E6, E3C	0.2 ft/s, tumbling
Distribution	ALK, ZE, E2, E6, E3C	0.2 ft/s, tumbling

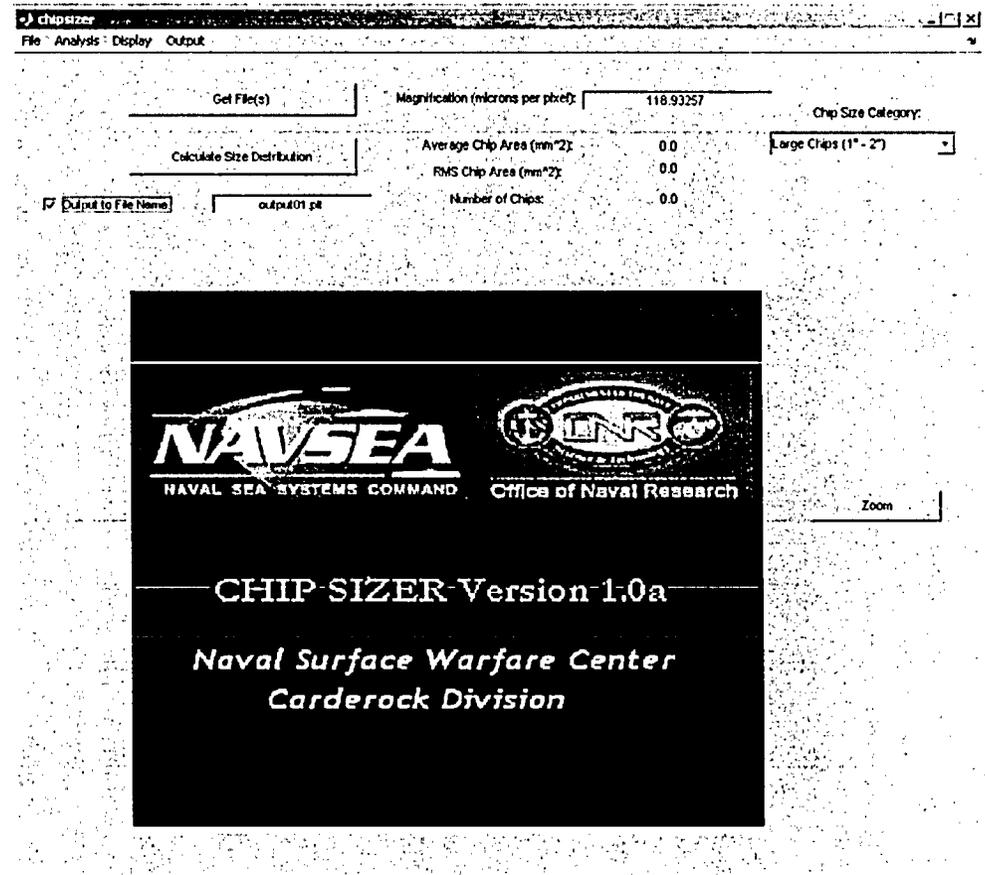
Data Acquisition/Processing Software

- ◆ Chip Sizing
- ◆ Chip Tracking

Chip Sizing Software

◆ Chip sizing software

- Calculates:
 - ◆ Average Chip Area
 - ◆ Major Axis / Minor Axis
 - ◆ Eccentricity
 - ◆ Orientation
 - ◆ RMS Values
- Used to quantify chip sample characteristics

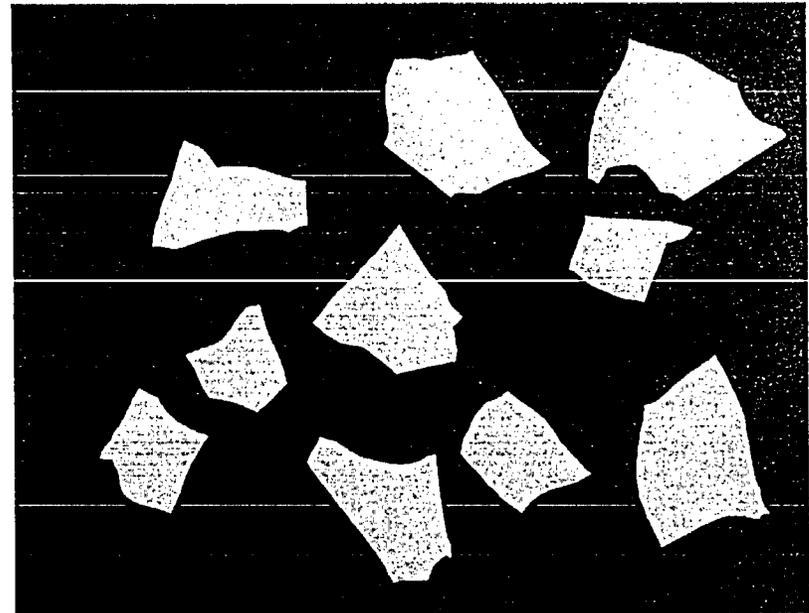


Chip Sizing GUI

Chip Sample Photographs

◆ Sample Characterization

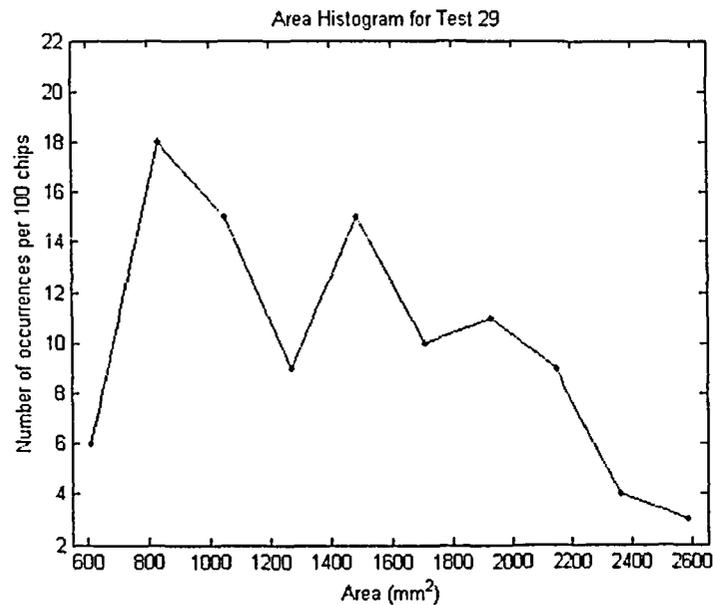
- Chip Sizing Setup:
 - ◆ Magnification: $\sim 118 \mu\text{m}/\text{pixel}$
 - ◆ Resolution: 2272 X 1704 pixels
 - ◆ Dark background
 - ◆ Calibrated using a scale
- Picture of sample taken before each run



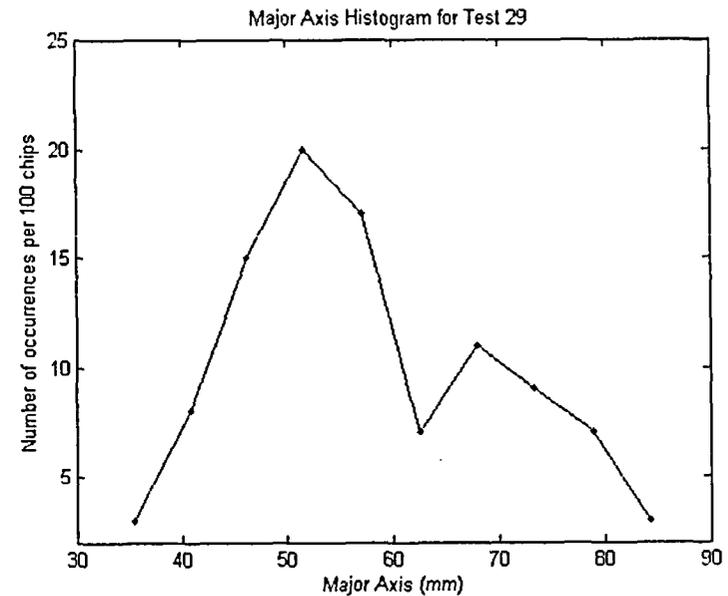
150°F Baked ZE Sample

Sample Population Histogram

- ◆ Characteristic histograms for E3C Time to Sink Test
 - Population of 100 chips



Area Histogram



Major Axis Histogram

Chip Tracking Software

◆ Chip tracking software

■ Calculates:

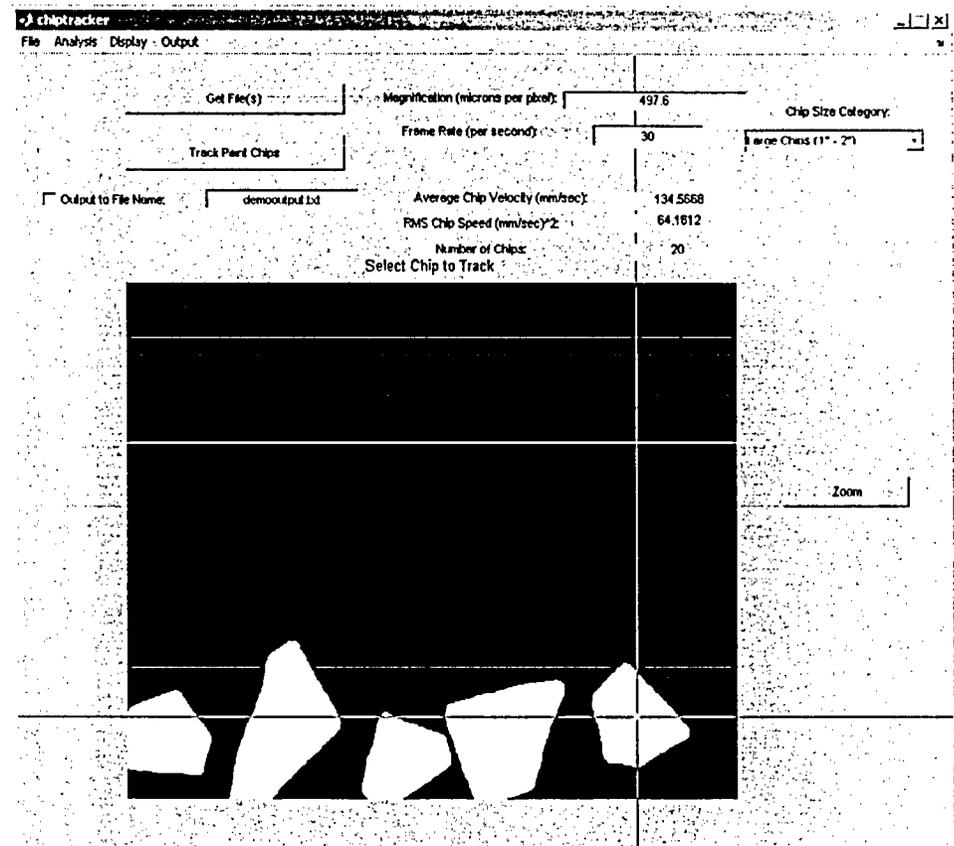
- ◆ Chip Apparent Area
- ◆ Chip Velocity (centroid differencing)

■ Postprocessing

- ◆ Average Chip Terminal / Tumbling Velocity
- ◆ RMS Chip Terminal / Tumbling Velocity

■ Software Modifications for Flume

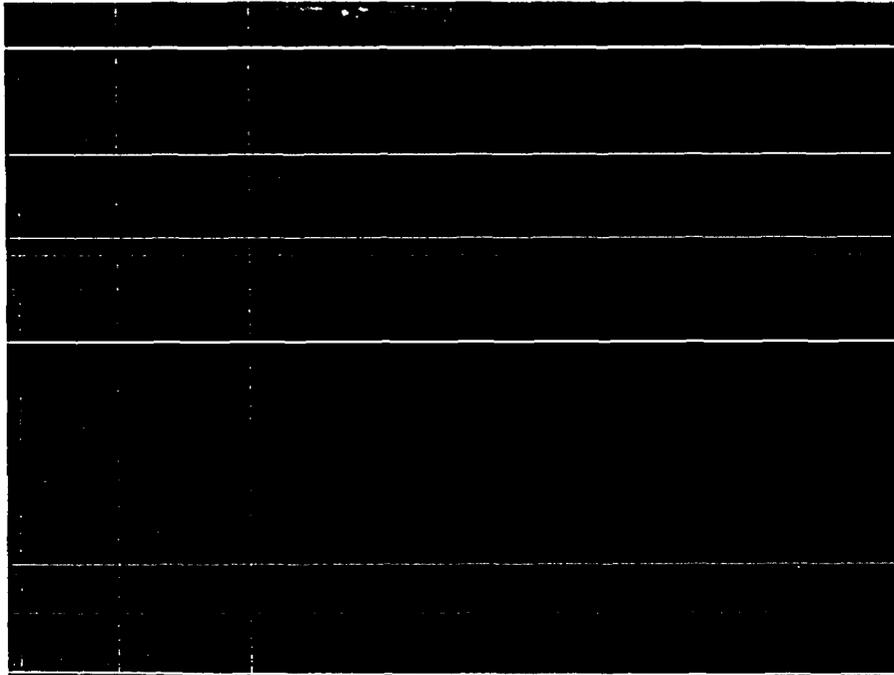
- ◆ Background Subtraction
- ◆ Calculate Chip velocity as function of time
- ◆ Sync with ADV measurement



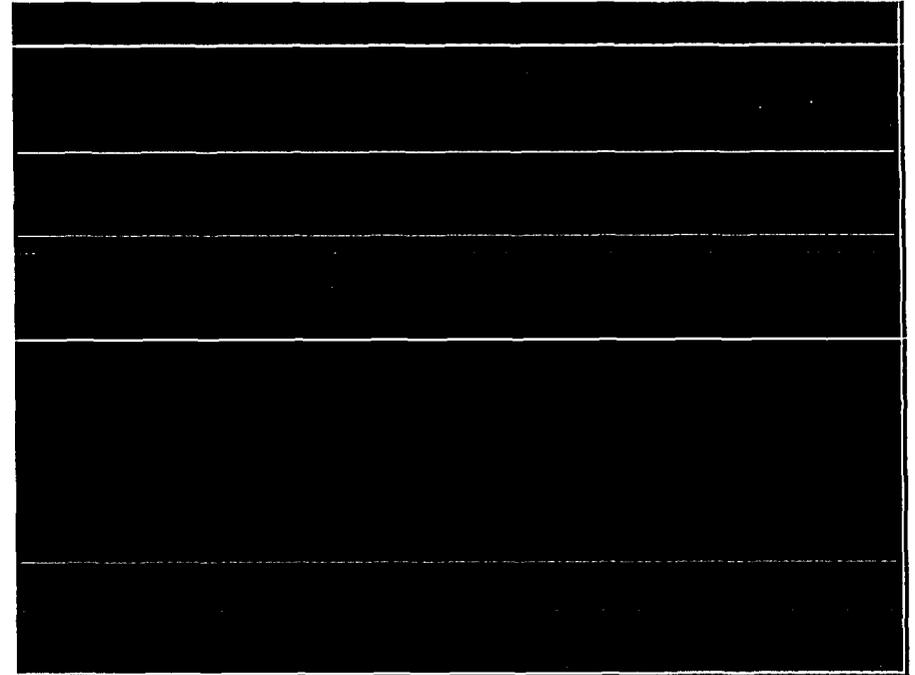
Chip tracking screen shot

Particle Tracking: Quiescent Tank

E3C Sample Raw Data



1 in. - 2 in. chips



1/8 in. - 1/4 in. chips

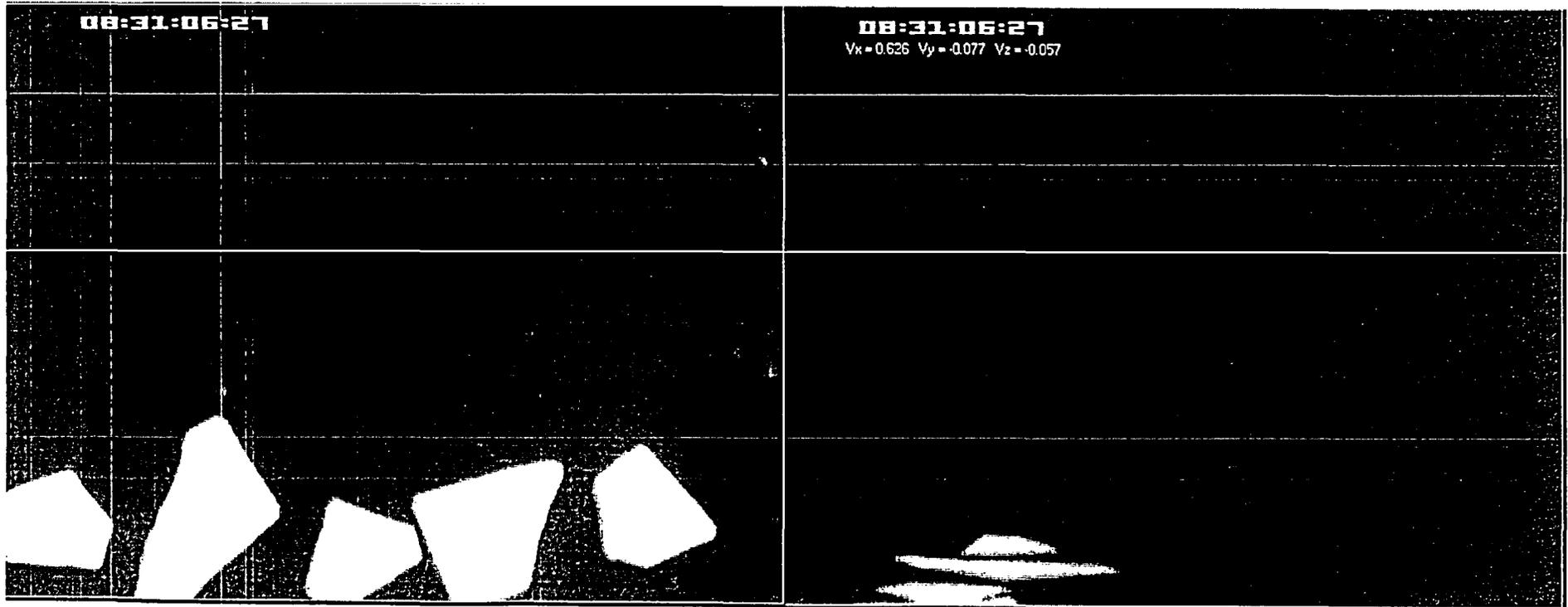
Movies played at half speed
Frame Rate: 30 frames per second
Magnification: 188.9 microns per pixel

Quiescent Testing Preliminary Observations

- Thermal cure
 - ◆ Effect is within standard deviation
- Heavier, more rigid samples fall faster
- ALK did not sink when dropped onto water surface

Particle Tracking: Tumbling Velocity

E6 Sample – Test 2 Run 10



Top View

Magnification: 497.6 microns per pixel

Side View

Magnification: 412.3 microns per pixel

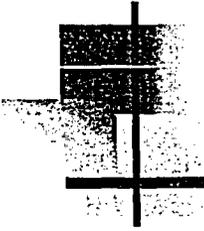
Frame Rate: 30 frames per second

Transport Tests Preliminary Observations

- ◆ Flat ALK debris had lowest tumbling velocity
- ◆ E6 and ZE had larger tumbling velocities
- ◆ In general, curled chips had lower tumbling velocities than the flat chips
- ◆ Very little transport at 0.2 ft/s for all but ALK samples

Summary

- ◆ Testing is complete
- ◆ Data analysis is in progress
- ◆ Report will be available in Fall 2006

A decorative graphic consisting of a vertical line and a horizontal line intersecting, with a shaded rectangular area to the left of the intersection.

Throttle Valve Clogging Testing

Robert L. Tregoning
Office of Nuclear Regulatory Research

Bruce C. Letellier
Los Alamos National Laboratory

ACRS Subcommittee on Thermal-Hydraulic Phenomena
February 14 - 16, 2006

Throttle Valve Clogging Testing

- Objective
 - Evaluate effect of insulation debris on blockage and, to a lesser extent, wear of surrogate high-pressure safety-injection (HPSI) throttle valves.
- Motivation
 - HPSI throttle valves are one possible source of ECCS performance degradation due to flow restrictions.
 - Little information on the severity of nuclear valve degradation is available.
- Background
 - **Phase I:** Scoping study conducted to examine variables that affect the amount of insulation debris that can pass through sump strainer screens (NUREG/CR-6885).
 - Determined ingested debris characteristics for throttle valve tests (**Phase II**) from the phase I findings.
 - Overview provided at ACRS T-H subcommittee meeting on 7/20/05.

Throttle Valve Clogging Testing

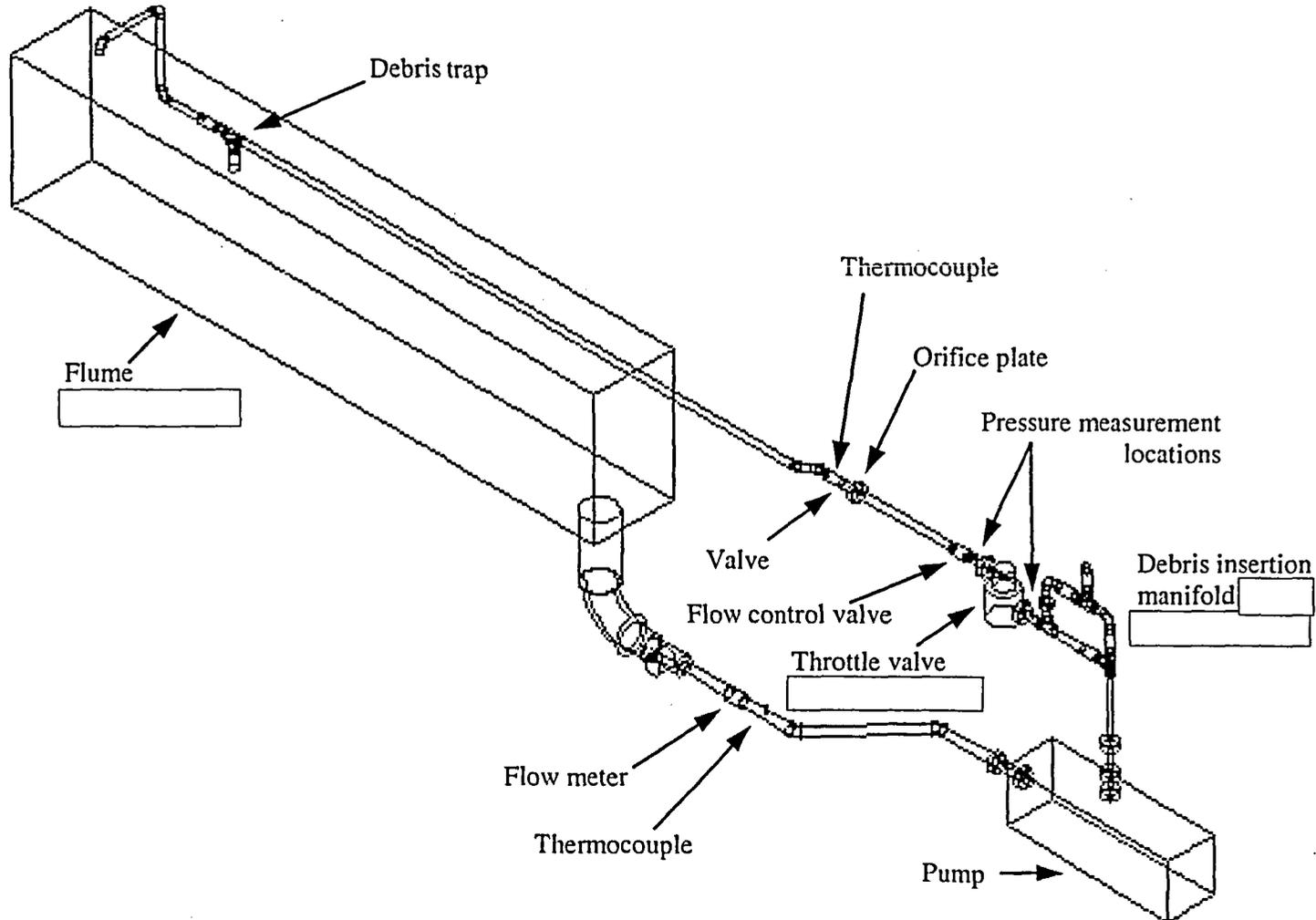
- Intended Regulatory Use
 - Provide information to aid assessment of licensees' GL 2004-02 evaluation and any necessary modifications.
 - Specifically, data may be used to help determine the affect of ingested debris on HPSI throttle valves and other components downstream of the sump strainer screen following a postulated LOCA.
- Status
 - Testing is complete.
 - Initial staff reviews of NUREG/CR have been completed.
 - Final version of NUREG/CR is in preparation.
- Schedule
 - NUREG/CR report publication: **March 2006.**
- Contractor: Los Alamos National Laboratory

Technical Approach

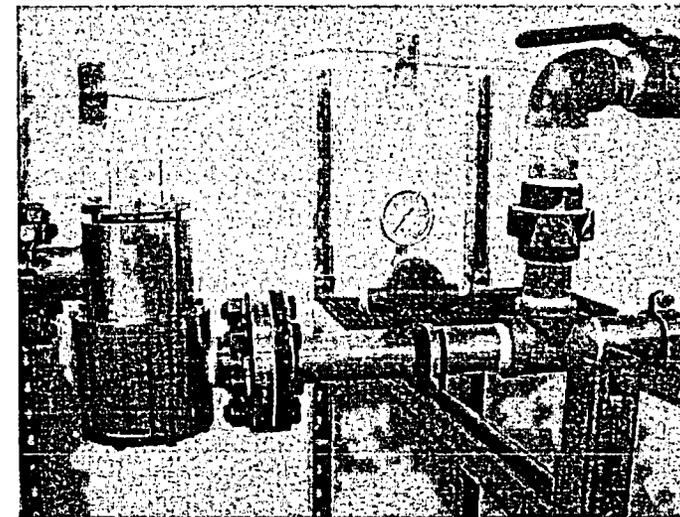
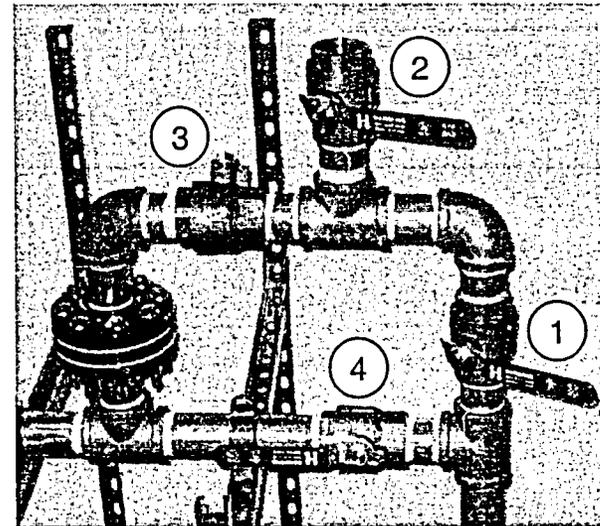
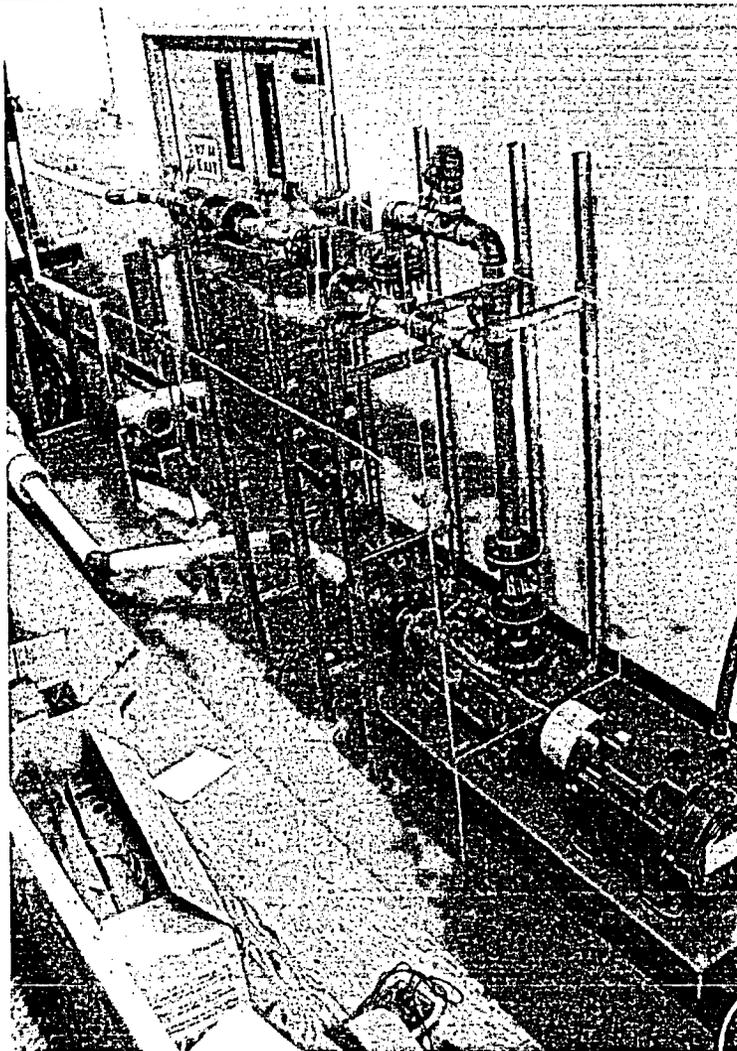
Exploratory testing of potential downstream blockage phenomena using flow conditions representative of a HPSI throttle valve

- Valve Selection
 - Option 1: Procure and test multiple industrial valves
 - Match inservice equipment, requires repeated calibration, impossible to inspect for internal debris retention (One industrial valve was obtained, but not tested)
 - Option 2: Fabricate a surrogate valve chamber with flexible geometry
 - Match nominal dimensions, tolerances and flow-path complexities
 - Permits inspection and debris recovery
 - Avoids "endorsement" of any single manufactured product
- Pump Selection
 - HPSI-type design matching initial flow and ΔP of LOCA transient with some margin for increasing pressure and decreasing flow in the event of blockage
- Debris Selection
 - Three major types of insulation (RMI, fiberglass, CalSil)
 - Sizes proven to pass through typical existing sump-screen configurations
 - Quantity and rate studied parametrically to identify any plausible mechanisms of debris retention

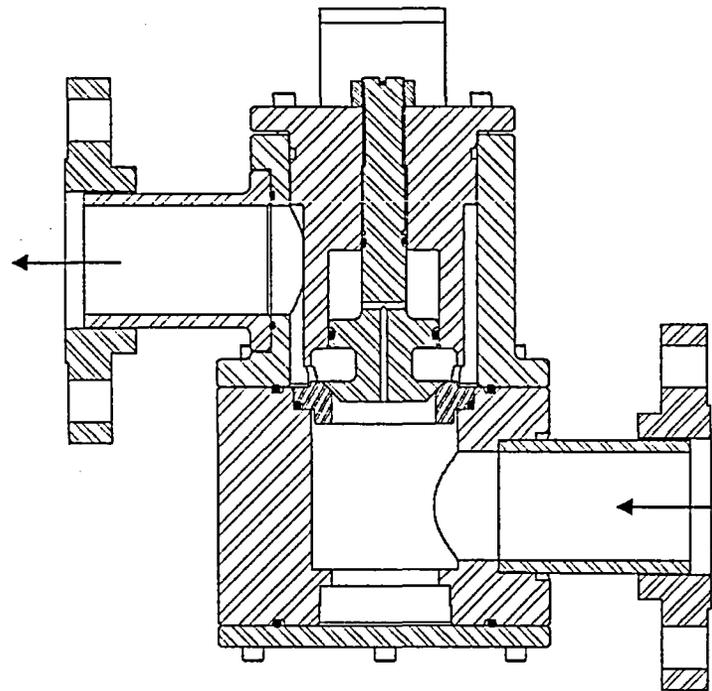
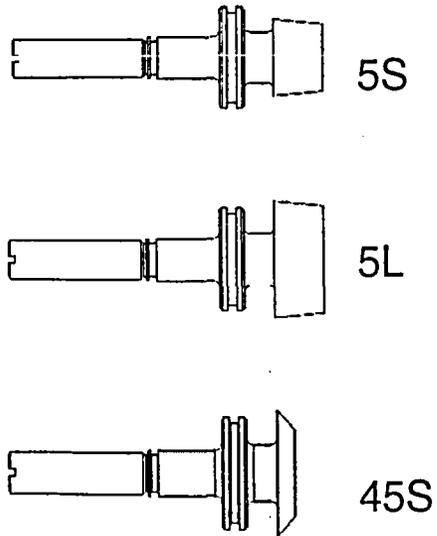
Test Apparatus Schematic



Test Apparatus Photographs

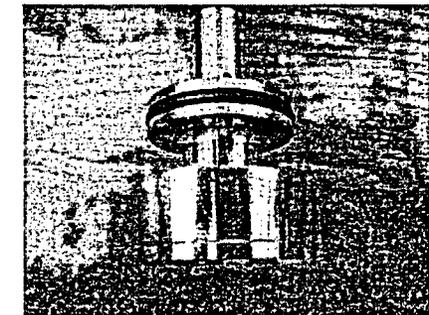
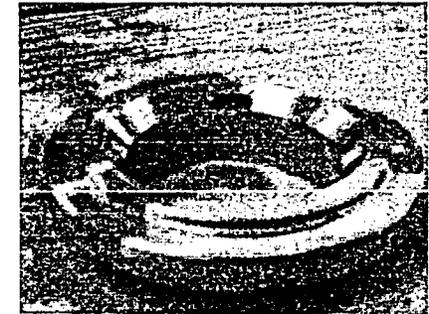


Surrogate Valve Design



Detail of stem and seat (shown in the fully closed position)

ring



stem

Measurements & Parameters

Measurements

- Type(s), size, shape, mass, & rate of debris introduced
- Shape, location, & mass of debris recovered
- Stem geometry and gap setting
- Water temperature upstream of pump and downstream of valve (visual)
- Gauge pressures upstream and downstream of valve (DAS & visual)
- Flow rate upstream of pump (DAS & visual)

Key Parameter – Valve-loss coefficient

- Valve-loss-coefficient K , calculated using measured pressure drop across the valve and flow rate through the valve.
- As valve flow area decreases from blockage, the loss coefficient increases

Energy Balance:

$$\Delta P = P_1 - P_2 = K \frac{\rho_1 V_1^2}{2}$$

Loss Coefficient:

$$K = 14269.2 \frac{\Delta P_{\text{psi}}}{Q_{\text{gpm}}^2}$$

Alternative Metric:

$$C_v = C_0 \sqrt{\frac{Q_{\text{gpm}}^2}{\Delta P_{\text{psi}}}}$$

Debris Characterization

- Debris Tested
 - RMI, NUKON™, and CalSil insulation debris
- Debris Size
 - Debris sizes based on screen penetration test results
 - RMI 1/8- and 1/4-in. square flat
 - NUKON preshredded and blender processed
 - CalSil coarsely crushed
- Debris Loading
 - Quantities, rates, and combinations of debris that may reach the throttle valves vary greatly, depending on break location, break size, and screen design
 - The amount of debris was examined parametrically in these tests

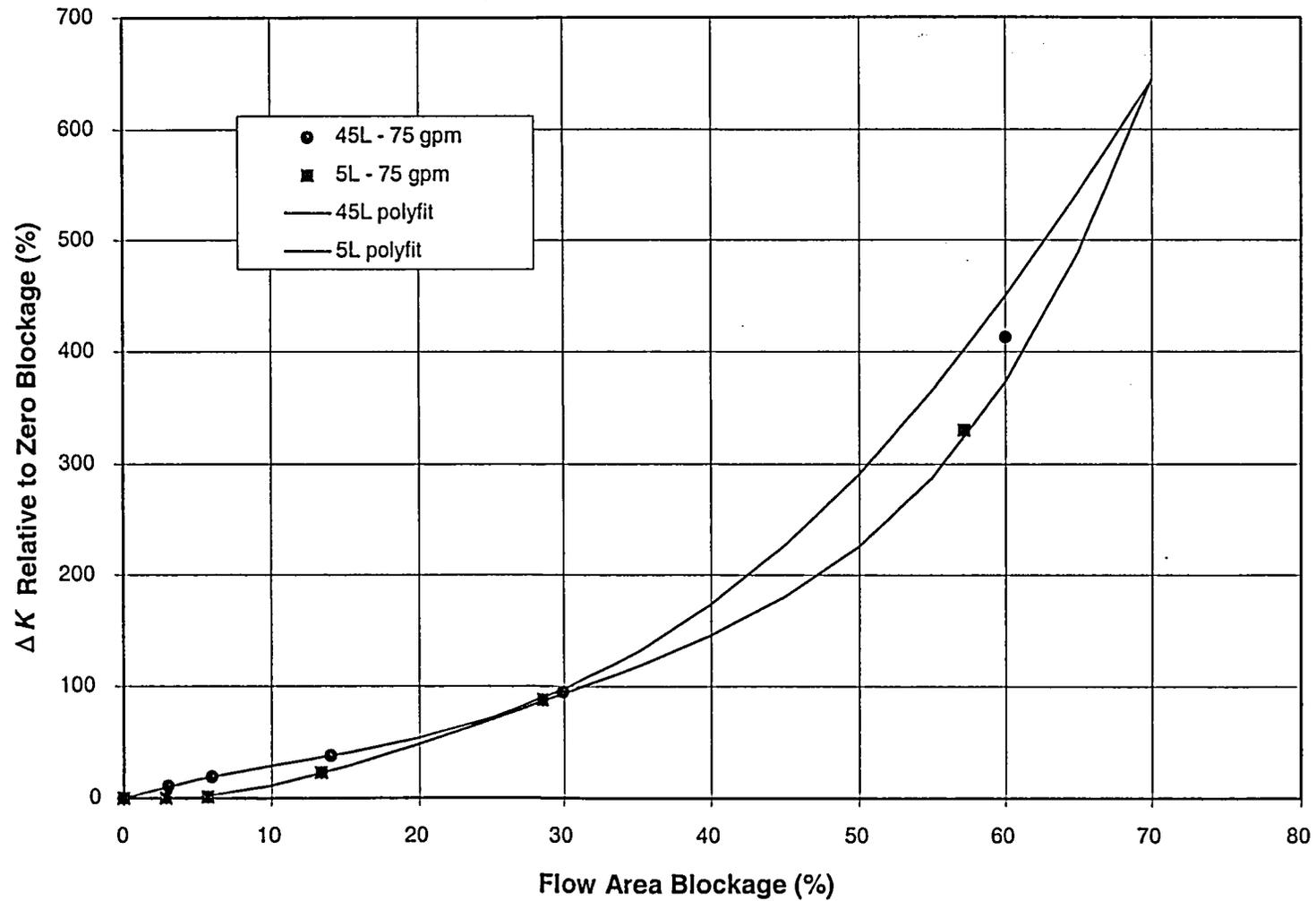
Experimental Approach

- First, establish baseline loss coefficient K for each valve configuration of interest (geometry, gap, and flow range)
- Loss coefficients were determined for selected known blockage conditions (blockage-area fractions simulated using shims)
- In most cases, percent increase in K was used to compare post-insertion with pre-insertion loss coefficients
- Loss coefficients for debris flow conditions then were compared with those for baseline blockage data to obtain estimates of the blockage-area fractions

Test Matrix

- Baseline Tests
- Shim Tests
- Debris Tests
 - Test Series 1: Single-debris tests
 - Test Series 2: Two- and three-component mixed debris tests
 - Test Series 3: Accumulation tests

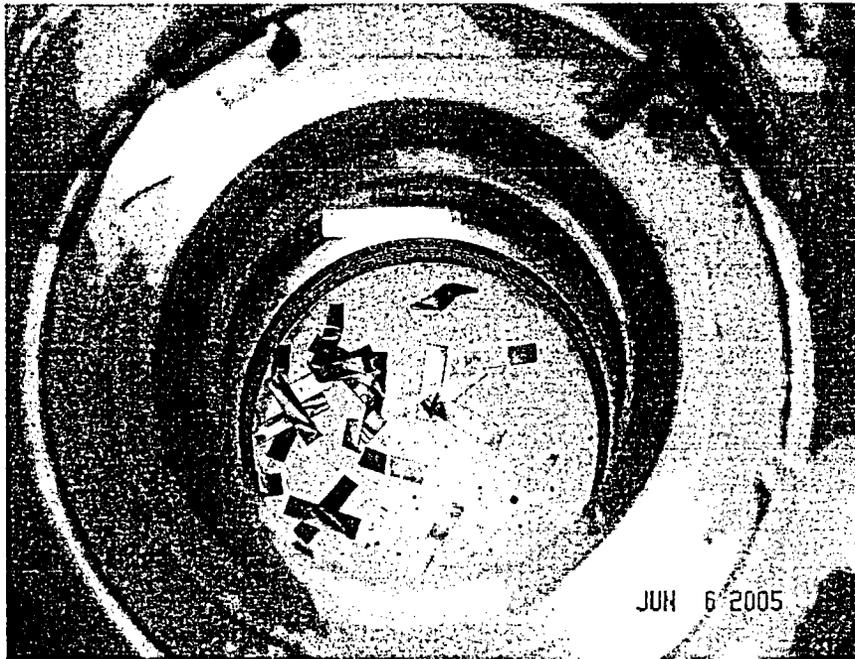
Shim Test Calibration



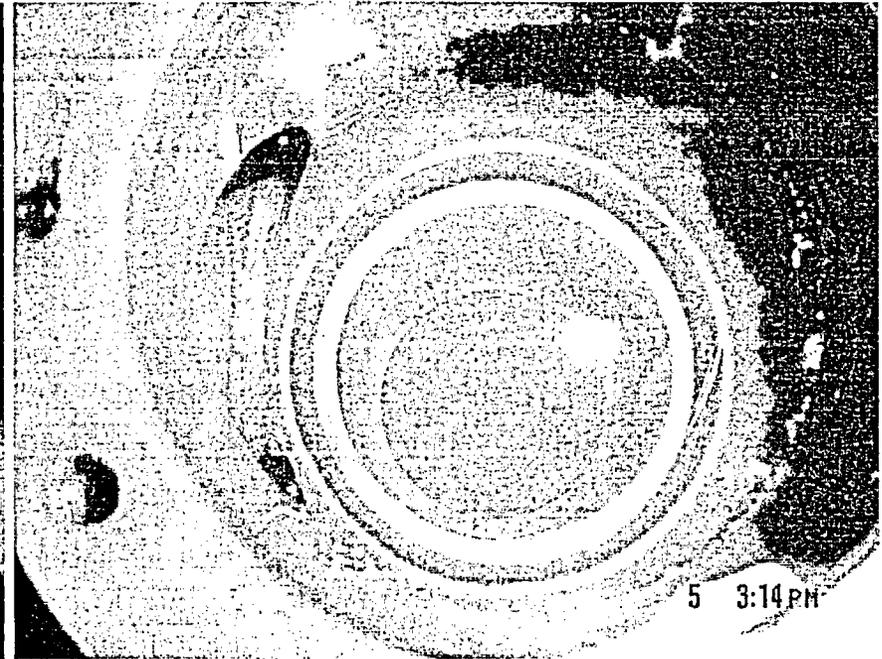
Single Debris Tests

- In general, higher loading of larger debris sizes (relative to the throttle valve opening) resulted in the highest measured increase in valve-loss-coefficient K .
- Based on the propensity for NUKON to transport and penetrate the screen, it is judged to be more likely than RMI or CalSil to cause throttle-valve blockage.
- However, for equivalent mass loading, the valve loss coefficients were higher for RMI than NUKON.
- The data also showed a high degree of variability in the valve-clogging data throughout testing.
 - Electronic noise minimized to $\pm 3\%$ mean signal
 - Random nature of debris flow
 - Self interaction within flow streams
 - Debris size relative to internal eddies
 - Orientation relative to gap
 - Number of debris elements per unit mass

Examples of Trapped Debris

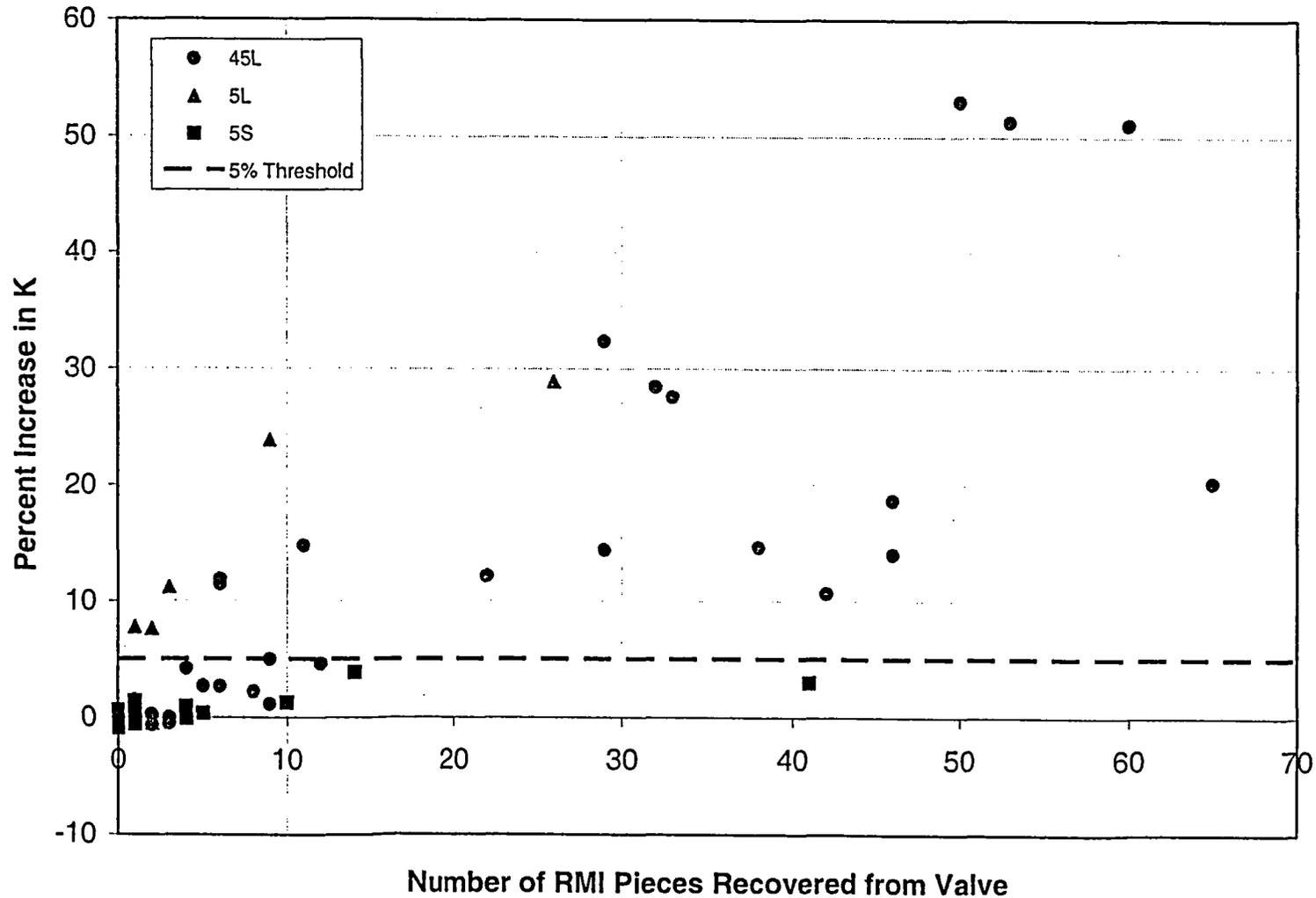


Single-Debris RMI Test

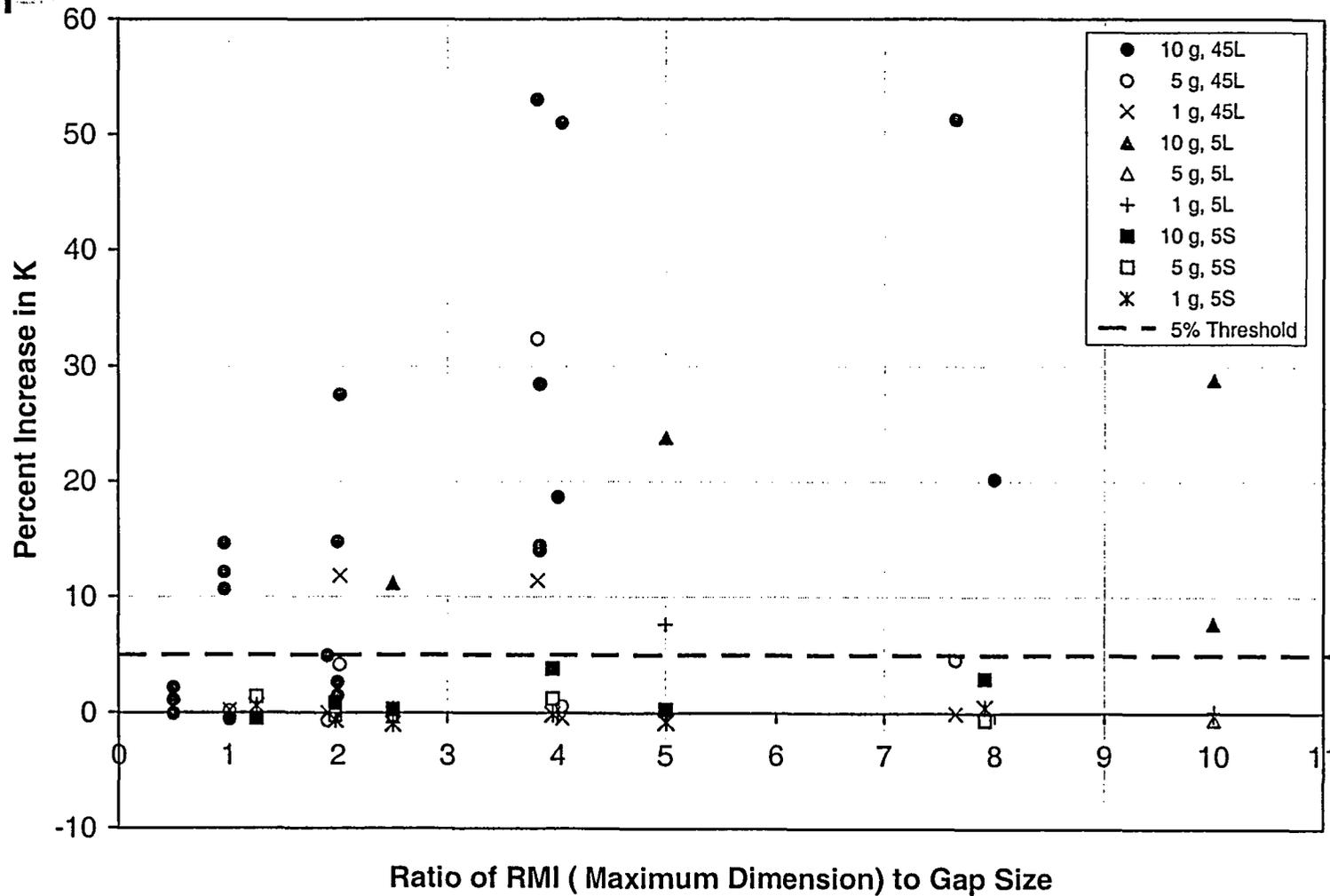


Single-Debris NUKON Test

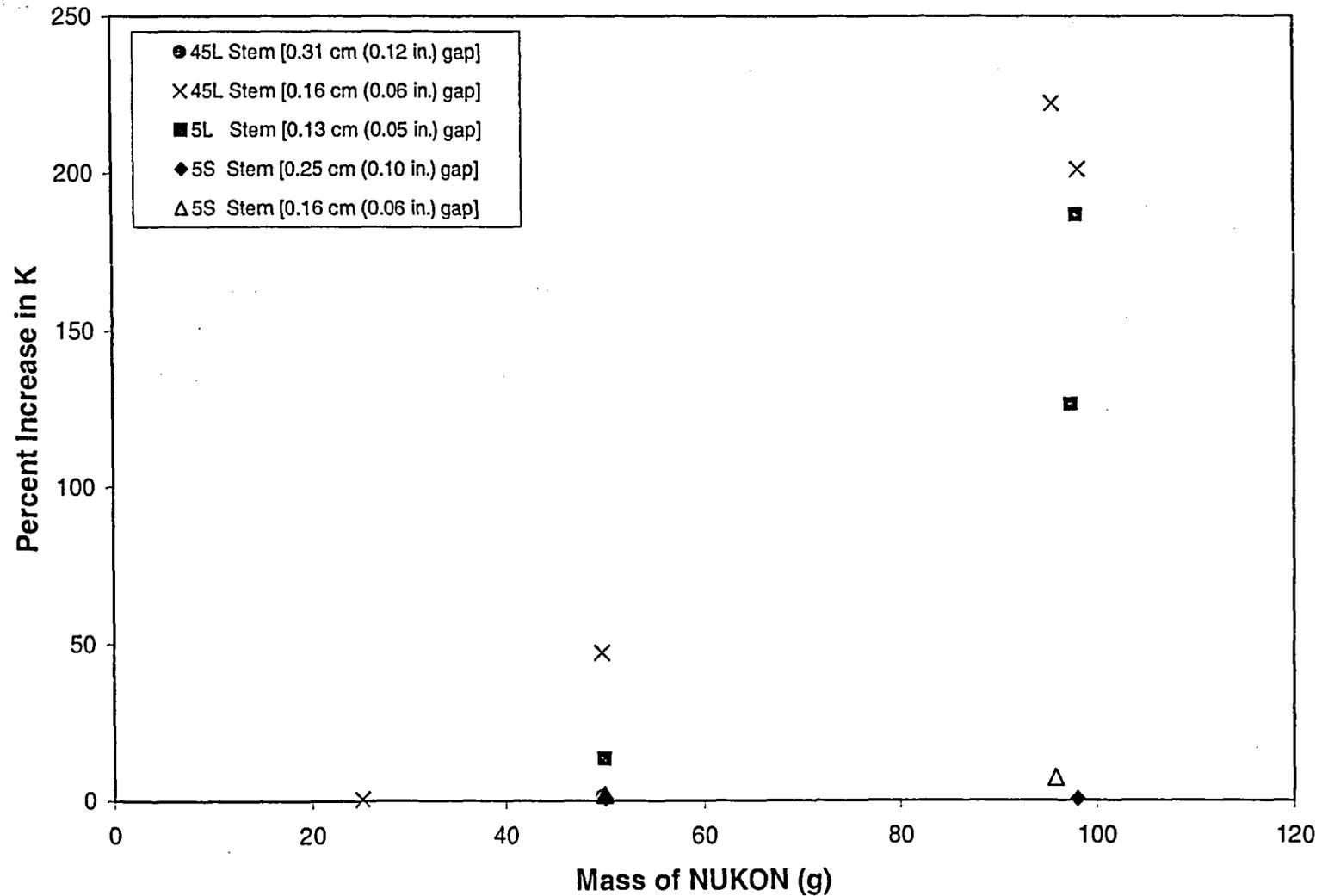
Single Debris – RMI



Single Debris – RMI



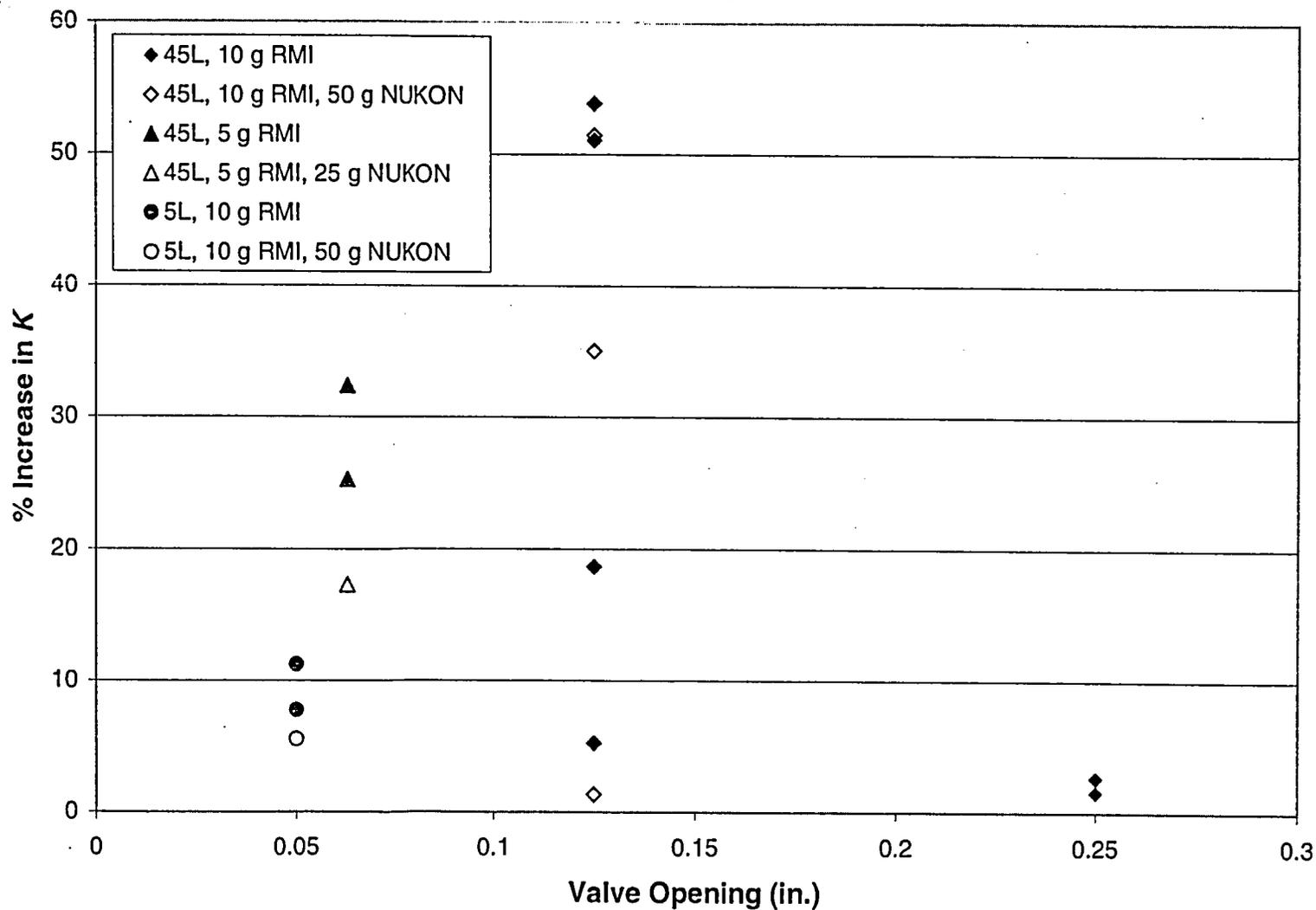
Single Debris – NUKON



Two-Component Mixtures

- The single test using CalSil-RMI mixtures were the only combination that exhibited a clear increase in K
- NUKON-RMI and CalSil-NUKON mixtures did not differ significantly from results for analogous separate tests
- Exception: One CalSil-NUKON mixture using unsieved CalSil showed an appreciable increase
 - Unclear if this result was caused by clumping of CalSil or NUKON fibers
 - Very high mass loading used for exploratory observation

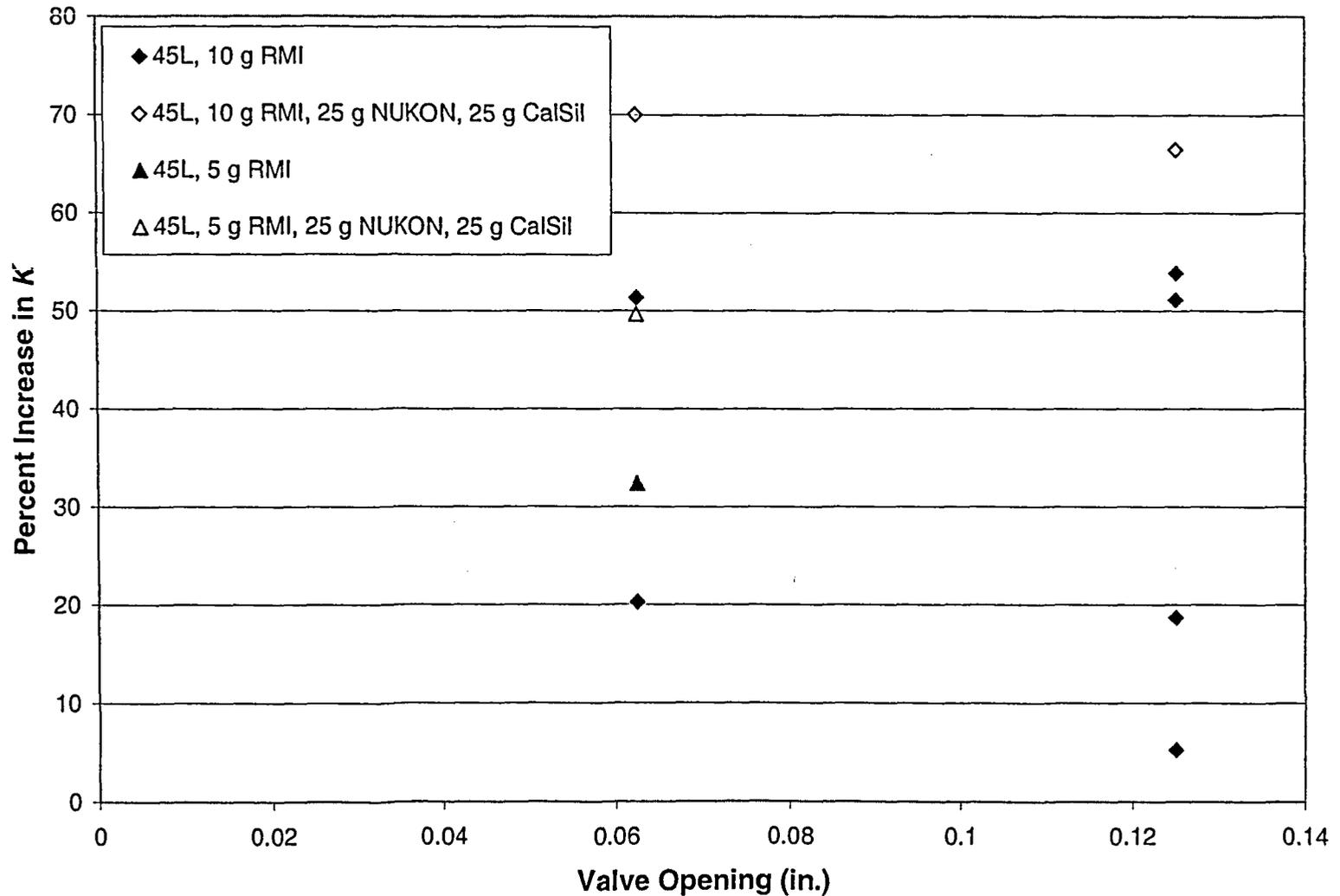
Mixed Debris RMI-NUKON



Three-Component Mixtures

- Homogeneous mixtures of RMI, CalSil, and NUKON
 - There is an apparent increase in valve blockage compared with analogous single-debris RMI tests.
- Sequential introduction of debris
 - No particular debris introduction sequence resulted in increases in valve blockage compared to results for homogeneous mixtures.
 - Additionally, in the tests where NUKON was introduced first in the debris sequence, the blockage was much less than the results for homogeneous mixtures.

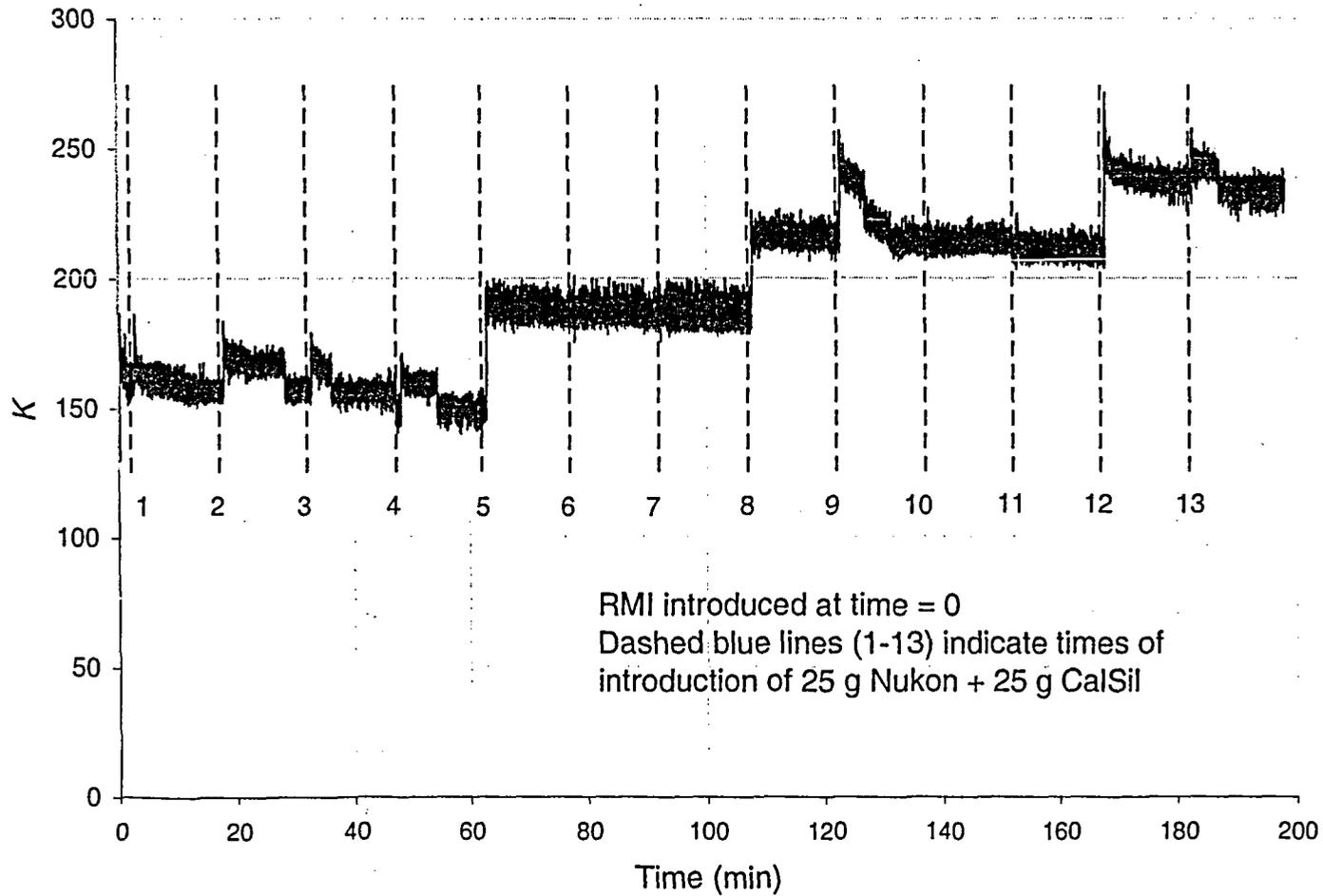
Mixed Debris RMI-NUKON-CaSi



Accumulation

- Multiple debris batches introduced at ~15-min intervals over a period of 3 h
- Tests with 25 g each of successive additions of NUKON-CaSiI showed a sustained increase in K over time
 - However, the increase in K was not observed following all additions of debris
 - Some debris additions did not result in any increase in K, suggesting that no net increase in valve blockage occurred at that step
- Periodic additions of CaSiI alone (after early introduction of NUKON) showed that some CaSiI additions triggered increases in K, while others did not
 - Relative to single-debris CaSiI tests, larger K increases were observed after some CaSiI additions which suggests that the potential exists for CaSiI to be trapped by NUKON or RMI that may be present in the valve

Accumulation Test A-1



Summary

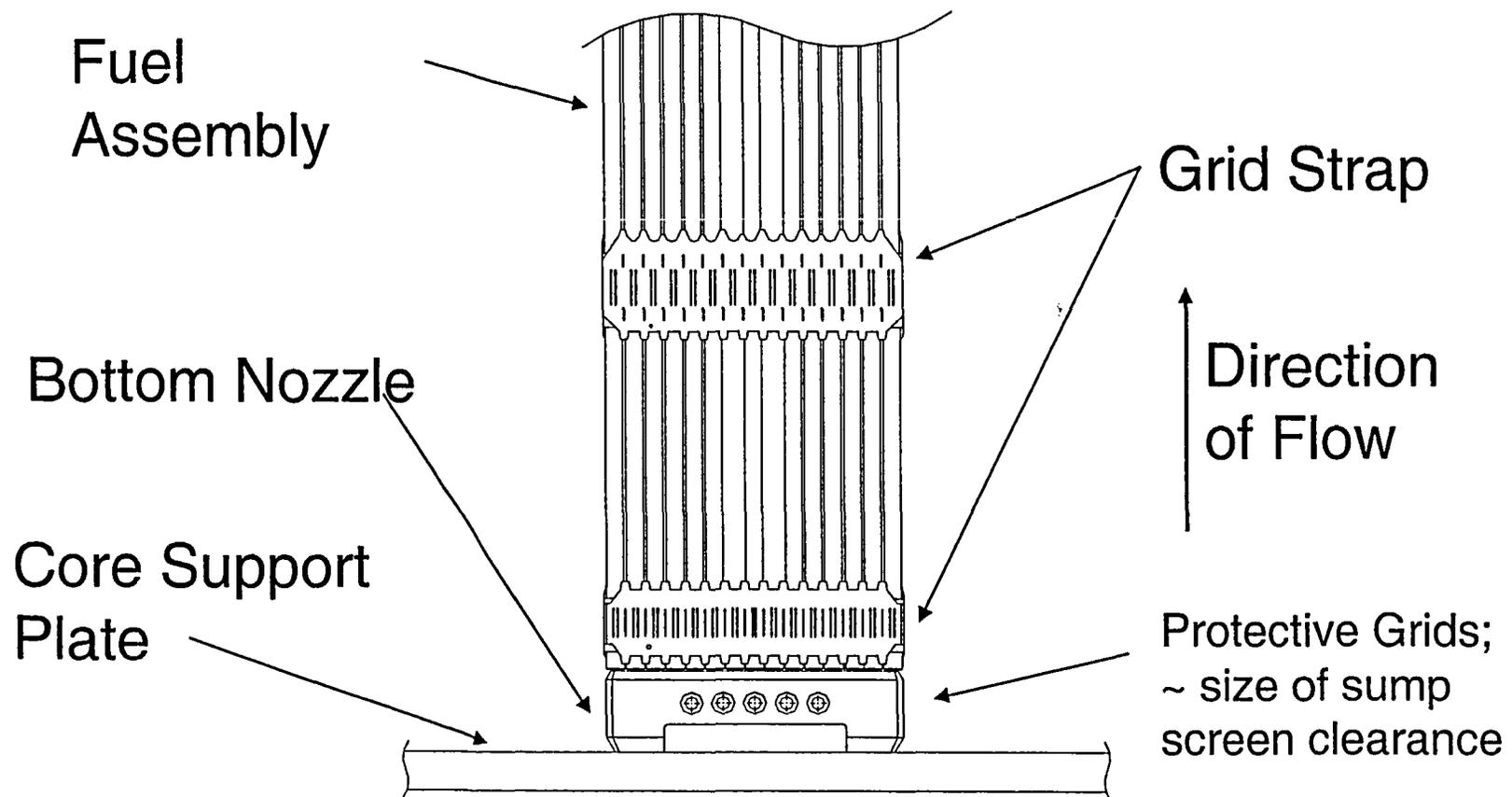
- Screen penetration rates and quantities were parameterized and selected in a range for measurable effects
 - No predictive capability for debris generation/transport/penetration
 - Sump screen and LOCA-specific dependencies
- Surrogate throttle-valve chamber proved effective for investigating potential blockage phenomena
 - Minimum blockage detection of $\sim 5\%$ flow area
 - Could not directly observe debris lodged in the throat
- All debris combinations except CalSil alone showed evidence of blockage potential
 - Clear evidence of accumulation over time at the tested rates
 - Some evidence of periodic self clearing
 - Tested blockage regimes *did not* exercise full range of test-pump ΔP
 - Tested blockage regimes *could not* exercise range of HPSI ΔP
- The basic phenomena affecting valve blockage are still evident despite the variability among test results.

**Additional Information
to support the
ACRS Thermal Hydraulics
Subcommittee**

February 16, 2006

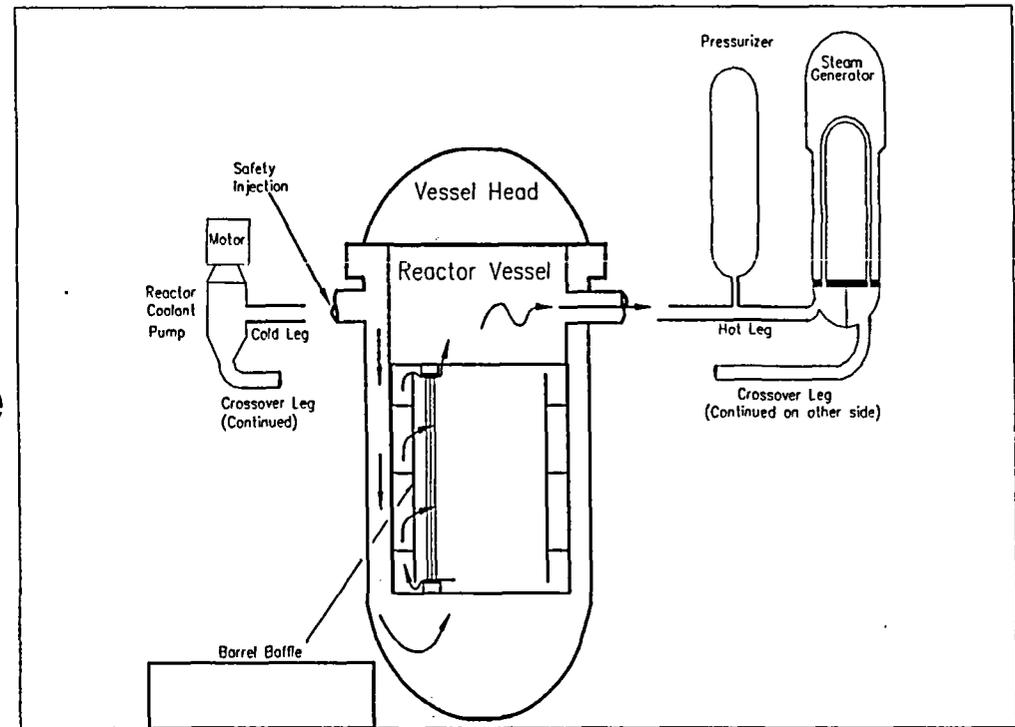
Schematic of a Fuel Assembly

Lower Portion of a Fuel Assembly



Alternate Flow Path

- Possible flow path exists
 - From lower plenum across bottom of Lower Core Plate/Bottom Nozzle to the Baffle/Barrel
 - Then through the Baffle/Barrel to the core through Pressure Relief Holes



Alternate Flow Path

- Alternate Flow Path provides acceptable flow to the core for majority of plants;
 - W plants with a standard upflow baffle/barrel
 - B&W plants with slots and holes in the baffle/barrel design
- Sufficient bypass flow considered available;
 - For converted upflow baffle/barrel plants
 - Majority of CE plants have an alternate flow path similar to that for Westinghouse converted upflow baffle/barrel plants
 - Additional reviews are needed
- Small number of plants may not have adequate bypass flow;
 - Alternate options are being considered

Lower Plenum as a Settle-out Volume

Free Volume of Lower Plenum:

- 300 cu. ft. – 375 cu. ft.
 - Region between lower core support plate and inside of vessel lower head
 - Provides volume for debris settle-out
- Actual value depends upon vessel design