Official Transcript of Proceedings ACRST-3362

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards Subcommittee on Thermal Hydraulics

Docket Number: (not applicable)

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

SUNSI REVIEW COMPLETE

Location: Rockville, Maryland

Date: Thursday, August 24, 2006

Work Order No.: NRC-1226 Pages 1-224

ORIGINAL

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

TR04

DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

August 24, 2006

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, taken on August 24, 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.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

\+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

\+ + + + +

SUBCOMMITTEE ON THERMAL HYDRAULICS

\+ + + + +

MEETING

\+ + + + +

THURSDAY,

AUGUST 24, 2006

\+ + + + +

The Committee met in Room T2B3 of the U.S. Nuclear Regulatory Commission, Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Graham B. Wallis, Chairman, presiding.

PRESENT:

GRAHAM B. WALLIS ACRS Chairman
MARIO V. BONACA ACRS Member
THOMAS S. KRESS ACRS Member
OTTO L. MAYNARD ACRS Member

CONTENTS

P R O C E E D I N G S

(8:31 a.m.)

CHAIRMAN WALLIS: Well, good morning. Welcome to the second day of the meeting of the Advisory Committee on Reactor Safeguards, Committee on Thermal Hydraulic Phenomena and our interesting investigation of what's going on with these studies of sump strainers.

We're going to hear from CCI this morning. Without more ado, I invite them to get started.

PARTICIPANT: Make a note that we're in open session.

CHAIRMAN WALLIS: This is an open session. We were closed yesterday afternoon. This is now an open session, and we're open for the rest of the day?

PARTICIPANT: Yes.

CHAIRMAN WALLIS: Yes. Thank you.

MR. BECK: Good morning, gentlemen. My name is Deane Beck. I'm a business unit manager for CCI Nuclear Services.

We're normally represented for regulatory type meetings by Dr. Urs Blumer. Urs is on holiday right now, and so we've asked for Tobias Zieger to speak to the group today. Tobias is our Deputy Director for Nuclear Division, and that would be

equivalent of chief engineer from our Swiss factory, which is where our strainers are tested and produced.

And with that I'll turn it over to Tobias.

CHAIRMAN WALLIS: Tobias Zieger is a Swisse?

MR. ZIEGER: No. I work in Switzerland, but I'm a German, and I'm probably the only non-American in this room. If you cannot understand me, please interrupt and ask me.

MEMBER KRESS: *Sprechen zie Deutsche*?

CHAIRMAN WALLIS: That's what I said, business *Deutsche*.

(Laughter.)

MR. ZIEGER: Shall we start? So Deane already introduced myself. I'm with Brunzer Defer (phonetic), our Nuclear Division for all technical issues.

As a consequence of today's presentation, at first we want to speak about some general topics. Yesterday I recognized that you are probably interested in how such as strainer replacement project is handled.

Then I will give you quickly some design features of our strainer. I will explain test facilities parameters which are important for strainer

design; a reference list related to testing. Also, where are we with the testing? Some key observations, and then some specific topics like scaling methodology, how we prepare the debris, how we introduce the debris into the test loops, and I'll give you also some results about chemical and bypass test.

How does it go? Of course, at first you have to study what kind of debris will be generated, and how much of it -- what are its characteristics? These are usually information we get from our client or from our customer.

The next one is the same. That's information we have to get from our customers because to size the strainer, of course, it's very essential to know how much of the generated debris will make it to the sump or to the strainer.

This is where we come into play. When we have all of this data, we usually start with the kind of footprint, which means we look at the data, what space is available, what is the debris condition, what's the flow, et cetera, and we come up with a proposal where we can install our strainer, what kind of strainer we can install. So that's the point where we start with our work.

Then, of course, up to now it was always part of the job. We are not doing only testing. We do all also the head loss calculation, which is primarily based on NUREG CR-6224. I think that is very well known here, what it is.

These theoretical calculations will be compared to real testing. I will explain later on what kind of test beds we have and what kind of testing we did, and usually you see when you compare testing, especially large scale testing with the calculation that there is remarkable margin between the real margin between NPSH and head loss and the theoretical calculation.

Of course, then we do the design test and calculation reports, and that was the one issue yesterday which came up very briefly. Of course, the licensee gets all documents from us which enables them to justify the sizing and design of our strainers. So we do design calculation reports. We do test reports. We do a design report itself, all documents which justify the design are available with the licensees.

Okay. Last but not least, we make it and sometimes at least we help to install it.

And now I want to give you some very brief features of our strainer design. We call it pocket

principle, and it was actually developed for our BWR strainers. Unfortunately, we had no business in the U.S. for PWR strainers, but that' where this pocket design comes from.

And for BWR strainers, of course, a round design is perfect. You usually find the flange, and what's better to fit to a flange than a round piece?

But for PWRs the situation is completely different, as you know. You have to find way to install the required surface area which can be inside the sump, next to the sump, on the containment floor, whatever. And for this kind of installation, it's much more convenient to have a rectangular shape, and so we used our proven pocket principle, modified for a new design used now for a the pressurized water reactors not only in the U.S., of course. We have worldwide projects.

MEMBER BONACA: May I ask a question?

CHAIRMAN WALLIS: You can ask a question any time you like.

MEMBER BONACA: All right. Well, you were pointing out a debris generation and debris transports which are inputs from the customer of defining some of the characteristics of the filters. Okay?

MR. ZIEGER: Un-huh.

MEMBER BONACA: Both, for example, in this design, I mean, what changes from customer to customer? Is it the size, the real size, not necessarily the --

MR. ZIEGER: What changes is, of course, the required surface area and the volume which you have available, and I think all my colleagues here know it very well. It's restricted. It can be part of the sump, can be the sump itself, can be a certain area in the containment, and then you have to live with what you get.

We get a certain volume, and depending on this volume, we modify, for example, the depth of the pocket. We usually don't modify the shape itself, mean height versus width. It's more or less a constant, but we vary the depth. We vary the number of pockets which are in one model. We vary the number of walls which are in one model. All of these are more or less variables to adopt to the plant situation.

MEMBER BONACA: But not necessarily a screen. I mean, the screen stays the way it is insofar as the size of the passages?

MR. ZIEGER: We have -- it comes later. Of course, this shape here is separate.

MEMBER BONACA: That's right.

MR. ZIEGER: That's why it's shown in a different color.

MEMBER BONACA: Oh, yeah, sure.

MR. ZIEGER: It's separated and we have many two hole sizes. We are using one slope and one sixteenth inch --

MEMBER BONACA: Okay, and you do have -- all right. You do have a variation in that, too.

MR. ZIEGER: We have a variation in hole size. The utilization of the punched sheetmetal is about the same. It is in the range of 35 percent.

MEMBER BONACA: Thank you.

CHAIRMAN WALLIS: So this pocket is smaller than the little pigeon hole into which it fits? It slides into a box.

MR. ZIEGER: Yes.

CHAIRMAN WALLIS: And it is smaller than the box.

MR. ZIEGER: This is the box.

CHAIRMAN WALLIS: And it is smaller than --

MR. ZIEGER: Over here is the badger (phonetic) pocket.

CHAIRMAN WALLIS: And that pocket is

smaller than the box. So the fluid flow around between the pocket and the box wall.

MR. ZIEGER: Yeah.

CHAIRMAN WALLIS: When it comes out.

MR. ZIEGER: What we see here, all of these small pieces touch pocket.

CHAIRMAN WALLIS: But the pocket is smaller than that. It must be smaller to let the fluid flow around it.

MR. ZIEGER: Of course.

MR. BECK: It has a taper to it.

CHAIRMAN WALLIS: And it's tapered, too.

MR. ZIEGER: You see it a little bit here.

CHAIRMAN WALLIS: Yes, the taper. It has a taper.

MR. ZIEGER: It has a taper, and then it leaves the space.

CHAIRMAN WALLIS: Leaves the space. Okay.

MR. ZIEGER: The water flows out.

MR. BECK: The opening or the window is a constant, but the depth of the pocket varies.

CHAIRMAN WALLIS: I'm tempted to ask how many pigeons you can fit in this thing.

(Laughter.)

CHAIRMAN WALLIS: It looks very much like

the pigeonhole in the Post Office. It does very much look like the Post Office sorting system. An interesting design.

MEMBER KRESS: Why do you vary the depth of the pocket?

MR. ZIEGER: Because it depends, as I said, on what space we have available. Sometimes, and I use here a picture label, for example, we have only the containment floor, but there's a wall. Next to the containment floor and in between we have to fit the strainer. So if you make a full length, I would say our full length is 400 millimeters, but for several of the cases we have to make it shorter to fit two roles of models into the available space.

CHAIRMAN WALLIS: It looks like they're --

MEMBER KRESS: It looks like on the module that they were different lengths in each module.

CHAIRMAN WALLIS: Different lengths in there. The black center is tapered like this in the middle.

MR. BECK: That's a collection box.

CHAIRMAN WALLIS: Yeah, but the black area between the yellow there is tapered. So that the pocket --

MR. ZIEGER: Not really.

CHAIRMAN WALLIS: Not really?

MR. ZIEGER: It is not very precisely shown.

CHAIRMAN WALLIS: It's not very precise. Okay.

MR. ZIEGER: It is a kind of frame which needs a rectangular (unintelligible).

CHAIRMAN WALLIS: Okay.

MR. ZIEGER: Okay. Here you see a little bit more how it is made. At first this frame is installed that you see here, a kind of simple structure, and after installation of the simple structure, the cartridges are, if you want, clipped or sticked (phonetic) onto the simple structure. There's only a little welding done. Only some pieces are welded. Here is a connection which is welded, but the overall installation is without welding, and the installation unsided (phonetic) would use without welding anyway. So these weldings are done in our workshop before delivery.

And this is another microphone.

I think you see how it works. The (unintelligible) fluid comes in here for all these pockets, which provide a high surface area. The ratio between the flat surface and the real surface area

inside the pocket is about ten to one. So we have about ten times more surface inside the pocket than on this screen.

The water goes off and then the clean water comes within two or three cartridges in a channel, and these channels can be fairly long, not in the U.S., but we have projects in France where the total length of the strainer is more than 180 degrees of the containment. So a regular chain of models.

And if you have any questions.

Three examples, real examples how a strainer is installed or will be installed. That's one of our (pause) -- okay. Thank you.

I'm not used to sit during a presentation.

MEMBER KRESS: You're welcome to stand.

CHAIRMAN WALLIS: That's okay.

MR. ZIEGER: Well, this is a design where all of the models are placed on top of the sump. Here's the sump pit, and in this case it was possible to install all of the required area on top of the sump pit.

Another design, and that's what I mentioned before, is, for example, this. Here we had no space or not enough space on top of the sump pit. Here you see the sump. So we had to install these

kind of chains, and here, for example, you see that there's very narrow space available. That means in this area we have different pockets. Here we have pockets which are only 200 millimeters deep simply because of the available space.

And where we have space, there we have our standard pockets like here. Here's enough space. These pockets are also a little bit smaller.

MR. CARUSO: That looks like it -- can you go back there? In a case like that it looks like it's sitting up against a wall.

MR. ZIEGER: No, that's not a real drawing. That's a schematic drawing. Of course, there is a distance between wall and the strainer. Otherwise the strainer makes an ascent.

MR. CARUSO: Right. That's what I was wondering.

MR. ZIEGER: The material has to be able to go through the strainer. So that is a schematic drawing; that's not a real one, but just to show the different situations we are faced with usually in the plant.

Now, of course, we need at the minimum space which is always free to a wall or to the next strainer. It's a minimum one foot. So it's never

closer than one foot.

And that's the third way to install strainers. There is a picture also out of the U.S. and two units of this station are already installed, and here the filters are inside the sump. The old strainers are installed inside the sump. There you see these level instruments, and here is the suction line for the pump, which is, of course, covered during installation.

MEMBER BONACA: What's the height of that structure?

MR. ZIEGER: It's about -- I have to convert from meter into feet -- it's about five feet. And it depends on the number of pockets because the height of one pocket is about a third of a feet, and as far as I remember, we have 12 pockets here.

Okay. That's a little bit of a repeat what I already told you. The input we need. then we do the preliminary sizing.

Of course, also during or very close to this step is the preliminary sizing. We have to define what kind of test we propose, and usually as the test specification, what tests are we doing, how are we doing the test in agreement with the customer. So we develop the specifications. Licensee looks over

it, comes back with input, and then we develop the specification, what we test together with the licensee. That is the normal way.

That was also mentioned yesterday, surrogate materials. We use only one surrogate material, which is the replacement of paint, which is a kind of stone flour, but I think it comes later with some more information.

For the scaling, that might be also a little bit different to others because yesterday I heard differently, for the scaling, to come up with the scaling factor for the test. We take away the sacrificial area. It means all area which can be covered by stickers and tapes and stuff are taken away from the total amount of screened area, and then we take this number to calculate the scaling factor.

To make an example, if you had 10,000 foot available area and sacrificial area is 1,000 foot, then we calculate with the 9,000 foot and, for example, our testing area is 100. Then we would have a scaling factor of nine feet instead of 100 because we take the area which could theoretically be covered by all of these stickers away from the available area.

Okay. Now, some information about our test loops. Small scale test loop, I think it's

similar to what the industry has. It's a vertical test loop. Of course, due to the vertical orientation there's no sedimentation possible.

What's also the case, and that was our observation during all of these testings, it results into more or less uniform debris distribution over the failed surface, but this test bed is very suitable to do kind of parametric studies.

CHAIRMAN WALLIS: Well, this doesn't have pockets. This just has a --

MR. ZIEGER: No, no. It has pockets.

CHAIRMAN WALLIS: It has pockets in it?

MR. ZIEGER: You will see a picture. It has pockets.

CHAIRMAN WALLIS: Ah.

MR. ZIEGER: It has pockets. Of course, what we install in this test loop, it depends on us, but usually it has pockets. We used also the same test loop to make some very basic studies in the beginning just as flat plates.

CHAIRMAN WALLIS: So uniform debris cake formation, that's around the walls of the pocket it's uniform?

MR. ZIEGER: Of course, it depends on --

CHAIRMAN WALLIS: This will go to the

bottom of the pocket, and then when it's placed in the vertical --

MR. ZIEGER: It depends on a lot of --

CHAIRMAN WALLIS: It must depend on a lot of things.

MR. ZIEGER: It depends on the density of the material you put in. It depends on the ratio between fiber and particle leads , for example. Of course, if you have a lot of heavy stuff, it sinks down.

CHAIRMAN WALLIS: To the bottom of the pocket, yet.

MR. ZIEGER: Yeah, but if you make a test, mainly this fiber, and you are using fine fibers, then it distributes very nicely. It depends very much.

CHAIRMAN WALLIS: Yeah.

MR. ZIEGER: It depends very much on the material.

CHAIRMAN WALLIS: It's like the inside of a vacuum cleaner bag.

MR. ZIEGER: Yes.

CHAIRMAN WALLIS: Very similar. I just asked you because you said it's uniform, and it's not always uniform.

MR. ZIEGER: No, no. It depends very much on the debris, but it is more uniform if you compare the same situation, small scale and large scale. It is more uniform than what you see in the large scale test.

MEMBER MAYNARD: The orientation of the bag is vertical. It's in a vertical tube?

MR. ZIEGER: Yes. But there is a picture coming. But you'll see a picture very soon.

Parametric studies, what I mean with this is, for example, if you want to see or if the customer wants to see what's the influence if I, for example, replace some of my fibers with I don't know what, we can do this very quickly because on this vertical test loop we can do about five to six tests per day. On the whole frontal one takes much longer and costs much more money.

So for these kinds of parametric studies we like to use this test to compare Situation A with Situation B, not to make quantitative assumptions or quantitative statements, but to compare situations to each other. It's a good thing. Of course and it's also used not so much for the earth project, but much more to my surprise for the Japanese project.

The vertical test loop is used to prove

that the NUREG CR-6224 is always conservative, and it is conservative. We find to my knowledge we didn't find any case where the calculation was lower than what we tested, even in the small test loop.

Yeah, and justification of surrogate materials --

CHAIRMAN WALLIS: It was lower or higher?

MR. ZIEGER: Huh?

CHAIRMAN WALLIS: You're calculating always --

MR. ZIEGER: Higher.

CHAIRMAN WALLIS: -- more than you observe.

MR. ZIEGER: Yes. And the calculation is very much based on the formulas.

CHAIRMAN WALLIS: Do you have any thin bed effects, what's called a thin bed effect?

MR. ZIEGER: No, we didn't observe it. It comes later as a conclusion, but I know this discussion with a one eighth of an inch and three millimeter, and in the calculation you can perfectly show this. In testing we haven't seen this up to now.

MEMBER KRESS: Could you explain that last bullet?

MR. ZIEGER: Which one?

MEMBER KRESS: The justification.

MR. ZIEGER: Yeah.

MEMBER KRESS: The justification of certain fields. How do you do that?

MR. ZIEGER: Because the use of real material is also sometimes a question of availability, not to produce a lot of this paint stuff. It's sometimes not possible. And for the small scale test we need only a small quantity and then we do a test with original stuff and we do a test with --

MEMBER KRESS: You do the original.

MR. ZIEGER: Yes.

MEMBER KRESS: That's what I was --

MR. ZIEGER: Yes, yes. To justify that the surrogate is at least a principal (unintelligible) or a similar replacement for --

CHAIRMAN WALLIS: So this is ersatz material?

MR. ZIEGER: Yes, *ersatz* material.

Okay. There is a drawing --

MEMBER KRESS: You're stretching my knowledge of German.

MR. ZIEGER: It's a very simple device. It's an open loop, of course. The test model is sitting here, and the test model for the PWRs, I must

say, is sitting here. If we test for BWRs where we have a conical test because of the round shape, then the test we do is sitting here. There are two possibilities.

Yes, then we have the usual things you need. We have pressure transmittals. We have a flow measurement, of course, and most of the test loop is made out of transparent material, plexiglass, to see what happens.

MEMBER KRESS: Is that open at the top where you dump in the debris?

MR. ZIEGER: That's open, yeah.

CHAIRMAN WALLIS: Well, you must be limited in the pressure drop if it's open.

MR. ZIEGER: Yes, we are limited in pressure drop to a little bit less than the height of the whole equipment.

And that's a picture. Here you see this plexiglass model. PWR test model is installed here. That is the lower part of it that's a pump. That is our GSRE, our flow meter, which is an adjusted valve to regulate the flow a little bit. It think it's not spectacular. It's a loop to circulate water.

CHAIRMAN WALLIS: That's the same thing?

MR. ZIEGER: It's the same. It's not so

good here.

Here you see the test model itself a little bit better. Here a model is installed with six pockets. You see here one, two, three, and two pockets where we can test only six pockets on our small scale test loop.

MR. CARUSO: So the pockets oriented -- where's the opening?

MR. ZIEGER: Here.

CHAIRMAN WALLIS: At the top.

MR. CARUSO: At the top. Okay.

MR. ZIEGER: The debris falls directly on top of the pockets, and this is the orientation at least for our design which you never find in a plant because in the plant the pockets are always oriented (unintelligible).

MR. CARUSO: So -- I'll let you finish. I just wonder how -- that to my mind introduces all sorts of distortions to the test, doesn't it?

MR. ZIEGER: No. But as I said, because all debris makes it to the strainer and there is a relatively large way from the pipe, which is up here, to the surface of the strainer, though it has time to distribute itself, here to this. The debris loading in the strainer is relatively -- we discussed it

before depending on density, et cetera, et cetera -- relatively uniform, which is, of course, conservative.

I think it's known to everybody here the worse thing you can have is a nicely equally distributed debris bed, and all that is unequal makes you unhappy because it reduces the head loss.

CHAIRMAN WALLIS: Reduces the head loss.

MR. ZIEGER: Yes.

MR. CARUSO: The debris does not accumulate at the bottom of the pocket.

MR. ZIEGER: Of course if the amount of debris is so much that you still have something on top of the pocket, then yes, but it depends very much on the actual situation in the plant. We have plants with very low fiber content where the debris bed with an equivalent thickness is in the range of three, four millimeter.

And then, of course, you see nothing here, but yet --

MR. CARUSO: I was just thinking in your test loop there because you've got the mouth of the pocket up, why doesn't all of the debris just gradually wash itself to the bottom?

CHAIRMAN WALLIS: And just flow through the walls holding --

MR. ZIEGER: Because it has to flow through the holes in the sheetmetal, because inside here are these pockets, and the water has to go through outside. There is no peak opening that it just can flow through, of course. It has to go through the holes, which held the debris back, and then it comes out to the side internally because, of course, between two pockets is a space. Otherwise the water cannot flow. Yeah, it goes out in this direction, in this direction, a little bit to the bottom because this lower part is also separated.

MEMBER KRESS: Are there more holes in the top than there are in the bottom to uniform the flow?

MR. ZIEGER: No.

MEMBER KRESS: No.

MR. ZIEGER: It's equal (unintelligible) distributions. The distance between the holes is always the same.

MR. BECK: The pocket is tapered.

CHAIRMAN WALLIS: It looks like a bag house for those who are familiar with coal plants.

MR. ZIEGER: Okay. More questions on small scale testing? No.

Large scale test loop, of course, it's a completely different roof. Horizontal flow and you

have gravity effect. You have sedimentation, but it's more realistic, in my opinion.

As a result of this, the debris distribution is not uniform over the strain or module. It means in the lower pockets we usually find more debris than in the pockets (unintelligible), and all of the pockets itself are not loaded uniformly.

CHAIRMAN WALLIS: Are you going to show us any data?

MR. ZIEGER: Yeah. Some data are coming later on.

CHAIRMAN WALLIS: So you're going for the data prize, are you?

MEMBER KRESS: There's a price for somebody that shows data.

CHAIRMAN WALLIS: There's a prize for the best data, right.

MR. ZIEGER: What we found just as a rough figure, and of course, you cannot take it as a fixed value, but approximately the ratio between small scale tests and large scale tests with the same kind of debris, of course, with a different scaling factor because the surface is bigger in the large scale test than in the small scale test, but all the rest is the same, the same flow, the same approach velocities, the

same debris mixing. We find about a ratio of ten to one between small scale test and large scale test.

For example, if you --

CHAIRMAN WALLIS: It's interesting because it means that you've got to be careful about scaling. There's something different about the large scale test.

MR. ZIEGER: Yeah, and the difference is the non-uniformity.

CHAIRMAN WALLIS: Non-uniformity, right.

MR. ZIEGER: Because you have areas --

CHAIRMAN WALLIS: It's gravity.

MR. ZIEGER: -- yeah, which are more or less free, and then I have only my clean head loss, which is much less than debris head loss.

There is a drawing.

CHAIRMAN WALLIS: I've seen this somewhere else.

MR. ZIEGER: And the large scale test loop is used to test an entire module. Of course, maxi hole chain of modules, if we have a chain of 180 degrees, we have to find a test bed first. But here we can test the whole module, which means, for example, six gussets (phonetic), three gussets here, three gussets here on each side. The total number of

pockets we can test there is about 300 or so, but it comes later.

And then we circulate water, of course. To introduce the water here, we have the special pipe which produces certain turbulences just to avoid settling of debris already here. So we make it intentionally turbulent to bring as much debris as possible to the pockets itself, but usually in 90 percent of the cases I would say, we introduce the debris directly here. Directly in front of the pockets we dump it in.

CHAIRMAN WALLIS: Do you ever do experiments where the whole thing is covered with debris?

MR. ZIEGER: Yes.

CHAIRMAN WALLIS: Where there's so much debris --

MR. ZIEGER: Yes.

CHAIRMAN WALLIS: -- that it covers everything?

MR. ZIEGER: A picture will come.

CHAIRMAN WALLIS: A picture of that.

MR. ZIEGER: But it's not covered with fiber. It's covered mainly with RMI. So that's one plant which has a huge amount of RMI and not so much

fiber, and there the strainer is completely covered. It submerge this RMI. There's a picture coming soon.

Okay. We did about 200 ones in this large-scale test that is the example of a test model. That's what we already saw, but I bring it again.

Because of these situations here, we have to adjust the test bed itself, and for this we have these kind of walls. So we can move the walls either to make a kind of flow channel or we can move the strainer module next to the wall to have the right distance between test model and wall in the blind. So we are very flexible with these kinds of things to go S, close S, possible to the real situation.

MEMBER KRESS: Are the walls helpful in the sense that they probably reduce the pressure drop by making it more non-uniform?

MR. ZIEGER: No. The walls are mainly used to make the geometry which you'll find in the plant.

MEMBER KRESS: I knew that.

MR. ZIEGER: Okay. There's a test model. These are separation plates. These are two pictures, first a picture with what you called thin bed. Of course, the picture was taken after the water was drained out of the pool, where we have no diver with

a camera to make pictures.

Then as the debris collapses, of course, during operation it was sitting here around the pocket surface, and here you see how thick it approximately was. So I would say that it is in this range of the thin bed testing, but we didn't find a peak in head loss.

MEMBER MAYNARD: Did you restart the pumps for any of these tests to see what happens to the debris that's fallen off or that has fallen down? Was it picked back up?

MR. ZIEGER: Not that I'm aware of. I'm not sure if we did this kind of testing.

CHAIRMAN WALLIS: I don't see any chickens.

MEMBER KRESS: No, no eggs or anything.

MR. ZIEGER: And this is another picture with much more debris in the pockets, but you see also here it's not uniformly. Some of the pockets are almost full. some of them are almost empty. So you have all of this areas here, way level, where you only have clean strainer head loss, and this explains the big difference between small --

MEMBER BONACA: But is it because it collapsed there?

MR. ZIEGER: Partly, yes.

MEMBER BONACA: Partly, yes.

MR. ZIEGER: Partly, yes, but this, for example, or this one here was never full, also not during operation, and this one here, I think, was almost full, and in between the water partly collapsed.

Then we have the third test loop which we call multi-functional test loop, and this test loop is mainly used to do chemical tests, but we also do -- it's a moment for one of our customers. We do a transportation test. The test loop is relatively long, but less meters, and then we introduce different kind of debris far away from the strainer, and with the flow we will have in the plant, we test how much of the debris is transported. That was with one of our customers and just going on in (unintelligible).

But we can also use the test loop for chemical tests. We use it for bypass testing, how much of the fiber goes through the screen, and I think due to this relatively long channel and velocities which are close to the reality, it's also a good test loop to show the so-called near field effect.

That's a picture, but it's only a part of the situation. In reality we have another four models

here because the test loop is longer than what is shown here on this drawing.

Up till now we did about 130 test runs, and that's again a schematic picture. The test model is sitting here. That's a small one. It can be up to ten pockets in height when it's about this size, but of course, the water level is still higher. So that's the test -- oh, sorry.

Maximum, 40 pockets. That's the biggest one, but this, what is shown here is not 40 pockets. It's maybe 15 or so or 18. Then what we also have, but have used it sometimes, sometimes not, and you will see later on why. To be conservative, the requirement was to bring all of the debris to the strainer, which is difficult, and we heard it yesterday several times. It's not so easy to bring all the debris to the strainer because the water velocity is low. The flow velocity of the water is very low, and so it's difficult to transport.

Then we looked for solutions to bring the debris more or less forced to the strainer without pushing it to the strainer over-over conservative because then we would create or we would reduce the porosity, increase density. So it makes no sense to push it manually in the strainer and then we were

looking for provisions.

It's a kind of -- I don't know how you will call it -- a guide where the debris can slip more or less throughout the strainer.

CHAIRMAN WALLIS: Are you going to talk about what you find on this bypass filter model?

MR. ZIEGER: Yeah.

CHAIRMAN WALLIS: You are going to talk about that.

MR. ZIEGER: Yeah, I give you some results.

And then here is a bypass filter very similar to what we saw yesterday, I think. The water is circulating here and it has to go through this filter and all that goes with the water through the main filter will be caught here. Well, not all; it's five micron, but almost all will be caught here in this filtermatte, and then the filter is taken out and it's applied and it's weighted, and in one case we also analyzed the size of the fiber and just used the result later on.

This is a summary of the parameters of our test loops, small scale, log scale and multi-functional test loop. Log scale is 120 pockets maximum.

CHAIRMAN WALLIS: What does scaling factors mean here?

MR. ZIEGER: Scaling factors mean what I explained before. For example, you have 10,000 square foot in the plant.

CHAIRMAN WALLIS: Really these are full scale tests. Every pocket is full scale., isn't it?

MR. ZIEGER: The pocket, yes.

CHAIRMAN WALLIS: Right.

MR. ZIEGER: But we cannot test 10,000 square foot because then you would need a big pump and we would need more or less a power plant.

CHAIRMAN WALLIS: Yeah, that's right.

MR. ZIEGER: And to come up with the real water flow, with the real amount of debris, we have to scale it down because we cannot put all of the debris which is dimension for 10,000 square feet and 1,000. that's not realistic. So we have to scale it down, and that's meant with a scaling factor.

And it varies because as the debris load in the plant varies. These are typical flow ranges, temperatures. At the moment we are not able to do testing at high temperatures, let's say 70, 80, 90 degrees because for this you would need a closed loop. You would need completely different equipment. We can

test only with slightly increased temperature compared to ambient.

MEMBER KRESS: Do you scale your results by temperature for the post scale?

MR. ZIEGER: The results are scaled with the viscosity because due to the very low flow we have, laminar flow, and as long as you have laminar flow you can scale with the viscosity, and that's what we are doing. We measure the temperature during testing continuously, and then the results are scaled to the design temperature by viscosity.

Some design parameters, high, low. The maximum would be design up to now was 19,000 square foot, but this is worldwide. So 19,000 in France, which is famous P.J., which has more than 180 degrees of containment strainers. That's not U.S., the 19,000, down to 2,300, an average. An average size is the range of 5,000 square foot, which is installed over here in the U.S.

When screen approach velocity, with screen approach velocity, I mean equivalent velocity to the entire filtering surface, the pocket area, if you want, and this is in this range.

CHAIRMAN WALLIS: Twenty-one feet of a vertical. That is crazy.

MR. ZIEGER: The pocket approach velocity, it's the footprint, if you want. You have the pocket itself which will provide about ten times more area, and then you have the inlet phase of the pocket. That's the velocity there.

What we see usually, we also saw these figures yesterday, but yesterday I think the lowest number was 0.6. We saw down to 0.1, but again, that's not U.S. That's France. Thirty centimeters, I think, and that's the reason why we needed these 90,000 --

CHAIRMAN WALLIS: That's .1 foot? That's three centimeters.

MR. ZIEGER: Three. Sorry. Three centimeters, yeah. That's nothing.

CHAIRMAN WALLIS: That's (speaking German).

MR. ZIEGER: yeah. And of course, that's the same. That's the same plant, 19,000 and 0.1. And the average is about three foot.

When temperature doesn't vary so much what we see there is between 212 and 190. The design temperature, of course, the relevant temperature for the next positive section. An average is about 200. Our hole size, mainly still 2.1 millimeter, which is one-twelfth of an inch. Some of the newer orders we

got with a hole size of one-sixteenth of an inch.

MEMBER BONACA: The filtering surface area, I mean, you are constrained by the sump size, I guess. How do you make the choices there? I mean, for example, in the French reactor we have 19,000 square feet.

MR. ZIEGER: Yeah, because the modules are not in the sump. The modules are at the containment wall.

MEMBER BONACA: Yeah, in the containment wall.

MR. ZIEGER: And more than 180 degrees. There's almost the whole containment is still this --

MEMBER BONACA: But the question then becomes for the low, for example, is 0.1 an adequate MPSH margin?

MR. ZIEGER: I cannot answer this question because that was the input we got at least from EDF. These are all EDF plants, and EDF gives us the input, MPSH allowable debris, et cetera, et cetera. Why it is so low I do not know.

MR. CARUSO: What's the open area in your strainers? How much of the strainer is open? Fifty percent?

MR. ZIEGER: You mean the ratio between

total sheetmetal and punched?

MR. CARUSO: Yes.

MR. ZIEGER: It's about 33 to 35 percent.

MR. CARUSO: Open?

MR. ZIEGER: Open. So that is where we are with the testing. At the moment all of the small scale-large scale testing is done, except with Calvert Cliff, because this is an order we got very recently. It's under preparation.

Bypass testing will stand for three units or three plants up to now. At the moment, but it's almost finished now, the transport testing for Oconee is ongoing, and for the Exelon plants we did chemical tests. That's just to give you a figure, what we are doing worldwide. We are working on a lot of other things, for example, and still BWR strainers may be a surprise because the Japanese did nothing u till now, and now we have a very good contract with Toshiba.

Generic test observations, that was already mentioned several times. Uniform debris beds are not formed in realistic conditions. At least we haven't seen it up till now, and this has to do with this one.

It's difficult to get all of the debris to the screen. You really have to think how to do it.

We tried this slit. We stirred it with a kind of mixer. We made it with a shovel. We did all kinds of things, but in reality, nobody will stay there and make it. So you will have settling. That's absolutely clear, but I can imagine the problem is to justify how much settling you'll have.

You will have sedimentation. For me that's absolutely clear, but how much it is in reality, that might be difficult to determine.

As I already mentioned also, up to now we have not seen such a thin bed effect in testing. Of course, in calculation you'll use it every time in the calculation, but in testing, we haven't seen it.

We have seen a kind of centered effect when we tested for the Japanese, and the Japanese have a lot of calcium silicate. Then we saw one time not really a peak, a very small thing, in this range of about three, four millimeter bed thickness, but for the American plants, we have never seen such a thing.

then what we also have not seen in our testing in (unintelligible), a strain completely covered with debris or with fiber was not the case, but what we have seen is a filter completely covered with RMI, and I hope the picture will come through. Here it is.

Underneath the RMI is the model. This is a model. There it's completely submerged. It's about from here, from the upper part of this wall, to the upper surface that's the strainer. It is, I would say, about half a foot. So it's completely under RMI.

MEMBER KRESS: That might just make a better filter.

CHAIRMAN WALLIS: Yeah, it is.

MR. ZIEGER: What we also found, I don't know if somebody talked about this already because I don't think we are the only one to find that. Can I use this?

MEMBER KRESS: Yes.

MR. ZIEGER: Because otherwise it's difficult to explain the so-called bore hole effect. The effect would be (unintelligible). We made a test. What you see here is the head loss. It's the pressure we measured.

We added the debris, particulates, fiber, all this stuff. When we let it go, you already see here kind of these things when we let it go, and here, actually here, not here; here we added RMI. And in my opinion what happened there was due to RMI, we put weight on the debris bed. We made it denser. We increased the head loss, but in reality it didn't

increase. It broke through some of the holes, and the mechanics, I think, is like this.

If this is the hole and you start loading with debris, you're building up a kind of bridge here, and of course, in my opinion you need particles which are able to make this bridge. This fiber, it's relatively quick. If you have only particulates, for example, only paints, it takes much longer.

So you build up this kind of bridge, and as long as the pressure increases slowly because you put more debris on and more debris on, it's okay, but if you put like the RMI on one shot, more debris and more weight, then it will be denser. The delta P increases and it breaks through, and you see it perfectly.

On the small scale test loop you can see it very good because there we have the plexiglass and directly behind is a filter model, and you see this effect. Sometimes it's like small explosions. Then it breaks through, and then it causes exactly the opposite what you would expect. The pressure goes down instead of up.

That's the so-called bore hole effect, and we see it from time to time. And, of course, when you have this one, you cannot anymore scale the test

result with the temperature because the reason why we have seen it here is the relatively high pressure drop at low temperature. At 60 or 80 or whatever degree or close to 100, you would not see this pressure drop. That means you would not break through this debris bed.

From here on, it's not really realistic or reliable to scale the test results with the temperature because in reality, all this would happen at a much lower pressure level but at a higher temperature.

CHAIRMAN WALLIS: Did you try this in your small scale facility? You have a pocket with fiberglass and then you add some RMI. Do you get a similar effect?

MR. ZIEGER: Not only RMI. You can try it if you want sometimes. If you --

CHAIRMAN WALLIS: But the small scale facility, you have better ability to understand what is happening.

MR. ZIEGER: Yes, because you see it perfectly.

CHAIRMAN WALLIS: Right. So you can duplicate this in the small scale or maybe not yet.

MR. ZIEGER: This was --

CHAIRMAN WALLIS: This is a big scale test, isn't it?

MR. ZIEGER: Yes, this was a big scale test. You see the same effect, but visually during testing is the best possibility to see if it's a small scale test.

CHAIRMAN WALLIS: Right.

MR. ZIEGER: But it happens, of course, over on the large scale test.

MR. BECK: So we also did it on the small scale then?

MR. ZIEGER: Yeah, yeah.

MR. BECK: Good.

MR. ZIEGER: That's where we found it or where we recognized it. Because it's alike a small explosion. Suddenly it comes through some of the holes, and then it's covered again.

MEMBER KRESS: Does that become part of the bypass then?

CHAIRMAN WALLIS: Yes.

MR. ZIEGER: Of course it has to do with the bypass, yeah. A lot of this bore hole effect, your bypass will be higher. That's clear, but on the other hand, just when we talk about bypass, my opinion, or that was at least our observation. Sooner

or later the water is absolutely clear. The bypass goes to zero, and it has to go. Otherwise you can never justify a one-year cooling period and still keeping the allowable bypass, which is maybe the maximum for the fuel.

So it has to go to zero, and the filter regarding bypass, the real filter, is not the punched hole. It's the debris by itself.

CHAIRMAN WALLIS: You mentioned a one-year cooling period.

MR. ZIEGER: That's what we saw sometimes in the specification, yeah.

MEMBER KRESS: That's a European requirement?

CHAIRMAN WALLIS: One-year cooling period?

MR. ZIEGER: Maybe it's from the French plants, yeah.

CHAIRMAN WALLIS: So this has to survive for a year.

MR. ZIEGER: Yeah.

CHAIRMAN WALLIS: With no problem, no additional chemical effects over a whole year?

(Laughter.)

MR. ZIEGER: Okay. That is the bore hole effect. Scaling I've already mentioned.

Temperature. Our tests are mainly at room temperature, and the conversion is by viscosity.

If I can explain something more.

CHAIRMAN WALLIS: That's okay. Please go on.

MR. ZIEGER: Okay. By temperature, except when you have effects like this bore hole effect, then it's not more realistic to do it by temperature. Geometry, that was already mentioned. We usually take not credit for settling, except it is a test to show how much the settling is, what we are doing now for Oconee, but for the moment, Adler's (phonetic) testing, we dump it directly in front of the spring so that it all makes --

MEMBER KRESS: When you get your specifications from the customer --

MR. ZIEGER: Yes.

MEMBER KRESS: -- has he taken credit for some settling in giving you the quantity?

MR. ZIEGER: No. In the sizing we never took credit up to now, but I have the impression that the licensee wants to know if the margin -- for example, we don't take credit. We make the sizing. We do the testing, small scale, large scale, and then we find out we have 25 percent margin or whatever.

The licensee wants to know if the margin is probably even higher, and then we do all of this kind of additional testing.

Bypass test. How it was made, I think I explained. We catch the by-pass on this mat, filtermatte, and then we apply it and we weight it, et cetera, et cetera.

These are some data points. All of these wet points were made with a hole size of 2.1 millimeter or one-twelfth of an inch. What varied, and all of these tests were made with the same flow or with the same approach velocity of 0.004 approximately foot per seconds.

And the number you see here is related to 1,000 square foot of filter area. If you have 5,000, in reality you have to multiply this number by five.

The reason why we are not talking about percentage, it's exactly what you see here because you see here with the theoretical or with the equivalent fiber bed thickness of about half an inch, we find bypasses in this range and the difference comes from a variation in test procedure. It was always the same condition, but we varied the test method.

So you will find the amount of bypass around one cubic foot per thousand (unintelligible).

When we increased the fiber load to three inch equivalent, six times more, nothing happened. By pass is the same. That means as soon as you build up a certain debris bed on top of the metal of the screen, and this is acting as a filter actually, you can put on what you want.

Of course, you increase head loss. That's not a head loss test. You increase head loss. That's clear, but you don't change anymore or --

CHAIRMAN WALLIS: But this is true if you have pretty homogeneous debris and it comes in and it fills all of the pockets. In reality you probably have more settling and more debris on the bottom, and so the top ones have a thin -- the high pockets may have a lower thickness. So this theoretical is some sort of average you have here.

MR. ZIEGER: It's not theoretical. These are test results. This is inch over every pocket?

I'm just saying in reality you probably have thin layers on the top pockets and thicker layers on the bottom because of settling.

MR. ZIEGER: That's exactly the reason, what you're mentioning, that we, for example, didn't find a difference how we make it turbulent because one assumption for this verity (phonetic) of test results,

because it varies in between 0.8 and 1.2; it could be 1,000 square foot. One idea was, yeah, it's a test method. How you bring it to the screen with a shovel or with distill or whatever, and we did all kinds of things.

One thing we did, we put the plate in the test loop just before the screen, and the plate had only an opening of about 50 millimeter and all of the water had to go through this, which created this roll of turbulence, and then our example -- oh, this will make a lot of bypass, and then we did the other extreme. We allowed sedimentation. We did nothing. We just filled in the fiber and weighted what happens.

And to our surprise, the result was exactly the same. My interpretation is what makes the bypass is what comes to us. It means that the smallest and lightest part which can swim best, they make it at first as a strainer, and this kind of debris bed is not yet developed and they make it through. And after that bigger pieces are coming. Normal fibers are coming, and then this stuff develops a debris bed and the bypass stops.

CHAIRMAN WALLIS: It's just the initial effect. It doesn't matter how thick it gets after that.

MR. ZIEGER: No.

CHAIRMAN WALLIS: It's just the very, very initial effect. It makes sense.

MR. ZIEGER: Yes.

CHAIRMAN WALLIS: It might even be predictable.

MR. ZIEGER: Yes.

MEMBER KRESS: So the interpretation is you're only going to -- no matter how much debris you're putting in, you're only going to get a certain amount bypassed.

CHAIRMAN WALLIS: Unless you put in an RMI to make the holes --

MEMBER KRESS: I'm not sure how to interpret cubic feet of bypass debris. How do you measure cubic feet of this stuff collected on that filtermatte?

MR. ZIEGER: Of course, what we collected on the filtermatte was not cubic feet because our filter area was much less than 1,000 square feet.

MEMBER KRESS: Yes, but what you got is a mass, right?

MR. ZIEGER: Right.

MEMBER KRESS: Convert that by density to cubic feet? You don't measure the volume. I guess

you could put it at --

MR. ZIEGER: No, because we didn't know the density. We know the density for the loose stuff. We know the density for the filter mode itself, and then we used to calculate back to volume. We used the density which we used for the loose stuff.

MEMBER KRESS: Okay. I understand.

MR. ZIEGER: There is one data point. We have unfortunately only one where we tested with a smaller hole size because one idea was reduce the hole size. This probably reduces the bypass with the square of the hole size because the area goes with the square.

That's not what we found. What we found is it was reduced, but unfortunately we have only one data point, and the one data point was done with the same test model like this one, but it is reduced with the linear with the hole size, not with the square of the hole size.

MEMBER KRESS: That probably means the debris closed it up a little faster than stopped the stuff with getting --

MR. ZIEGER: My interpretation is if you have a smaller hole, you build the bridges a little bit earlier.

MEMBER KRESS: A little faster, yeah.

MR. ZIEGER: Okay. Some pictures of the different methods. Yeah, my computer looks better than here. Sorry.

Hands job means we put the mixer with the long axis and went into the test lube and zzzzzz, tried to bring it to the strainer. High turbulence flow, that's what I explained before, and here you see it very good what happens. Here's a plate with only a small opening on the bottom, and then it creates a turbulence.

And last but not least, and this was really a surprise to us, sedimentation. Here we did nothing, and you see it settles down. It goes only up to here. All the rest is almost free, but the bypass was exactly the same, like on this one. It was a little bit of a surprise, but it was as it was.

That's also interesting, I assume. The size of the bypass, we analyzed it. So we took this material, took it away, and put it to Salsa Innotec (phonetic), which is a kind of research facility in our vicinity, and they measured it, and then they made a classification.

Class 1 was called from 0.1 to 0.5 lengths. It's always the lengths, the fiber lengths.

The diameter is more or less all the same.

Class 2 was 0.2 to 1, 1 to 2, bigger than 2.

What we found is that about two-thirds are smaller than half a millimeter, which is where I have the inches, 0.02 inches. And 90 percent were smaller than one millimeter, 0.04 inches, and I think because the whole reason why we did this is to find out what is the bypass doing with the downstream equipment, like fuel, like -- I don't know what -- strainers and stumps (phonetic), et cetera.

I can imagine with this small particle size is probably not really critical for downstream equipment. I don't know. I'm not a fuel designer, of course, but just an assumption.

CHAIRMAN WALLIS: So this is an initial shock, that you would not want to back flush the filter because when you clean it, you get that new --

MR. ZIEGER: You create your bypass again.

CHAIRMAN WALLIS: Yeah.

MR. ZIEGER: That's also the reason why I think, yeah, some systems which are moving continuously are difficult.

CHAIRMAN WALLIS: About, yeah, right.

MR. ZIEGER: Okay. I think I already

mentioned this during my discussion. That's what you saw in this diagram, above about a quarter of an inch equivalent fiber bed thickness. The bypass is more or less constant.

Size of perforation has more or less a linear influence. The test procedure does not really hardly influence what comes out, and of course, I'm always talking about bypass. I'm not talking about head loss here.

And that's also a conclusion, and we made other tests. The test I showed you was always at the same flow with the same approach velocity.

Of course, we did other tests with varying flow. That means approach velocity, and with approach velocity or with a higher flow, the delta P, the head loss varies.

And the conclusion was out of this testing -- unfortunately I don't have a diagram to show the data points, but to reduce the bypass, the reduction of the screen size is not the best idea because due to the smaller screen your flow is constant. The water flow is given. The licensee tells us how much water he has to feed to his reactor. So water flow is given.

But if you reduce screen size necessarily

you reduce the water velocity because the flow has to go through a smaller area. So you increased water velocity, which increases head loss, which increases bypass more proportional or over proportional.

That means our observation was if you reduce screen size you get even more fiber. Of course, you have to test with the same amount of water. So if you reduce the screen, we have to increase the flow to have sustained situation.

If you keep the flow, then it's clear. Then you reduce it. It's a simple thing, but that's not reality. In reality if you reduce the size, you have to increase flow, and this makes it even worse. That was at least our observation. I don't know if somebody else made different observations, but we did this because one argument was, okay, then let's reduce the screen size. No, it doesn't work.

And this you have seen. The size of (unintelligible) the screen is small.

Chemical. Some chemical tests. Of course, it is a different issue, and I must say I'm a mechanical engineer. I'm not a chemist, and for this chemical test we need a lot of advice from chemical people, and if you ask me something about how they made this precipitant and what they mixed, sorry. I

cannot really tell about it, but I can tell about how we make the test.

Now, we did small scale and large scale test with chemical precipitates because these tests were done already about three months ago. It was not done at that time on our multi-functional test loop because this was not available at that time.

CHAIRMAN WALLIS: Now, number two is very important. The chemical particulate generator is the loop itself.

MR. ZIEGER: Yes.

CHAIRMAN WALLIS: The chemical reaction is happening in your loop.

MR. ZIEGER: Yes.

CHAIRMAN WALLIS: You're not putting in this artificial --

MR. ZIEGER: And that's also the reason why we need the experts, because we didn't want to put some strange things in our loop without knowing what happens or you'll get chemical reactions. You'll get changes in temperature. It gets warmer. It's heated up a little bit, not significantly, and therefore, we needed advice from specialists, and they tested it before, outside the loop where they put the stuff together and look what happened and how much falls out

and how much you need to create so many and so on.

And then we use these data which were generated by the experts and put the chemicals directly into the loop. Those precipitates were developed in the loop.

And of course, because of these chemicals --

CHAIRMAN WALLIS: You run it for a whole year to find out what happens.

(Laughter.)

MR. ZIEGER: No.

MEMBER KRESS: They drop the temperature.

MR. ZIEGER: We run it longer than usual for a head loss test, but of course --

CHAIRMAN WALLIS: Well, this is an interesting question though. The chemistry depends on the temperature, and your temperature is low.

MR. ZIEGER: Yeah.

CHAIRMAN WALLIS: Okay. Yeah, how you have two scaling factors. This is the usual scaling factor which has to do with the screen size, flow rate, and the other debris like particulate fiber, et cetera, but for the chemicals, of course, you have to take into consideration that test bed volumes to reach the same concentrations like you have in the plant.

So these are two different scaling factors.

And of course, both have to be met. So the flow rate is given by the geometry, and then the amount of chemicals which are added to the loop are given by special volume and necessary concentration.

And then what I explained also, all of the chemical experts from Salsa Innotec did a lot of investigations before they could start with the test. For example, they looked at the influence of tap water compared with the real water chemistry because we cannot test this reactor water with all of these ingredients. So we are using as a basic fluid, of course, tap water, and then they looked at this influence.

And so the outcome of this investigation was we can use tap water. We don't have to use the de-ionized water with all of these chemistries.

Then surrogate material. As I mentioned before, we use only one. We use only this stone flour as a surrogate for painting, and they also looked at this and they compared it, how it dissolved in boric acid, and the outcome was the same. It's usable.

Then with integral chemical tests we mean all what was needed to create the precipitates we wanted to have based on this other medium, and these

were several chemicals. I think five or six or seven. All of this was put into the test loop during the circulation with a very straight order. They told us exactly at this time you have to put in this and this amount and 20 minutes later this and this and that, and we were also all the time under observation of this chemical guise.

Yeah, and what they did in their laboratory, for example, mixing before we did the test because the test is relatively expensive if you bill this whole pool, and if it doesn't work, you waste a lot of money. If the ingredients really mix together, if it works, they found out how many of these chemicals they had to put together to get this other medium precipitant which we wanted, and so we played with the pH barrier, viscosity.

That's the loop again, but that's a picture for all future chemical tests. As I said, this test we are talking about, although I will give you some results was made on our large scale test loop, but all that are coming now will be done here, and this with the function test loop, and I already explained the test model here.

The plate to create vertical flow because in one of the locations of the customer we have a wall

relatively close to the strainer, and then this is almost filled with debris or with RMI, and of course, it's a different if the water can come from here or if it has to go down all the way to the bottom of the strainer that we built in this.

And here is a kind of -- I don't know how to call in English -- a kind of rectifier kind of mixing plate to create a turbulent flow after that one year to guarantee a good mixing.

So these are some data. That's a fail to surface approach velocity, and with fail to surface I mean the whole surface, the whole pocket area. That was 0.0117 foot per second.

The fiber loading or the debris loading, it was like you see here. It was fiber, Transco stuff and glass fiber, but it was also zinc dust and this is the surrogate that we are using, stone flour, and it was RMI.

And the equivalent fiber bed thickness was about 0.05 inch, which is not very much, and the test was performed at ambient temperature. This is the text matrix. All of this here is chemical stuff.

CHAIRMAN WALLIS: I'm surprised by the amount of zinc dust. Is that a right number, a correct number? The zinc seems to be the biggest

component strain.

MR. ZIEGER: Yes. That's why in this case for this plant it is the case. It is the biggest thing, the zinc dust, and when you actually circulate it when you do the test, the water is almost gray because the zinc dust is very fine stuff, and with this testing you never get this if the circulating more or less continues.

And then some of the results. This was a test which has the same debris and the same chemicals like these two tests. The only difference between these two lines and the red line is here we put all together or we put the RMI together with the rest of the debris. So these are viable with the same test. Altogether was mixed and put not, of course, at once, but mixed batch by batch into the loop.

The side is this, and you see the increase in head loss due to chemicals because this is without chemicals here, zero, and this is with what they call 140 percent. One hundred percent is what they really expect in their plant, and of course, nuclear, all kinds of activity, that's clear you always do more than you have to do. So we tested up to 140 percent.

CHAIRMAN WALLIS: Excuse me. Does this pressure drop change with time as the chemical

reactions happen or is this -- this is some time you're plotting here presumably.

MR. ZIEGER: No, that's not the time here, but --

CHAIRMAN WALLIS: No, no, no. But this must be some time after putting --

MEMBER KRESS: Each point, each point must be here.

CHAIRMAN WALLIS: Does everything come to some equilibrium or what has happened?

MR. ZIEGER: What we did, we had a certain criteria. How long we waited to put the next batch --

CHAIRMAN WALLIS: Is a termination criteria.

MR. ZIEGER: A termination criteria.

CHAIRMAN WALLIS: Something is leveled off.

MR. ZIEGER: And this was for this test, was relatively strict. As far as I remember, it was at two percent per hour, which means one percent per 30 minutes.

CHAIRMAN WALLIS: Nothing much is happening.

MR. ZIEGER: Yeah, and then when it was stabilized, we put in the next batch, and then it

makes -- it takes some time until it arrives, et cetera, but then it goes up.

Okay. Now I might say it was not really a surprise that this line was so low because RMI makes mainly porosity, and porosity is good.

MEMBER KRESS: So RMI is helpful, right?

MR. ZIEGER: Yeah. Then we did another test, and this test was not with chemicals. That's why it is here on the zero line. We wanted to find out what is more conservative, the original paint stuff or the stone flour. For this test we used original stuff, and these are the two data points. The lower one is without RMI. The bigger one is with RMI. And the green ones are with surrogate, and as a conclusion for the chemical tests number three, four, five we used this surrogate material because it was conservative, because higher than the original one.

And a surprise again, but not really a surprise, here we have again such bore hole effect. Without RMI we were here. After adding the RMI, we measured the lower head loss.

Here it was the opposite, and here, here, and here the RMI was added at the end. This test number four was done without RMI. So up to here it was exactly the same, but for test number five, we put

the RMI on top of it, and in this case it increased the head loss.

But I think what this curve shows us, it's a relatively good repeatability of statis -- of course, they are not exactly the same, and I think there are a lot of influences in how it distributes and the strainer itself. It's more or less by accident, but it's a fairly good repeatability, I think, and especially -- of course, it's by accident, I think -- but if you look at the 100 percent point, it was exactly the same for both tests, the 100 percent chemicals and the head loss increased from 1.7 foot water column to about 2.2.

Of course, if your allowable is here, that is a significant thing, but usually the allowable is somewhere up there, and then I would say it's not really critical. It depends very much on what you have available.

It is an increase of about how much is it, 1.2 to 2.2? That is about 40 percent or so, but compared with a lot of it, it was not critical. And due to the huge amount of RMI, as I mentioned, the strainer, again, is fully submerged under the RMI, and here's a test model that was removed, and you see a lot of RMI inside the pockets.

And this test was a test without RMI. The quality of the picture is not so good, but here you see all of these it looks like -- I don't know -- like dust mat. It looks very muddy there inside.

Okay. Some conclusions, but due to the very limited number of tests, these conclusions might be a little bit of speculation.

this statement, of course, has very much to do with what you have available. What is your allowable NPSH? In this case allowable was far away. We could state it's not significant, but it was a 40 percent increase. So it can be significant. It depends very much on your situation.

Repeatability at least for the two tests which we did was exactly the same condition, the same flow, the same debris, the same chemicals. Repeatability was, in my opinion, good, and that's also not a big surprise. If fibers and particulates are -- sorry -- and RMI is mixed, you will reduce your head loss, but I think that that's more an ideal role, but I can imagine a reality in the plant. At first the fiber comes because it swims best, and at a very, very late point in time maybe some RMI is coming. I think this situation you will probably not have in reality in the plant.

Debris preparation methodology, fiberglass, transfer mat, stone flour, zinc filler, and RMI.

We do at first -- the pictures are not very nice in quality -- we do at first mechanical, mechanical -- how do you call? -- dispulsion (phonetic). We put it in a leaf shredder, you know, what you use in your garden. Put it and double it and then it comes out, and then after shreddering it, we put it with the watershed, with the high watershed.

We mix it until it looks like this, but we don't cook it. We didn't -- up to now we didn't cook the fiber and the Transco material.

I don't know if cooking is really needed. It was always agreed with our licensee because they know our procedures. They know the specification. We do it that way, and it results into very fine stuff. I think proof that it is very fine was our analysis of the bypass, with most of the materials smaller than one millimeter.

That's the same for (unintelligible) for the Transco material after treating with the watershed, and that's the RMI. Okay. That's more or less crunched.

CHAIRMAN WALLIS: That's in a leaf

shredder, too, or something else?

MR. ZIEGER: That is a kind of leaf shredder, too, yeah, and in the beginning we cut it more or less with a kind of knife and then some people were fitting it, and then we found the company who does it for us in a kind of leaf shredder.

It's not really a leaf shredder. It's a little bit different device, but it makes these kind of pieces, and then what we also do, we sort them by size so that we don't have only big ones. We have a certain mixture between big ones, smaller ones, smaller ones.

So briefly in production methodology was already mentioned. Simultaneously, which means accept with IV plate. Usually we put it in at the end, which is probably closest to reality, but all of the rest, zinc dust or particulates, et cetera, are mixed in batches and then put into that, in batches mixed already, except the chemicals. The chemicals I explained before. Chemicals were put in after the debris was put in.

Now, this tends to lead to the closest uniform, but uniform can never be reached with the vertical. It is always done with a test configuration.

And debris settling not credited, it was all the wish of our customer or the licensees to be conservative. As I told you several times, we dump it directly in front of the strainer.

Now we do some tests for another customer to find out what the transportation mechanism really is.

So I think that's all. That's my last slide.

Termination criteria, that was not the simplest thing up till now because everybody had a little bit different idea how they want to have it. What I deleted here are all of the different customers. These are all different tests for different customers, and we have really a huge variety of termination criteria. I think the most complicated is this one, which means as long as the head loss is in a band between zero and half a feet, to go to the next step of testing we waited 20 minutes and maximum change was six percent. Then for the next step of head loss, half an inch to one inch. Again, six percent, but the time was double. That means this is an early quote which gives you really a comparison that is percentage per hour.

then it went down to nine percent per hour

change or gradient, and finally when the head loss reached one foot and the buff determination for the area was two percent per 60 minutes or one percent for 30 minutes, but two percent per hour.

but you see it varied. It was different. We mainly did what our customer asked us to do, but I think for future testing and for the normal functional test loop, we will use -- if we can choose determination criteria, we will go to the quantity of one or two percent per hour.

CHAIRMAN WALLIS: I think the only problem with termination criteria may be with some of the chemical effects tests where some chemical effects take time to develop. Otherwise it's probably okay.

MR. ZIEGER: Okay.

CHAIRMAN WALLIS: Thank you very much.

MEMBER MAYNARD: Your modules, once they're installed, are they permanent or can they be removed if you need access for maintenance or --

MR. ZIEGER: yes, they can be removed. It's a modular design, and the modulars could be removed, but this takes more effort because you have to disassemble it, but the cartridges, we call it the cartridge. A cartridge is two rows of pockets in one piece, and you can handle it without any crane or any

additional device. Maximum weight is about 40 kilos or 80 pounds, and this can be removed by hand, and then you get Xes, for example, to this channel. Then you could inspect inside the channel if needed or if you need Xes to your Section 9, whatever. It can be removed without cutting or without reevaluating. It's only assembled.

MEMBER BONACA: Well, they must be protected from blow-down, I mean.

MR. ZIEGER: Yeah. It depends also very much on the situation in the plant. Sometimes we have a kind of roof covers this strainers for protection if something comes from above, for missile, missile protection.

MEMBER BONACA: Yeah, or blow-down during a LOCA.

MR. ZIEGER: Yeah. But it depends very much where this -- of course inside the strainer we don't have this, and with one installation, but in the other installation where it goes a little bit around the containment, we have a kind of roof on top of it. It depends.

CHAIRMAN WALLIS: Everyone is looking at me.

MEMBER KRESS: Well, you're the man.

PARTICIPANT: You're the man with the gavel.

MEMBER KRESS: You're the man with the agenda and the gavel.

CHAIRMAN WALLIS: We're going to take a break if there's no more presentation. Are you going to make anymore presentation or this is --

MEMBER KRESS: That was it.

CHAIRMAN WALLIS: Finished.

MR. ZIEGER: That was all that I prepared. I can --

CHAIRMAN WALLIS: That's fine.

MR. ZIEGER: I can talk another three hours about that if you want.

(Laughter.)

CHAIRMAN WALLIS: Does the committee have any desire to ask anymore questions or more explanations?

MEMBER BONACA: It was informative.

MEMBER KRESS: I thought it was very clear and informative. Thank you very much.

MR. ZIEGER: You're welcome.

CHAIRMAN WALLIS: Thank you.

Well, now we're ready to take a break, take a break 15 minutes.

PARTICIPANTS: 20 minutes.

CHAIRMAN WALLIS: Well, let's come in at 10:30 then. Ten, thirty is easy.

MEMBER KRESS: Yeah.

CHAIRMAN WALLIS: Ten, thirty is still ahead of schedule. So we'll break until 10:30.

(Whereupon, the foregoing matter went off the record at 10:06 a.m. and went back on the record at 10:34 a.m.)

CHAIRMAN WALLIS: We're not going to hear from the ACL about their work on strainers, and we're looking forward to it. So please go ahead.

MR. FISHER: My name is Nigel Fisher. I am the testing lead on the CLO strainers, and with me I have Dr. Dave Guzonas, who is a reactor chemist, who is going to be helping me out when we get to chemical effects test.

We're following the same outline that the other vendor followed. We'll give a discussion of the scaling methodology, how we prepared debris, how we introduced debris into the test sections, what we're planning to do on chemical effects because we have no started the chemical effects testing yet, what we've done on bypass testing, what the determination criteria is for head loss test, and --

CHAIRMAN WALLIS: Where does this term come from? Does it come from the NRC?

MR. FISHER: The termination criteria?

CHAIRMAN WALLIS: Yes.

MR. FISHER: I don't know. I guess the NRC is going to --

CHAIRMAN WALLIS: Universal.

MR. FISHER: -- various standards.

DR. LU: Shan Lu with ESS.

One of the issues we raised there, you can express our expectation during our meeting with NEI. That's right.

CHAIRMAN WALLIS: Thank you.

MR. FISHER: And then I'll show you some jobs in what we call our reduced scale facility and some results from what we call our large scale facility.

First of all, I'd like to spend a few minutes on the concept of our strainer. Our strainer is what we termed a thin strainer. The straining surface is sets of fins and they are attached to --

CHAIRMAN WALLIS: Presumably two-sided fins?

MR. FISHER: That's right. Two-sided fins. Each side is perforated metal, and the fins are

attached to a collection header which then meets into the plumb.

So it's a modular design. We customize the size of the fin and the pitch of the fin for the various applications, and fins can be horizontal as those are or vertical.

We have a model here. I'll show you some features of it. This is a mock-up, an instrumentation of a horizontal fin. So it's two pieces of corrugated, perforated metal, and corrugated to increase the surface area, and so the water comes in on each side of the fin and then flows through the channels that are formed by the corrugations, and the corrugations also give us strength to resist collapse of the fin.

And then we have end caps at the end where it goes into a header, and then there are orifices in the header to balance the head loss, a key strainer condition to have the same water entry in the fin that's furthest from the pump as entry to the fin that's closest to the pump.

Once the fins are attached into the header, then there are structural ends on the ends and tops of the fins to give the structure resistance to hydraulic loops. We have to pull the fins in place

during seismic events. That's always the challenge.

We test in two facilities, in Chalk River and Ontario. We have what we call a reduced scale facility and there we test a section of two or three fins. They are full sized fins, but we call them a reduced scale because we're only logging two or three fins for the whole strainer.

We do testing here if we want to try to optimize the strainer area, optimize the fin pitch, and that's where we plan to do our chemical effects testing.

By optimize strainer area, it's essentially a head loss test. For us it's looking at the thin bed head loss to determine how much area we need.

MEMBER KRESS: Fin pitch, that's the spacing between the two plates?

MR. FISHER: That's right. The fin pitch is the spacing, and there we're controlled by the full debris load. You want the fins far enough apart that we have the interstitial volume to accommodate all of the fiber. We don't have too much encapsulation. We do allow encapsulation to a certain degree.

Then our large scale facilities are really for proof testing for each customer, and there we test

a whole module, which would be typically between eight and 16 fins. So it's really just a larger scale version of the reduced scale facility.

MEMBER KRESS: Is CANDU a head loss problem.

MR. FISHER: Yes. We installed this type of strainer. So rather than being corrugated, they were flat plates at that point and call of the CANDU reactors in the late '90s and early 2000 brought that up. The CANDU industry is looking at right now though chemical effects. That was not addressed the first time around, ad so David here is doing work on the chemical effects for CANDUs.

This is a photograph of the reduced scale facility. It's essentially a plastic tank about 90 inches diameter, and you see a test module sitting in there, which is three fins attached to a collecting header, and these fins are actually modeling the RS portion of the Surry strainer for Dominion (unintelligible) Surry plant, and here the fins are about 30 inches long and about 12 and a half inches high.

And there are three fins, but the straining area we're modeling is that of two fins. The center fin has perforated material on both sides,

whereas the two outer fins are only perforated on the inside surface. So it is two fin spaces of a model.

We make every attempt to get all of the debris introduce into this tank on the strainer. So we have a stirrer that is knocked on the side of the --

(Short loss of electronic transmission.)

MR. FISHER: So we put baffles around the strainer itself.

This is a thin bed test. So we have a baffle at the back of the header so the curve of the flow doesn't sweep under the header and come up against the fins, and then we have baffles on each side of the outer fins. So, again, just so we don't get turbulence flow coming under the test section.

And then we have a baffle at the front of the fin so that we don't have turbine eddies come in the front spaces.

So the fin test, the flow path into the fin spaces is either from the top or it can come in from the sides because there the baffles are an inch or two back from the side of the fin.

CHAIRMAN WALLIS: Well, this is somewhat unrealistic. In the plant either you have turbulence or you don't, and you don't have these baffles, do

you, in the plant?

MR. FISHER: That's right. Yeah, the baffles are to give us laminar flow close to the strainer. The turbulence is to --

CHAIRMAN WALLIS: It's a mix, but in the plant you won't have all of those conditions at the same time. You might have turbulence or you don't, and if you have it, then the baffles aren't there. So presumably --

MR. FISHER: You don't expect to have turbulence in the plant. the purpose of turbulence is just to stop settling of the debris.

These are the characteristics of that facility. It's 1,500 gallons. It's a simple nuke. We operate up to just under 100 gallons per minute, and we can work up to 120 Fahrenheit. We use service water, which has a little bit of suspended solids in it when we get it, and as I said, we use a stirrer to mix the water, keeping turbulent conditions to maintain the suspension of the debris.

We have two large scale facilities.

CHAIRMAN WALLIS: Is it true that the term "crud" means Chalk River unidentified debris? Is that true?

MR. FISHER: We'd like to think that.

(Laughter.)

MR. FISHER: I don't know if it's true, but it's certainly written down at Chalk River that it's true. We don't have crud in these tests, I hope. Well, I guess we do really.

We have two large scale facilities. We call them Rig 42 and Rig 85. The difference is that 85 is taller, which we have built to test taller strainers.

The test section that's installed in Rig 42 on the left is a large scale model of the Millstone 2 strainer, which would be a horizontal strainer with fins that are about four feet long and three feet tall.

MEMBER KRESS: They look like --

MR. FISHER: Sorry?

MEMBER KRESS: It looks like a large pitch on those.

MR. FISHER: Yes, it is. It's a ten inch pitch. It's also with all of the fibrous debris. So we have a big spacing on the fence.

And here we have baffles at each end of this module to simulate the position of the next fin on the next module. Because we want all of the fibrous debris we had in here to have to pack into the

area of the one module.

On the left we have a vertical type strainer there for one of the French plants. So there the flow once it gets into the fin is down into a header that's on or a plenum that's on the floor and then across the sump pit where we are doing a similar thing for Millstone 3.

Here are the characteristics of these two rigs. Sixty-five hundred gallons and 8,000 gallons, respectively, but issued the same way. Higher flow rates, the same temperature ranges, and originally the same water.

CHAIRMAN WALLIS: I'm assuming the water temperature in the room doesn't get to 120.

MR. FISHER: No. We have heaters to heat it up and cool it. At this time of year it's not bad. You bring the water in at about 60 Fahrenheit and heat it to about 204 Fahrenheit. In the winter you could bring it in in about 40 Fahrenheit and have to heat for overnight to get it up to 104 Fahrenheit. So our tests are going faster now than they were in wintertime.

Here's the forward yield of the licensees. We have two U.S. clients, Dominion where we have six plants, four designs. The Surry plants will be very

close to each other and so will North Anna, and we're also putting in a strainer for South Carolina Electric and Gas, the VC Summer plant.

The RS means that we're doing reduced scale testing. So Dominion has chosen to do reduced scale testing to try and make the strainer smaller than were originally predicted by using NUREG calculations, and so we've first of all used the testing to try to remove any conservatism that was in NUREG, and then where that still doesn't get it down small enough to show that removing various types of debris, the more difficult particulates like calcium silicate or microtherm to reduce the strainer even further.

And so we finished that sort of testing for Millstone 2 and for the Surry design. We are currently doing North Anna testing, and we will be doing Millstone 3 testing in September.

VC Summer has chosen not to do that sort of testing. We are going directly into the proof testing in the large scale facility. There we're using a strainer which is the largest that could fit within their pit, which is slightly larger than the NUREG size.

We've done large scale testing for

Millstone 2. Next month we'll be doing Surry, and then the following month Millstone and North Anna.

Chemical effects testing. We're going to start some benchtop testing in the next few weeks and get into chemical effects testing in the fall and then fall off in the winter.

We have down there that chemical effects testing is not required right now for VC Summer, and that's based on computations that Dave has done for the amount of chemical precipitates that are predicted to be present in VC Summer. It's a very small amount, and we hope to be able to show with debris testing that we don't need to do chemical effects testing for VC Summer.

However, if we show this small amounts of precipitates do cause a larger pit, then we'll have to reconsider that decision for VC Summer.

Here's an overview of the design parameters. So all of the Dominion plants are mixed fiber and particulate beds. Surry has very little fibers, mostly particulate. North Anna has a large both. Millstone 2 was heavier on particulate but a lot more fiber than Surry, and Millstone 3 is sort of in the middle ground as well. VC Summer is an RMI plant with a very small amount of fiber.

The hole size that both clients wanted was one-sixteenth of an inch. So that's what we're using for their designs. We used one-eighth of an inch for the CANDU industry and three-thirty-seconds in France because, in general, there has been a drive by clients down in hole size for time.

The available NPSH margin as shown there is really the allowable. That's how much of the larger --

CHAIRMAN WALLIS: Do you still use these English units in Canada?

MR. FISHER: No, we don't. So that's why you'll see in the last column I have approach velocities, and they'll be in meters per second because I can understand that a lot better than the feet per second.

Yes, so we're bilingual on units as much as possible.

And you can see that the strainer areas are quite large, and that's because they're being controlled on area by a thing bed effect that we're observing. The ones that don't have the approximation sign in front of them are the decision has already been made that that will be the size.

And then on top of what's there will be

also some additional area, a sacrificial area for labels and text. The ones that still have the approximate size, that's what NUREG is saying the size will be, and we have to confirm that by testing.

CHAIRMAN WALLIS: Stainless steel?

MR. FISHER: They're all stainless steel.

CHAIRMAN WALLIS: I guess that's true of all manufacturers.

MR. FISHER: I think so. So we're really increasing the price of stainless steel because we're sucking it up around the world, I think.

The approach velocity is of interest in the last column. You'll see with Millstone 2, which I'll show you some results from later, has a lower approach velocity than Surry, and we see the effect of that in how thick the thin bed is. We find that with lower approach velocities, it takes more fiber to form the thin bed than with high approach velocities.

These are some pictures of the reduced scale test sections. On the left we have the section for Millstone 2, and that's in a thin bed test result. You can see there's a brown thin layer covering, all of the thin surface, and it's about a quarter of an inch thick. It's thicker on the top of the accordion section due to gravity, but we still do get sticky to

the bottom because of the flow of water coming in.

And then on top of that, you can see some patches of yellow. Those are additional fiber deposit after we had already formed a thin bed. So we're not picking up any particulate in that additional fiber addition, and so the stain yellow.

The one on the right is Surry. There because we need a very large surface area and there's very little fiber in the plant, we've put the fins very close together. The pitch is four inches. So it's a two inch space, and the test there is both a thin bed and a full debris test all in one.

The first report on the thin bed and then we add in the additional fiber until all of the fiber is present. So you can see that with this technique of stirring the water, and we also brush the bottom during our full debris load test to try to maximize the settlement of debris on the test section rather than on tank bottom. We are getting the majority to settle on the test section.

We get more to settle on the Surry test section. I believe that's because it's a higher approach velocity than for Millstone 2.

We use the same scaling methodology that all of the vendors are using, which is we adjust the

available head loss by the ratio of the dynamic viscosities of our test temperature and sump temperature to give us what we call viscosity corrected allowable, and then we compare our test results to that viscosity corrected allowable.

CHAIRMAN WALLIS: Presumably when you heat the water, sometimes air is involved, is it?

MR. FISHER: That's right. Especially in the winter, a lot of air comes out of the water. So as our heating procedure, we overheat by 10 degrees Celsius and then we back that off so that we're below the saturated gas conditions. Otherwise gas bubbles will tend to (unintelligible) large solution and --

CHAIRMAN WALLIS: If you have enough pressure drop in the screen, you can get bubbles in there.

MR. FISHER: Yeah, that's right. Even with a low pressure drop as it squeezes to go through the hole you get bulk coming out, and that can knock off fiber and you can't pour it through that because the air bubbles are not enough.

If the vendor, if the clients could actually use that as a way of keeping their --

CHAIRMAN WALLIS: That works when it's a thin bed. If you have a thicker bed and you start to

get bubbles, then it actually can lodge inside the bed and increase the pressure drop.

MR. FISHER: Yeah, I guess it can become --

CHAIRMAN WALLIS: Stuck in the middle itself.

MR. FISHER: The particular problems we had before we started, overheating and cooling, especially in wintertime, was that the initial fiber deposits would start to collect and the air bubbles would form.

CHAIRMAN WALLIS: And they would get buoyant, and then they would go to the top and the bubble bursts and they fall down again.

MR. FISHER: Yeah. You'd come in and all of your fiber was floating whereas before it was on the thin.

CHAIRMAN WALLIS: So if you have chemical reactions in there that make bubbles then this would also happen.

MR. FISHER: That's true.

Here's the other case where rather than being a thin bed we have a four degree load. Here we do allow in some designs some level of encapsulation, and so that encapsulation forms a bridging layer on

top of and in front of our vents.

And here we get head losses that are greater than what NUREG would predict for this condition because of the encapsulation effect, but this is not the controlling case for our area. So head loss --

CHAIRMAN WALLIS: NUREG would predict if you used the full area of the screen.

MR. FISHER: That's right.

CHAIRMAN WALLIS: So encapsulation is your term for circumscribed.

MR. FISHER: That's right. But on the left is Millstone 2 and on the right is North Anna. For Millstone 2 we're allowing a layer of up to six inches height to form on top of it, whereas for North Anna we're allowing a layer of about three inches height.

CHAIRMAN WALLIS: What is that, something floating on the left there or what is that?

MR. FISHER: Yes, that is some of the Fibrex debris. Again, we don't boil or bake our debris, and Fibrex narrow wall is very difficult to wet. So that would be skimmed off and re-pressure washed and put back in with the next.

CHAIRMAN WALLIS: Okay.

MR. FISHER: So that's a little bit of floating debris there.

So debris types. We have RMI in all the plants. At the Dominion plants it's a small amount. In North Anna -- sorry -- in VC Summer it's a very large amount. Transco RMI Foil is what we're using. That's a stainless steel in all cases.

For fibers we've been using mineral fibers for Knauf. For Millstone 2, mineral wool, both a Fibrex brand and a Poroff (phonetic) brand, which is a European brand, and various types of fiberglass, Nukon, TempMat, Cerafiber, Thermal Wrap.

For particulates, we've come up against calcium silicate, Marinite and Microtherm, and coatings both qualify and unqualified.

The surrogates we're using, currently we're using walnut shell flour as a surrogate for our coatings. We started with silicone carbide, and we found that because that particle was so heavy -- it's 187 pounds per cubic foot -- it would tend to settle out rather than come to the strainer and be picked up by the fiber. So we could not form a thin bed when we were using silicone carbide.

We switched to walnut shell flour because its density is much closer to that of paint. It's 81

pounds per cubic foot, and so it stays suspended much easier and makes its way through the debris bed.

For asbestos, we've been using a dense fiberglass. For latent fiber we've been using fiberglass as a surrogate, and for latent particulate we're using walnut shell flour again.

A few slides here on debris preparation. These will show RMI being prepared for the Dominion tests, and as the other vendor showed, we make it in various sizes from half inch by half inch up to six inches by six inch, and then it's crumpled.

For Dominion where it's relatively small amounts, it's done by hand, but for VC Summer, we've had to go to a mechanical process to do it.

So here are some examples of what we're preparing currently for VC Summer.

CHAIRMAN WALLIS: Have you heard of this MIN-K stuff?

MR. FISHER: I've heard of MIN-K. We haven't tested it as part of the U.S. program. It's similar to Microtherm. It's a microporous.

CHAIRMAN WALLIS: Apparently it's pretty potent as a head loss producer.

MR. FISHER: Yeah. So is Microtherm. In fact, the Dominion plant that has Microtherm, they're

going to have to take it out in order to have a strainer fit in containment.

Here we mechanically crumple by putting the small pieces through a wood chipper and the large pieces through a leaf shredder.

Here are some examples of fiberglass. This is after it's being put through a leaf shredder to shred into small pieces. We have Paroc on the left, which is a type of mineral oil, and the Paroc and the Fibrex tend to have a lot of particulate in them. I guess it's from the process in which they're made.

We have Cerafiber in the center, which is a fiberglass, and it's like cotton balls. TempMat on the right is another fiberglass, but here the strands are much longer. It's more like horse hair.

Later in the process after we wet the stuff, then we use a pressure washer to break the fibers down to smaller clumps and more fibers.

Here are some examples of particulates. The walnut shell flour that is purchased in a ground and sized --

CHAIRMAN WALLIS: What is walnut shell flour used for normally?

MR. FISHER: I'm not completely sure, but

I think it's used as a supplement to soil in some cases.

MR. BLEIGH: I think they also use it as like a sandblaster, like sandblasting.

CHAIRMAN WALLIS: Oh.

MR. BLEIGH: Jim Bleigh with PCI.

MR. FISHER: And on the right there is calcium silicate, which has been broken up using a hammer mill to get down to a smaller size.

CHAIRMAN WALLIS: Is this the same calcium silicate which is in CalSil insulation?

MR. FISHER: Yeah, this is modern CalSil which would have a little bit of binder which is known asbestos, and it's made by Johns-Mansville.

CHAIRMAN WALLIS: So it's similar to real CalSil?

MR. FISHER: That's right. Because we switched from silicon carbide as our particulate to walnut shell flour, we wanted to do some work on characterizing walnut shell flour. So we have some histograms here of particle diameters that were measured using SEM for --

CHAIRMAN WALLIS: The walnut shell presumably has quite different chemistry than these others.

MR. FISHER: Yeah, it's --

CHAIRMAN WALLIS: Organic material.

MR. FISHER: It's organic, but it's considered inert, and we've done tests to see whether it breaks down over time and found it doesn't in the wire temperatures that we're using, and we've done tests to show that it doesn't clump together or flocculate, and we've done tests to show that it doesn't soak up water with time.

And we will have to before we get into chemical effects testing look at the effect of boric acid on it.

On these graphs here you can see that material from two different suppliers is quite similar, but the mean size is larger than for the silicone carbide that we are using. You can purchase silicone carbide with a mean of ten microns, ranging from about two to 40 microns. Here the finest mesh size walnut shell flour you can buy; the mean is about 20 microns and it ranges from two to 65 microns.

I have a couple of slides here on how we introduce debris into the test tanks.

CHAIRMAN WALLIS: It doesn't clump up at all in this walnut shell flour? There's no kind of --

MR. FISHER: No, we've done tests, beaker

tests, and it doesn't clump up, no.

CHAIRMAN WALLIS: Nothing like regular wheat flour then. Wheat flour is terrible. You make flour paste out of it.

MR. FISHER: I think that's because the wheat flour is absorbing water, and the walnut shell is not absorbing water.

CHAIRMAN WALLIS: Has gluten and stuff. No starch in it?

MR. FISHER: Well, it's an organic. So it probably have lots of different things. I don't know what those are, but --

CHAIRMAN WALLIS: Oh, it has lignens and all kinds of stuff. Well, leave that to the chemists.

MR. FISHER: Yeah.

MR. GUZONAS: I don't think there's anything leachable in the walnut shell because it's the external part. It's not part of the fruit itself.

CHAIRMAN WALLIS: It's more like wood, isn't it? Cellulosic. Okay.

MR. FISHER: So our procedure for what we call a thin bed test, which others would call a high particulate test or low fiber test, is we mix up the particulate and we add that to the test loop first and have that circulating through the test loop, and at

first it's all going through the holes in the strainer and going through the loop, and then we prepare the batches of fiber, and we prepare those in a one-sixteenth inch theoretical bed thickness per batch, and then we add the fiber in batches, and we wait between additions for the pressure to stabilize with that amount of fiber in it before we go on to the next addition.

CHAIRMAN WALLIS: What you're assuming is that there's enough particulate to fill the gaps in the fiber because of sillital (phonetic) fiber? That's what gives you your thin bed?

MR. FISHER: That's right. So what we typically find is that one-sixteenth of an inch we will capture some particulate, but we won't capture it all. The water will stay cloudy. When we go to one-eighth of an inch for Surry and North Anna, we find that we are able to capture all of the particulate, but it takes a long time to do it.

Here's some photographs of mixing and adding particulate and then fiber. So in the upper left we've already mixed up the walnut shell. That's why the water is that brownish color, and here we're adding CalSil. This would be a Surry test.

And then on the upper right we are now

adding that particulate into the tank, and you can see it's going in as a brown, soup-like mixture, and we put it in by buckets over towards where we have the stirrer. So it gets disbursed across the whole tank.

Then in the lower left we have our batch of fiber after we've added it to water, mechanically stirred it, and then used a pressure washer for at least two minutes to break up the fibers. What we have here is a combination of Thermal Wrap, Cerafiber, and TempMat in that addition there, and then again we add that as shown in the lower right in buckets under the water surface and putting it over towards the stirrer so that it gets mixed up and disbursed around the tank.

The re-addition is slightly different if we're looking at the full debris load case. Here we use RMI, whereas we don't use RMI in the thin bed test, and to start with once we have flow stabilized, we drop the large pieces of RMI between the fins, and then we mix the particulate, the fiber, and the small pieces of RMI together in batches, either 25 percent of the total or ten percent of the total, depending on how much total fiber we have to add, and then we add those batches to the tank.

And between additions and periodically

after we have all additions in, we brush the bottom of the tank to re-suspend any fiber and particulate that's dropped on the suspension to encourage it to transport to the test section.

I jump now to debris introduction to the large scale test, and large scale is just a larger operation as compared to the reduced scale. So rather than mixing in a bucket, here we're mixing in a pool, in ground pool that we use as our mixing tank, and you can see that on the left.

And this is a fiber addition in this particular test for a thin bed test, but rather than using all fresh water, we pull water out of the test tank to mix the fiber in, and that's why the water is brown, because we already have the particulate in the water, and then we've added the first debris addition there.

And I think a word that someone used yesterday to describe this is it's like oatmeal, the mixture, and you can see that the greenish type of fiber is floating more than the yellowish, and that's the Fibrex which is more difficult to wet.

And then we pump this up into the tank using a sludge pump, and that's what we're showing on the right, it being pumped up into the tank.

And we put it into the tank --

CHAIRMAN WALLIS: It's like oatmeal. Oatmeal, this is oatmeal before it is cooked. Oatmeal cooked is pretty goopy.

MR. FISHER: Yeah, this is before it's cooked, when it's clumps of goop and --

CHAIRMAN WALLIS: Yeah, but cooked oatmeal is really pretty stiff stuff. You don't get to that constituency, surely.

MR. FISHER: No, we don't.

Now, as I said, we haven't started chemical effects testing yet, but the purpose of that would be as a bump-up factor to determine the increase in debris bed head loss due to the chemical reactions that form precipitates, and our intent is to do that in the reduced scale facility with the water in that facility having the appropriate pH and the appropriate boron concentration.

CHAIRMAN WALLIS: Do you let the chemical reaction occur in the loop itself?

MR. FISHER: Right now our plan is no. I've argued against that. As a mechanical engineer, I don't want chemistry taking place in my loop. It seems to be too uncontrolled as to what's happening.

CHAIRMAN WALLIS: Well, that's the whole

point. There's the whole question about how the precipitate forms and does this make a difference to its actual nature and how it fills up the pores or whatever it's going to do.

MR. FISHER: Right, and so in reality it would be nice to start with the loop very hot, put the chemicals in and then lower the temperature of the loop, the time, and precipitates form, but we're going to be running a constant temperature. One hundred and four Fahrenheit is what we normally use, and so what we're proposing to do is to first start with a benchtop program to show that we can on the benchtop at least form precipitates that look or can be characterized like the ones that the WCAP calls for.

And then if we can do that, then we want to add chemicals done that way or precipitates done that way to the test tank, and the idea would be to first form a thin bed on the test section and then produce the precipitate in a smaller tank and then add the precipitate from the smaller tank into our test tank and observe the increase in head loss.

So that's what we're negotiating right now with our clients, is that approach.

CHAIRMAN WALLIS: Well, you're saying observe increase in head loss. You're actually going

to observe the head loss, whatever it does, right?

MR. FISHER: Right, right.

We have done some bypass testing. WE've done these as a separate test. We've done tests to look up fiber bypass, and we've done separate tests to look at particulate bypass. When we're looking at fiber bypass, we only added the fiber to the tank. When we're doing the particulate bypass. We put the latent fiber in with the particulate, and the major way that we're measuring and coming up with results is by taking grab samples from the pump line and then filtering that and drawing the filter paper and then weighing filter paper to determine the total bypass as a total suspended solids.

And then in limited cases we are then taking pieces of the filter paper and cutting them down and putting them under an SEM/EDX and using that to identify types and sizes of the debris and to actually count fibers to determine the fiber bypass.

Here's a typical result from Millstone 2 testing.

CHAIRMAN WALLIS: What's the length of that strangely coiled --

MR. FISHER: There's a bar at the bottom which is one millimeter.

CHAIRMAN WALLIS: Yeah, but what's the length of that thing that's sort of a squashed figure eight.

MR. FISHER: Yeah.

CHAIRMAN WALLIS: What's its length? Is its length the --

MR. FISHER: In the order of one millimeter.

CHAIRMAN WALLIS: Is its length when it's stretched out? That's what you mean by length?

MR. FISHER: That's a good question. We'll ask Dave here. He actually --

MR. GUZONAS: The length is the stretched out length.

CHAIRMAN WALLIS: Stretched out length. Okay.

MR. GUZONAS: So it's measured in segments.

CHAIRMAN WALLIS: Okay.

MR. FISHER: On the right is a histogram of fiber lengths, and the results are similar to what other vendors we were talking about this morning, which is that most of the fibers are a millimeter or less in length, 80 thou. We do see a small number of fibers as large as two millimeters in length, but the

vast majority of them are less than half a millimeter.

In this particular test we added the fiber in ten increments, and we measured the bypass before we started adding fiber, and then between each increment of ten percent we put more and more fiber into the test loop, and then we measured the fiber -- sorry -- the bypass for an additional five turnovers of the loop after all the fiber was in.

And this particular sample I show here is half of the third turnover after all of the fiber was in.

On this page here we show the fiber concentration at each of the five turnovers after all of the fiber was in, and you could see us going down with time. These numbers here were calculated by the SEM results, actually counting up the fibers and then coming up with weight by calculating the volume of fibers from the lengths and diameters and multiplying by the particle weight of the fiber.

This is the result of a particular bypass test. Here we ran for many more turnovers and the results here are from time zero. At time zero we added in the particulate, and then we added in the latent fiber, and so time zero is how much particulate was circulating through the system before the fiber,

and the next data point is once the latent fiber is added and we have data points and turnovers --

CHAIRMAN WALLIS: Taking a long time to come out.

MR. FISHER: It took a long time to come down, but it does come down with time.

The turnover for this test was 15 minutes. So we went to 172 turnovers, which was 40 hours. It came down significantly over time, but we can't say how much of that is from debris capture on the latent bed and how much is from settlement of the circulating particulate.

Here's a typical test result for a thin bed test. Focus on the pink line, please. That's the head loss measured over time, the time scale on the bottom. It's 48 hours, the whole test from one end to the other, and I think it's seven divisions. So each division is about seven hours.

CHAIRMAN WALLIS: But it's going up because you keep on collecting more particulates. Is that the idea?

MR. FISHER: Yeah, but we have several behaviors here. At first we have a slight increase. The fiber addition went in right here.

CHAIRMAN WALLIS: Whatever you do, don't

write on the screen.

MR. FISHER: No, it's turned off. Actually it might be a laser printer. There you go.

CHAIRMAN WALLIS: Okay. That's all right, fine.

MR. FISHER: So the first five additions right here, and for the first addition of one-sixteenth of an inch we only wait an hour and a half. So we see --

CHAIRMAN WALLIS: You keep adding fibers now? Is that what's happening?

MR. FISHER: Yeah. Here, and an hour and a half later we added a second sixteenth of an inch, and we had a little S curve as that fiber accumulated on the screen, and then once it accumulated on the screen, then we have this linear behavior here as we're slowing picking up the particulate, and that went for over a day to slowly raise the head loss from around .2, about .1 or .2 psi all the way up to over 1.4 psi.

Finally at this point here we get a curve and then a stable region as we've soaked up all of the particulate we can.

CHAIRMAN WALLIS: That leap up is because you change the flow rate or something?

MR. FISHER: Yeah, and then we have another debris addition here.

CHAIRMAN WALLIS: Add some more stuff.

MR. FISHER: Add more stuff, and here, this is the Surry test section, and here we get quite an increase as we put that third one-sixteenth in. I believe it's because the pins are so close together that it's really more of a confinement effect than a debris capture effect. At this point here the water was very clear. You could see right to the bottom of the tank, and here we don't have this linear portion. It quickly stabilizes. So that's why I think it's a different behavior.

And then we have that once more here as we go to a quarter inch. At this point all of the fiber that is present in the station is in. So that's the total head loss. For Surry it's a combination of a thin bed effect, and then a confinement effect.

And we ran a test a total of two days, 48 hours. So it takes a long time to capture all of the particulate.

Our termination criteria is similar to everybody else's. We go with a five percent change within three tank turnovers, which in this case for Surry a tank turnover was half an hour. So it's one

and a half hours.

But what we tend to run up against more often is the no general increase. So along the way here we may have hit the five percent criteria, but we still had a general increase in trend. So we would allow it to keep going.

There's what the debris on the test section looks like at the end of one of these tests, and the majority of the debris has settled on the fins or between the fins, just under 90 percent, and I see that in the photo in the left, and then the photo in the middle here, once we drained the water from the test section, the debris bed has come off of the test section, and it's composed of two different parts, the dark, thin bed which had been pressed up against the fin and then the additional fiber deposits from that third and fourth addition which had just squeezed into the gap between the fins.

On the right-hand side --

CHAIRMAN WALLIS: Did you do anything with these sort of felted layers afterwards? Did you examine them in some way?

MR. FISHER: At this point, no. We just take this level of photographs of them. We have two pieces lying on a cloth here on the right. The piece

in the upper left-hand part of the photograph is lined such that the part of the bed had been up against the thin surface is upwards, and you see that's very dark because there's a lot of particulate in it.

CHAIRMAN WALLIS: There's no impression of the perforations on the --

MR. FISHER: Yes, there are.

CHAIRMAN WALLIS: I don't see it, but there is in reality?

MR. FISHER: In reality there is.

CHAIRMAN WALLIS: Okay.

MR. FISHER: You can see where every hole was.

CHAIRMAN WALLIS: I expect you would, but you don't. It's not shown in the picture very well.

MR. FISHER: No. And then the other piece of fiber which is in the lower right, again, it's lined with the thin side up, but you can see on that one the less dark area where it's the additional fiber that we put in after we had already soaked up all of the particulate.

MR. CARUSO: So does this mean that you think you formed the thin bed of fact on top of an existing --

CHAIRMAN WALLIS: Underneath.

MR. CARUSO: On top or underneath?

MR. FISHER: Underneath.

MR. CARUSO: Underneath.

MR. FISHER: Underneath. These pieces are turned over.

CHAIRMAN WALLIS: Now, they made a sandwich, but the thin bed is against the filter, isn't it? Isn't the thing bed against the strainer?

MR. FISHER: Yes, and then we have additional fiber on top of that from the third and fourth --

CHAIRMAN WALLIS: And you could probably lay down another thin bed if you wanted to keep going.

MR. FISHER: There's debate upon whether you can. It depends on how well the particulates migrate.

CHAIRMAN WALLIS: Right. That's right.

MR. FISHER: To go through the fiber.

CHAIRMAN WALLIS: That's right.

MR. FISHER: The smaller the particulate, the further they'll travel through the fiber.

CHAIRMAN WALLIS: Since they're so difficult to separate out in one pass, that means that they go through.

MR. FISHER: They go through multiple

times, yeah.

CHAIRMAN WALLIS: That's right.

MR. FISHER: And what we find is that it takes time to filter them all out because first you're picking up the larger ones and they're making the bed more dense and allowing the bed to collapse down and become more of a dense bed, and then you start picking up the finer ones.

CHAIRMAN WALLIS: It presumably means that a slurry of particulate is going through the reactor.

MR. FISHER: That's right.

CHAIRMAN WALLIS: And we assume or we hope that nothing happens to them as they go through because of the heating or anything like that or what is going on in there.

MR. CARUSO: But you didn't look at the morphology of the pad, did you?

MR. FISHER: No. No, we haven't.

Here's a comparison of a thin bed test result to the NUREG correlation. On the horizontal axis we have the theoretical bed thickness, and on the vertical axis on log scale is the head loss, and the lower curve is called fiber only. There the only particulate we have there is the suspended solid that comes in in our service water when we pull onto the

pipes, which at this time of year was about 0.8 ppm. So that's what causes the head loss on that curve.

The upper curve is the head loss for the reactor condition.

CHAIRMAN WALLIS: The head loss is bigger than the NUREG or what are you saying?

MR. FISHER: In this case the head loss is 30 percent less than the NUREG. There are three test points there and --

CHAIRMAN WALLIS: Because it's a log scale.

MR. FISHER: It's a log scale, and NUREG is about 1.3 PSI.

CHAIRMAN WALLIS: Okay. So that's the NUREG with the particulates.

MR. FISHER: That's right, and that straight portion there is where it's cut off by the thin bed effect and then --

CHAIRMAN WALLIS: And then it falls down again?

MR. FISHER: -- the sludge compression.

Sorry?

CHAIRMAN WALLIS: It actually comes down?

MR. FISHER: It comes down.

CHAIRMAN WALLIS: If you distribute the

particles throughout the whole bed.

MR. FISHER: That's right.

CHAIRMAN WALLIS: Okay.

MR. FISHER: Yeah.

CHAIRMAN WALLIS: Once the thin bed is there, it's there forever.

MR. FISHER: That's right.

CHAIRMAN WALLIS: So you continue flat.

MR. FISHER: Right. If you can design a strainer that avoids that thin bed area, then you can have a smaller strainer.

CHAIRMAN WALLIS: Or you can get more fibers to arrive early or something.

MR. FISHER: Right, and with our testing we haven't been able to prove that we can get away from that.

CHAIRMAN WALLIS: I'm not quite sure how you managed to get a NUREG thin bed effect because I thought the NUREG couldn't predict thin bed very well. Maybe that's only the Los Alamos test they couldn't predict very well.

MR. FISHER: Well, the current formulation of NUREG has a cutoff. It used to go asymptotically up as you went with less and less --

CHAIRMAN WALLIS: You have to put in some

number though for the area, for the unit volume of the particulates.

MR. FISHER: You have to put in numbers for the --

CHAIRMAN WALLIS: So you determine experimentally or by doing a head loss tests. So it's sort of circular, isn't it?

MR. FISHER: Well, what's required to get that straight line across is the sludge density. How tight will this thing pack? And what we're using in this is numbers from the NEI-0407 guidance.

CHAIRMAN WALLIS: You also need a surface area of unit volume for the particulate. I mean a particulate size or something.

MR. FISHER: Yes, you do, yeah.

CHAIRMAN WALLIS: And you're putting in the particulate size that you measured or are you putting in the particulate size that correlates the data?

MR. FISHER: We're using the average particulate size of what we measured.

CHAIRMAN WALLIS: So that's pretty good because usually folks actually claimed that it doesn't work too well because the effective particulate size is different.

MR. FISHER: The particulate in this test is all walnut shell flour, and we put it in as being 20 microns diameter with 23 where we measured it.

CHAIRMAN WALLIS: Well, maybe it behaves better than CalSil in some ways.

MR. FISHER: Sorry?

CHAIRMAN WALLIS: Maybe it's better than CalSil perhaps.

MR. FISHER: Yes.

CHAIRMAN WALLIS: In terms of correlating.

MR. FISHER: Yes. When you have CalSil in, we're not near as close. In fact, we're over predicting. We're over measuring in some cases. We're measuring above what we're predicting, and perhaps we're using too large a particle size in our predictions.

MR. CARUSO: You have particle sizes for the walnut shells dry, right?

MR. FISHER: Yeah.

MR. CARUSO: And they don't absorb any water and swell?

MR. FISHER: We've done swelling tests on them. It's less than five percent increase.

MR. CARUSO: So you've actually measured sizes before and after, size distributions dry and

size distributions wet?

MR. FISHER: No, our swelling tests weren't quite done that way.

Dave?

MR. GUZONAS: What we did, because it was easier and also we thought that doing an SEM measurement of the particle size after wetting it would actually dry it out --

MR. CARUSO: Right.

MR. GUZONAS: -- was measure the volume in a narrow tube of the wetted and dry materials. So it was a sedimentation volume measurement more than anything.

We would leave it sit for 24 hours, 48 hours, 72 hours and simply measure the volume of the walnut shells, a fixed mass of walnut shells as a function of time, and there was no noticeable change in volume.

It was a well packed, initially dry mass of walnut shells. We then wetted it, let it sit as a function of time, and then we heated it to see whether heating the walnut shells for a certain period of time would increase the volume as well, and there was no change.. That was the only way that we believed we could do the measurement without introducing an

artifact from drying the particles again.

MR. FISHER: There are three points on this curve here. It's from one test, but it's the three one-sixteenth inch additions, and here we found it took three-sixteenth of an inch for Millstone to form a debris bed.

We actually went to a fourth and fifth addition after that, and the head loss is increasing only due to the additional fiber, and you don't see an increase on a log scale.

CHAIRMAN WALLIS: But on a log scale the pressure drops when you put the particulates int. It's 100 times bigger than it is the fibers alone.

MR. FISHER: Yeah, and it's a very sharp drop from the thin bed regime to the mixed bed regime.

CHAIRMAN WALLIS: And it's a big difference, a big factor. Talking about a factor of 30 to one or something.

MR. FISHER: Yeah, over an order of magnitude change.

CHAIRMAN WALLIS: But it's really striking if you look at the fiber. You've got a factor of 1,000 from fibers alone to fibers per thin bed when you're down at a quarter of an inch or something.

MR. FISHER: Here are some pictures at the

end of a full degree load for Millstone 2, where we allow it to what we call encapsulate, and on the left-hand side we still have water in the tank there, and you can see how clear it becomes even in this case. We do filter all of the particulate out, but it's not a high head loss because the particulate is distributed over a much larger volume of fiber, and you see it packs in between the fins.

Now, the design here you can see in the center quarter graph. We have a support structure between the fins we call ladders to hold the fins apart during a seismic event, and those form a barrier under the full debris load even though there's wide spaces in them. The fiber bridges those spaces.

So we get heavy packing of the fiber in front of those ladders, but we don't get heavy packing back behind them. We have cavities, but then we get a bridging effect across the whole top of the strainer where we're bridging across ten inch gaps, and we end up with this big, thick layer on top.

When we're doing a full debris load test, we remove the baffle that's at the front of the strainer to allow the fiber to tumble out the front end as it would in reality. So we do get some debris in front of the fins as shown on the right-hand side.

Here's a head loss curve for the full debris load case, and here, again, is time scale and the pink line is head loss, and you see more of the traditional S curve here where things stabilize much more quickly than in the procedure we're using for thin bed.

The test here ran for -- started at 9:00 a.m. and ended at 5:00 p.m. So about nine hours, and we waited until we had a stable head loss over an hour and a half at the end there to terminate the test.

So overall the head loss here is much less than in the thin bed case.

CHAIRMAN WALLIS: It's a log scale though. So that's --

MR. FISHER: No, the head loss is a linear scale.

CHAIRMAN WALLIS: Oh, okay.

MR. FISHER: Sorry. Used a log scale on the left-hand side to show the other parameters.

And here's some pictures of the thin bed test done in the large scale rig for Millstone 2, and we formed a bed very similar to what we saw in the reduced scale break away, a brownish thin bed attached all over our strainer, and then lumps of fiber on top of that from the later fiber additions once we stopped

picking up any particulate.

You can see that some of the bed has fallen off on the left-hand photograph. On the left-hand photograph we drained the water down about a foot. The black you see between the fins there is the top of the water layer, and you can see that the thin bed has peeled off the very top of the fin.

And it's almost like a chalk substance, the thin bed for Millstone 2. There's so much particulate in it that it's very hard to see the fibers. And you can see that some of the fibers have collected on the ladders.

Now, this is the other case for Millstone 2 where we put all of the fiber in. Now, the top photograph here, end of test cover all, and you can see the water is pretty clear, but you can't see the strainer because there's a stainless steel plate over top.

The client has asked for us to provide a cover over the strainer so that they can use it as a lay-down area during outages, but not drop things down in there that they have to then retrieve.

So we are testing under this load condition with this cover in place because it will add some confinement for this case, and we have to show

that our pressure loss stayed low enough.

So then along the bottom I have three photographs of the strainer once the covers are moved. The center one is looking at the center pins, and there we can see there are two cavities behind the ladders, and then the right and left photographs show the outer fins on each end, and there the fiber had piled up, all the way up to be touching the underneath of the cover in two locations.

The cover was nine inches above the top of the fins.

So a summary of our key observations. We are finding that our surface area is being determined by thin bed, but the amount of real estate we take up in the reactor, what we call footprint, is determined by how far apart we have to put the fins to handle a full degree load.

We're finding that the measured head loss is comparable to the NUREG predictions, and as I mentioned before, we find that it takes more fiber additions to form a thin bed when you're at lower approach velocities.

And the fiber bypass, we find that what's bypassing is short fibers.

CHAIRMAN WALLIS: Let me ask you about

this thin bed. In this thin bed, when Los Alamos did tests with thin beds with CalSil, they got some somewhat anomalous results where the pressure drops versus flow rate would go along on some curve, and then it would suddenly leap up by a factor of maybe size ten at some flow rate where something has changed in the structure of the bed, and you couldn't say that it was a thin bed. It was something that was actually not just a thin bed effect. Something fundamentally seemed to be changing in the structure of the bed itself.

You haven't observed anything like that?

MR. FISHER: No, but we haven't done that sort of test where we're changing the flow rate.

CHAIRMAN WALLIS: Because their flow rate is much bigger than yours. Maybe the velocity through the bed was higher or something.

MR. FISHER: We're running at a constant flow rate and --

CHAIRMAN WALLIS: Yeah, but even so --

MR. FISHER: And the one odd thing that we have seen is our thin bed tests where we have calcium silicate in there, we've seen that the head loss has increased to a point and then started to fall off slowly, and we're attributing that to perhaps the

CalSil is continuing to break down into smaller pieces, and then going right through the strainer, but we don't have the evidence to support that.

But I would certainly think with CalSil it's a more complicated bed than without.

CHAIRMAN WALLIS: And then when they tried to correlate it, what they did was they changed the specific area of the CalSil, passed the test in order to correlate the data, which means that they didn't have a very good predictive tool perhaps.

MR. FISHER: Right, yeah. When we're using --

CHAIRMAN WALLIS: We haven't heard anything from any of these experiments in the last couple of days, which seem to show this sort of anomalous result.

MR. FISHER: When we're using CalSil in our predictions we say it's a five micron size, the average size from NEI-0407, and we're finding for both surry and North Anna that our measured head loss is going above the prediction in those cases.

And that could be a reason, that the actual outlet is small.

CHAIRMAN WALLIS: What is your superficial velocity through the bed typically? It's very low I

think, compared with anything they did.

MR. FISHER: It's low compared to anything. The upper range of what we're testing when we're testing a real strain of the sizes we're doing is smaller than their smallest number when they're deriving the correlation.

So to finish off here, obviously if we have no fiber bed, all of the particulate is bypassing, but we did find that the latent fiber was sufficient in the test we did there to capture some of the debris. So we can't differentiate between capture and settlement.

And that's everything.

CHAIRMAN WALLIS: Very good. Thank you very much. So we don't need to see you this afternoon?

MR. FISHER: Unless you come up with additional questions, which I hope not.

CHAIRMAN WALLIS: Well, that is a good sign and a bad sign if there are no questions.

MR. FISHER: I'll take it as the --

CHAIRMAN WALLIS: The good sign might be that you did a great job. A bad sign might be that no one was interested.

MR. FISHER: Yeah, that's right. I think

being the last one, all of the questions have been answered.

MEMBER MAYNARD: From my perspective it would be a good sign because I thought it was a good presentation.

MR. FISHER: Thank you.

CHAIRMAN WALLIS: Yes, I thought it was a good presentation, too.

Are there any other observations from the committee? Are you ready to take a break?

I think we ought to take a break until about one o'clock. Would that be appropriate?

MEMBER KRESS: Let's do that.

CHAIRMAN WALLIS: Or do we have to have -- are we allowed to start with Tim Andreychek at one o'clock?

MR. CARUSO: I think so.

CHAIRMAN WALLIS: You think so or you actually confirmed that that is --

MR. CARUSO: We didn't actually publish the agenda in the Federal Register.

CHAIRMAN WALLIS: Okay. So we'll look forward to Andreychek at one o'clock.

MEMBER KRESS: Maybe we should never publish the agendas.

CHAIRMAN WALLIS: Okay. So we're ready. We're thanking everybody who presented this morning, and we're taking a break until one o'clock.

(Whereupon, at 11:47 a.m., the meeting was recessed for lunch, to reconvene at 1:00 p.m., the same day.)

AFTERNOON SESSION

(1:00 p.m.)

CHAIRMAN WALLIS: Tim Andreychek, telling us what's going on, where we are today.

MR. DINGLER: Somebody gets men who are actions, and as John says, we're not going to win the data war, but what we want to do is give you an overview of where we're looking at fuels.

What we have done so far in the field area with our data research and testing and that is to give you an idea where we're going and what we're seeing today. We're just getting started on some of this,a nd so keep that in mind as you go forward. We're on the initial stages and a lot of work yet to be done, but we think as you heard the last couple of days from the NRC and previously, we believe we have a path forward that we can minimize this approach for the majority of the plant for stuff like that.

So I want to turn it over to the Tim to give you the details.

MR. ANDREYCHEK: Thank you.

Good afternoon, and thank you for the opportunity to address this subcommittee meeting.

With regards to fuel valuations and downstream effects, the method presented in WCAP

16406-P, which was submitted to NRC for a safety evaluation, was used to evaluate collection of fibrous debris on components. The method assumed a very large capture efficiency of fibrous debris on the first fuel components in the flow path, and by large, I'm talking about a 95 or so percent capture frequency. Sometimes --

CHAIRMAN WALLIS: First fuel component, do you mean the debris catching plate?

MR. ANDREYCHEK: The bottom nozzle? Yes, the bottom nozzle which had in it the debris capturing device, and it's approximately accurate for all three fuel designs, whether it be the former Combustion Engineering, the AREVA design, or the Westinghouse design. The fuel capturing device is right down there.

CHAIRMAN WALLIS: Now, we hear this morning or yesterday and this morning that what gets through these strainers is often the very short fibers, less than a millimeter maybe, and I doubt if they would be captured. I mean, you say fibrous debris. You mean the longer fibers, don't you?

MR. ANDREYCHEK: Well, you are correct, and when we wrote the WCAP and we wrote the methods described in the WCAP, we did not have bypass data

from sump screens at that point in time. So what I'm talking about is where we are today with the methods that were defined in that particular WCAP, and I'm going to lead you to where what we're looking at moving ahead and moving forward. Okay?

And, again, the second sub-bullet we assumed that the fibrous debris mattered like those forms on flat screens with the large fibers.

The NUREG 6224 head loss correlations used to conservatively address head drop across this fiber bed, and based on this approach, relatively small amounts of fibrous debris would result in the prediction of thin bed effect pressure drops, very large pressure drops with a very small amount of fiber.

And this particular method was used to evaluate all PWRs for fuel blockage for the submittals that were given to NRC to Generic Letter 2004-02.

MR. DINGLER: And if we were good in the screening and everybody passed, we shouldn't be back up here talking to you.

MR. ANDREYCHEK: That's correct.

There has been some initial testing with the specific debris mix in fuel assembly geometry that showed that the fibrous debris did not mat. I think

you saw that yesterday. And, therefore, the NUREG CR-6224 correlation over predicts pressure drop for fibrous collection on the bottom of the fuel. It's our conclusion that additional valuations are needed to refine the analysis while demonstrating significant margin to overheating the core and also to address certain phenomena in more detail.

CHAIRMAN WALLIS: To go back to this statement, "Fibrous debris does not mat," do you mean that it does not collect?

MR. ANDREYCHEK: It does not compress in a tightly formed mat.

CHAIRMAN WALLIS: So it does collect.

MR. ANDREYCHEK: Yes, yes.

CHAIRMAN WALLIS: And presumably it captures particulates within it.

MR. ANDREYCHEK: If the particulates are moved up in their --

CHAIRMAN WALLIS: But it's the particulates which are most likely to bypass.

MR. ANDREYCHEK: That's correct, and I believe the data that you saw yesterday included particulates with that fiber matting, and as a consequence, again, the hydraulic forces associated with the flow going up into the core -- remember that

fuel assembly -- did not have enough hydraulic energy to compress that combined particulate --

CHAIRMAN WALLIS: Really because the flow rate is so low.

MR. ANDREYCHEK: That's correct, sir.

MEMBER BONACA: But some of the data shown by Alcion yesterday showed if you had chemical, some chemical effects may cause the --

MR. DINGLER: That's one area we should have looked at, Tim.

MR. ANDREYCHEK: And, in fact, it's a valid point and addresses the phenomenon in more detailed. One of them is chemical effects. That's what we're looking to do moving forward.

We're looking at blockage at the fuel inlet, local blockages or hot spots, and we know that crud does collect on fuel assemblies at certain locations and chemical effects and what it would --

CHAIRMAN WALLIS: Probably any sort of very fine chemical precipitate is the kind of thing which would get through the strainers, too, and get through perhaps the areas which don't have fibers on them.

MR. ANDREYCHEK: Correct.

CHAIRMAN WALLIS: Which is very, very

fine.

MR. ANDREYCHEK: Yes, yes. Looking ahead, using as our guidance, we're going to take a look at 10 CFR 5046 for long-term cooling, and these quotes come straight out of 5046.

The calculates core temperature shall be maintained in an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactive --

CHAIRMAN WALLIS: Are you talking about the extended period of time? We heard this morning about one year. How long is this extended period of time?

MR. ANDREYCHEK: We looking at the 30-day period of time that we've been using --

CHAIRMAN WALLIS: -- just to keep the core cool.

MR. ANDREYCHEK: I beg your pardon?

CHAIRMAN WALLIS: You'd have to keep the core cool as long as it's there.

MR. ANDREYCHEK: Correct.

CHAIRMAN WALLIS: Until you remove it or do something else.

MR. ANDREYCHEK: That's correct.

CHAIRMAN WALLIS: So this could be a much

longer time than a month.

MR. DINGLER: Keep that question. We've got a slide in there which shows that after about 40 hours our flow is very varied and it keeps going down because decay heat goes down. So keep that in mind. We understand. So we're trying to get the area where it's most crucial to us, and then decay heat takes away or the amount of water goes down considerably.

CHAIRMAN WALLIS: Sure.

MR. ANDREYCHEK: And our success criteria is demonstrating sufficient long-term core cooling that we insure sufficient flow to remove decay heat relative to Mo's comment just a moment ago in maintaining a coolable core geometry.

There is a PWR project. The objective to do this, the project objective is to develop methods and evaluations to show the acceptance criteria for long term core cooling are met. We're going to look at blockage of normal core flow paths and assess the need for flow, how much flow is needed to remove decay heat.

We'll look at localized build-up of debris and hot spots at grid spacers due to -- and due to plate-out of chemical effects. The chemical effects we're going to also be looking at are precipitates and

plate-out on fuel.

Any questions?

CHAIRMAN WALLIS: Now, plate-out is an interesting question.

MR. ANDREYCHEK: Okay.

CHAIRMAN WALLIS: How are you going to do that? Heat up some zirc and flow stuff by it and see what happens or what?

MR. ANDREYCHEK: First we have a tremendous amount of information about what the chemistry is of certain things inside the reactor as it stands right now. We're going to use that as a basis to build on. Whether or not we need tests is yet to be defined, but we're going to take a look at what we know about the chemicals that are currently in the reactor mix.

CHAIRMAN WALLIS: So starting from the beginning really with this plate-out question?

MR. ANDREYCHEK: We're going to look at where we -- what we know right now today and then build from there as necessary to address the questions.

We've identified several tasks under this project. The tasks have been scheduled such that they address areas of uncertainty and vulnerability,

confirm long-term core cooling capability and take advantages of lessons learned from previous work.

The way we've scheduled the work is to look at the blockage of normal core flow paths, the localized build-up, and then coincident with that chemical effects on long-term cooling capabilities.

With regards to blockage of normal core flow paths, we want to demonstrate long-term core cooling with significant blockage at the core inlet. When you demonstrate that there's sufficient flow to remove decay heat, that this is due in part to cross-flow within the core that will allow redistribution of the flow to remove decay heat such that the peak clad temperatures are local and moderate.

CHAIRMAN WALLIS: Is there boiling occurring in this core?

MR. ANDREYCHEK: It depends on the transient that you're looking at. If it's a cold leg break and it occurred -- the block of the core occurs early, there might be boiling at the upper elevations of the core.

If you're dealing with a hot leg break, then all of the ECCS flow runs through the core. then you might have a little bit of subcooled boiling early in the transient if it occurs early. I have two

photographs and I'll address that in just a few moments.

We'll look at effects of degradation of cladding oxide layer, hydrogen embrittlement of the cladding, and accumulated diffusion of oxygen within the cladding micro structure. I don't think that that's going to be a significant issue given that the core has already been quenched, but we'll take a look at it.

We'll neglect alternate flow paths into the core if such is flow through the baffle barrel region in feeding the core, and the goal here is to cover all Westinghouse and AREVA fuel pipes.

this is the diagram that Mo mentioned a few moments ago. This shows minimum SI flow requirements for a four-look PWR. You can see from the trend that the amount of flow that's necessary decreases rapidly following the initiation event. At ten hours it's only 200 gpm that's required to remove decay heat. At 30 hours it's about 150 gallons per minute.

CHAIRMAN WALLIS: Is this gallons at normal temperature? I mean, the gallons are room temperature?

MR. ANDREYCHEK: That's correct.

MR. CARUSO: Is that assuming that that flow rate is boiled or just --

MR. ANDREYCHEK: This system may boil off.

MR. CARUSO: That's a boil-off.

MR. DINGLER: This is the career boil-off. These figures are actually out of the plan COPs. So when we did the bulletin for containment for --

CHAIRMAN WALLIS: This is all based on boiling it all away or what?

MR. DINGLER: This is to remove decay heat so you don't have boiling in your coolant.

CHAIRMAN WALLIS: So you don't have any boiling, and the decay heat goes to the whatever, some of the exchange.

MR. DINGLER: RHR heat exchanger, yeah. It can go from there.

MR. CARUSO: Wait a minute. So 150 gallons per minute is enough to remove decay heat without boiling the water.

MR. DINGLER: That's correct.

MR. CARUSO: To take it from whatever the injection temperature is to saturation temperature, liquid.

MR. DINGLER: Because once the core is quenched, you provide this much flow and push that

much out the outlet and go through the RHR and keep the core from boiling.

CHAIRMAN WALLIS: So it's just the delta T going through the core. It heats up from what, 100 degrees to 200 or something?

MR. DINGLER: Whatever, yeah.

MEMBER BONACA: At this time there's a circulation of flow, right?

MR. ANDREYCHEK: yes.

MEMBER BONACA: You're picking up and so the temperature, what's the temperature of the water?

MR. DINGLER: The temperature of the water would be, if you're actually feeding the water, would be the temperature of the containment sump at that point in time.

MEMBER MAYNARD: Typically you're varying your heat exchanger temperature to control your reactor temperature. So if the reactor is heating up, then you crank in more cooling. So you're not necessarily -- you're controlling the temperature of the water going in, but not really determining how much heat exchange is going on in the heat exchanger is what is your core temperature is.

MR. ANDREYCHEK: Any other questions?

For the cold leg break scenario, I share

this schematic. We're looking at some blockage down at the bottom. The flow path is from the ECCS flow down, up through. Again, as I pointed out and we discussed a few moments ago, there would be some localized boiling at the very top of the core after quenching, and the steam-water mixture would be going out the hot leg. You might get some condensation falling back the hot leg. The water might not make it all the way over the top of the steam generator.

And excess flow provided by the ECCS would be out the break. Again, when I look at this situation, we have limited ability to lift debris up into the -- either fibrous or particulate up into the core. The reason for that is that the velocities that you see in the lower plenum are matching boil-off.

MR. CARUSO: I'm confused now. This is boil-off or are you talking about -- I'm going back to that GPN Monday. Is that a boil-off number or is that a blow number?

I mean you remove a lot more heat when you boil something. Where's the heating going out? Is the heat going out as steam or is the heat going out as a liquid?

MR. ANDREYCHEK: The 200 gpm number, if I understand it correctly, comes from the EOPs, what you

need to remove decay heat. Now, if that's the hot leg break and you're moving decay heat, that's all you need is 200 gpm. If you're looking at a cold leg break, you need less flow, and you're going to be given that flow not by a pump, but by the difference in gravity head between what's in the core and what's in the downcomer.

And at that point you're not really going to be able to drive flow into the core unless you're going through injection in the hot leg.

So that number that Mo gave you is what you need to remove decay heat for a hot leg break.

MR. CARUSO: All right. I'm going to have to go do some calculations. I don't know the decay heat number at ten hours. That's the thing.

You think it's a boil-off. I think it's a boil-off number.

CHAIRMAN WALLIS: Though we were told it's a heat exchange number. It just heats the water up.

MR. CARUSO: Well, there's a big difference because if you have boiling occurring instead of --

CHAIRMAN WALLIS: A factor of ten difference or something.

MR. CARUSO: Oh, yeah. Okay. We'll find

out.

MR. HAFERA: Well, you have to recognize that as Mr. Maynard was saying, the decay heat removal heat exchanger is well over sized for the decay heat load at that time, and that's going to be controlled by the operator. So it really comes down to it's not quite important whether it's single phase flow or boil-off. An operator is going to adjust his system as needed if it's a hot leg break to remove the decay heat.

And the cold leg break, as Tim mentioned, is going to be self-regulated by the flow out of the break and the boil-off.

MR. CARUSO: Well, it does matter because if you have a liquid flow out of the core, then you're flushing debris out the break, but if you are boiling in the core and just removing steam, you're leaving all of that debris behind and you're concentrating it in the core.

So the phenomena are very different and the effect on the core coolability is very different.

MR. ANDREYCHEK: I don't disagree with you that in one case you'd be building up particulates or debris in the core, and you also will address that through hot leg injection or recirculation at the

appropriate time and flush that out of the core at that point in time.

And depending upon the plant, there's some variability in that time period.

Okay. For the hot leg breaks --

CHAIRMAN WALLIS: It looks like a boil-off to me.

MR. CARUSO: I just don't know what the decay heat number is.

CHAIRMAN WALLIS: It looks like 30 megawatts. We'll look at that.

MR. CARUSO: We'll look at it.

MR. ANDREYCHEK: Okay. Thank you.

For the hot leg scenario again, we're looking at the earliest time for blockage formation would occur at approximately 20 minutes after the large break LOCA when you switch over from recirculation or injection from the refueling water storage tank or the borated water storage tank to recirculation from the sump.

The flow rate into the core is determined by the ECCS pump capacity. Again, not looking at alternate flow paths, we have a little larger capability of -- a little more capability of moving fibers and particulate debris up in towards the fuel.

However, again, based on the information that was shared with you yesterday, there's still marginal ability to compact the fiber that's collected there, and I think what I would like to share with you is we do get a recirculation pattern behind this blockage, and I'll show you an example of that in a moment.

We have conducted some core blockage studies. The objective was to demonstrate that redistribution across flow, across fuel grids will be established behind blockage. The conditions were we looked at a 3,411 megawatt thermal reactor core. We studied four different blockages. Twenty percent of the fuel block -- this is right below the active length of the fuel -- deterministically didn't care what the blockage mechanism was. It just occurred. Forty percent, 60 percent, and 80 percent, and those are denoted by the different colored rings, 20 percent in the middle. The yellow is the 40 percent. Sixty percent is green, and the 80 percent is the blue.

We started and we assumed that the hot rod and the hot assembly was in the dead center of the core. So that gave us a maximum decay heat location to address.

And based on the current study sufficient

flow was provided with 80 percent blockage to remove the decay heat.

Next slide, please.

We used to find an element code to do this calculation. This is the core center line right here. The blockage was at the first elevation here, and what you see is the flow redistribution flow path running up through to the top of the core, being up here, and this stream line is the recirculation pattern that occurs directly behind the blockage that was assumed and shows you the lines of constant velocity.

Next slide.

The net results were that the majority of the core was minimally affected by the 80 percent blockage. Some boiling would occur above the blockage, but as the steam rises cooler fluid from the periphery would be drawn in laterally. Behavior was observed to be limited to the lower portion of the core.

We did a bounding calculation of super heat at the fuel rod surface and found that the upper bound was about 400 degrees Fahrenheit, which in turn was correlated to a clad surface temperature of about 600 degrees Fahrenheit. It's well below the 2,200 degree Dewey-Fahrenheit PCP limit.

MR. CARUSO: Are you familiar with historical staff practice with regard to the acceptability of allowing core heat-up during the long-term cooling phase of a LOCA?

MR. ANDREYCHEK: There's a letter that we just got from the staff that indicated that the long-term reheating capability or concerns would be addressed if we demonstrated that there was minimal bulk increase in temperature through the core.

MR. CARUSO: Is that consistent with the historical staff practice on this issue?

MR. ANDREYCHEK: I can't answer that.

MR. SCOTT: Let me add something. Mike Scott, NRC staff.

What's being referred to is a letter that was it Westinghouse or the owner's group submitted to us?

MR. ANDREYCHEK: Westinghouse.

MR. SCOTT: Westinghouse submitted to the staff asking for our interpretation of what those requirements you're referring to are, Ralph, and we responded noting the fact that the staff's practice in the past has been that there would not be any long term heat-up, and we indicated that we would be open to consideration of proposals that Westinghouse might

come up with that satisfied certain specific criteria regarding the longevity of the core. It was more or less to kind of put the ball back in their court to demonstrate to us that the fuel would not be damaged if we allowed additional heat-up, some small amount.

MR. CARUSO: So the staff is in the position now that it's changing its historical policy regarding this criteria.

MR. SCOTT: That's not what I said. What I said is the staff is willing for Westinghouse to advance the proposal if they can justify it.

MR. ANDREYCHEK: There have been some additional core blockage studies that have been performed. One was using the RELAP 5 code. It used a Westinghouse four-loop reactor core, reactor vessel flow areas, and loss coefficient data. The double ended guillotine break was assumed and analyzed in limiting the full condition for water being supplied to the core. The results were that no core reheat for blockages up to, and this is a little understated here. The actual total blockage considered was 99.7 percent at the beginning.

CHAIRMAN WALLIS: The .53 feet squared is the flow rate that's left?

MR. ANDREYCHEK: That's correct, sir.

CHAIRMAN WALLIS: The area that's still available.

MR. ANDREYCHEK: That's correct. That's correct.

The second evaluation that was done was using the TRACE code. It used the core inlet strainer in place from industry. Again, it was, I believe, Westinghouse input that was used for that particular calculation.

The core was divided into eight radial segments with four rings and 14 elevations. No bypass flow was assumed, and again, a double ended guillotine break on the cold leg was assumed with recirculation starting at approximately 1,200 seconds, and the initial results that were obtained were comparable to those of the RELAP 5 code.

The reason that I presented these was this information tends to support that we can get adequate core cooling with very small flow areas once we get out into the transient.

Looking at the localized build-up of debris and hot spots, again, to demonstrate long term core cooling with localized debris at fuel grids is acceptable. We want to assess the localized build-up of debris at spacer grids. How do we collect it?

We've heard over the last day and a half a considerable amount of information about debris passing through the screen of both fibrous and particulate. Look at actual conduction through the fuel rod as well as flow rates through the fuel. Demonstrate sufficient heat is removed to address local blockage concerns.

And the effects of degradation of clad oxide layer, hydrogen embrittlement of the cladding, and accumulated diffusion of oxygen within the cladding micro structure will be considered under these conditions.

There has been some additional work that was done in support of the VWR resolution of containment sump performance issue that was published in the NEA/CNSI/R(95)11, otherwise known as the Green Book. The adherence of fibrous debris to fuel rods was addressed in a particular section. They used a knife blade, steel heater rod or steel heated rods heated to 2,200 degrees Fahrenheit, quenched in a slurry of glass wool and associated insulation blanket materials.

What was observed was there was very little adherence of fibrous material to the knife blade or to the steel rod. If something did adhere,

it was due to the binder material that came with that insulation, and the binder material brought very limited fibrous material with it. And much of the insulation binder was driven off under normal operating conditions of the plant. The binder material is pretty much gone by the time an event would occur.

There is also a study of fibrous debris collection on fuel grids. The test conditions were looking at an unheated BWR bundle three meters long with three spacer grids. The flow rate was typical of a post LOCA natural circulation for boiling water reactors, and rockwool debris was used.

The rockwool was thermally treated to drive off the binder, and it was disintegrated by small steam jets similar to what some of the debris preparation was described to you over the past day and a half.

The observations were that the fibrous debris did collect in spacer grids, and there was some head loss associated with the increase of fiber collection. However, flow continued to be provided through the fiber bed. Again, it did not compress or compact due to the low flow rates running through the fuel.

MR. DINGLER: In addition, we do not know what the length size of those fibers were at this point. so we're doing some looking and saying was it the long three inch, four inch, whatever length or the five millimeters or whatever we came up with today in here on the bypass stuff.

MR. ANDREYCHEK: With regards to localized build-up and debris in hot spots, local fuel blockage in broad numbers has been studied under re-flood conditions. The full length emergency core heat transfer test program, 1970 and '71 looked at the blockages. The thermal hydraulic test bundles with balloon rods simulating re-flood phase of a LOCAl as reported in 1977 at the ANS meeting. I believe it was in San Francisco, and the flooding experiments with blocked arrays and a partially blocked 25 rod bundle, 1980 time frame.

The initial conditions were at the start of quench high decay heat; heater rod temperatures of at least 1,100 degrees Fahrenheit, maybe higher and various blockage configurations were studied as well as different refluc. rates.

The observations were that the presence of up to about 90 percent blockage in the fuel rod bundles themselves actually improved heat transfer

downstream of the blocked area. Due to increased turbulence in mixing of the fluids that move through the bundle, and although this doesn't apply to what we would necessarily be looking at, the break-up of a liquid phase droplets increasing liquid surface break further de-superheat the steam through the bundle.

The fundamental issue was that the blockages actually create a turbulence, which improved heat transfer in the fuel bundle.

Go back.

CHAIRMAN WALLIS: A different kind of blockage than fibrous blockage.

MR. ANDREYCHEK: I don't disagree with you, but the fibrous blockage doesn't necessarily form all at one time, and as it forms, you're going to get increased turbulence behind it because you're going to actually constrict the flow. Then it's going to expand up a little bit again. And that increase in turbulence will increase the heat transfer as the blockage arises.

MR. CARUSO: That's downstream of the blocked area, but what about in the blocked area itself?

MR. ANDREYCHEK: Well, I'm glad you asked that question. I appreciate you being a straight man

for me, Ralph. Thank you.

We're also looking at blockage, and effective blockage, at localized areas of the fuel. We've done a calculation so far, one calculation so far that looks at the blockage that forms in a grid. The highest power location was assumed, and the blockage was assumed to be circumferential all the way around the fuel rod in the middle of the grid, and no credit was taken for radial heat transfer to the blockage, i.e., it was a perfect insulator, and the conduction in the clad was in the actual direction.

The one calculation done so far is one blockage was evaluated and calculated temperature was sufficiently cool that clad integrity was not challenged.

CHAIRMAN WALLIS: So it's the fiberglass and the blockage presumably melts.

MR. ANDREYCHEK: If it were fiberglass at the temperatures that we're talking about, yes, it would.

MR. DINGLER: We're assuming that it melted or whatever and completely totally insulated.

MEMBER MAYNARD: From the tests that we've seen some of the results, this stuff doesn't seem to be packing. It seems to be wet, and I would think

even if you had some localized boiling there, that would actually start moving some of the stuff around, too.

MR. DINGLER: That's correct, and that's what we're seeing, too, but we just wanted to do a completely blocked area and see what happens to us.

MR. ANDREYCHEK: This is a bounding case, and we just wanted to do a bounding case to see where we're at.

Okay. Chemical effect. It's one of the three tasks that we've identified. We want to look at precipitation in particulate deposition on fuel surfaces and precipitation and in particulate deposition on non-fuel surfaces. It could restrict flow, including surfaces such as the reactor vessel inlet baffle region.

And finally, precipitation in particulate deposition in fiber beds formed from solid materials that pass through the sump strainers, i.e., fiberglass.

And again, part of this problem statement was written before some of the data that's becoming available now with regards to how this fiber material appears to be collecting on fuel assemblies, which is loose and flocky. It's not really compacting.

Another part of the chemical effects to demonstrate techniques, perform sensitivity analyses for the effects of pH and temperature on solubility of chemical precips, and to identify the influence of these parameters on key chemical reactions that would occur.

CHAIRMAN WALLIS: There is some concern that this stuff goes through the heat exchangers which are cold; that there would be precipitation in the cold region of the heat exchanger. Are you looking at that, too?

MR. ANDREYCHEK: I've looked at that from the integrated chemical effects test, and we didn't see a whole heck of a lot of that. Now, the precips that -- and if they do change and you do get some precipitation coming out --

CHAIRMAN WALLIS: And the cooling, yeah.

MR. ANDREYCHEK: Cooling, and that's always a possibility. That would tend to be diverted into the lower plenum of the reactor vessel. In some cases under very low flow conditions, it would tend to settle out there if you have a hot leg break.

CHAIRMAN WALLIS: Played out in the RHR.

MR. ANDREYCHEK: The velocities in the RHR system tend to be fairly high, and I would not expect

them to play out because the velocities are on the order of around ten feet per second.

CHAIRMAN WALLIS: Well, isn't there an ICET test? They got some played out in the piping, some white material, whatever it was?

MR. ANDREYCHEK: You are correct, and there was some I want to call it played out or some material that was deposited there. However -- and here's where the "however" comes in at. So please bear with me.

The material was noted after the test was shut down, cooled, and drained. So it's not clear that it was deposited during the test or if it occurred as part of the shutdown of the facility. That same type of deposition that was noted on some of the piping was also noted on the sides of the reactor that was used, the big 250 gallon reactor, and it was very lose and very flocky on the inside of the reactor vessel by and large, and some of it did come off fairly easy.

There was one test, I believe, that I think it had to do with fibrous material that got carried through and did bind a flow meter up, but it's not clear to me that the material that actually formed on the piping was due to precipitation because there

was very little temperature change. It stayed relatively isothermal.

CHAIRMAN WALLIS: We do know that when they cooled down the test, they did get the --

MR. ANDREYCHEK: Exactly, exactly, but that was also under stagnant conditions, and the water was sort of drained down gradually. So it's not clear to me.

MR. KLINE: And if I could also clarify from the ICET series, in ICET-1 you're correct. The scale seemed to occur. It was noticed on the tank in other surface areas after it was drained down. In ICET-3 there was what we think was a calcium phosphate that formed on the flow meter during the test and they shut the test down, I believe, around day nine or so to clean it.

MR. ANDREYCHEK: Yes.

MR. KLINE: All fine from NRR.

CHAIRMAN WALLIS: So it did form during the test. Well, did it form there because it was colder there or why did it form in the flow meter?

MR. KLINE: It probably wasn't much colder in the piping because it was insulated.

CHAIRMAN WALLIS: Because of the flow restriction or something?

MR. KLINE: I think we just generated a huge quantity of calcium phosphate initially, in the early part of that test, and some of it was carried downstream and collected.

MR. ANDREYCHEK: I would agree that there was a fair amount of that material that was generated, but it's not clear that what actually caused it to form on that roto-meter was the fact that there was a flow restriction and there was a good site for it to actually collect. I don't know.

And, again, the ultimate objective is for the chemical effects evaluation, to demonstrate the long term core cooling is maintained. It may be plant specific. We might have to use plant specific inputs for chemical interactions. We're going to identify some methods to predict precipitation and deposition on relevant core components and perform some sample evaluations to guide plant specific --

CHAIRMAN WALLIS: Well, you've talked about these things which might or might not occur, and you folks have got to figure out. You can solve those issues by looking at what's been done before or if you need to do some other tests or whatever. You're going to figure all of that out.

MR. ANDREYCHEK: That's correct.

MR. DINGLER: As I say, we're just getting initiated because our screening like the chemical effects, we couldn't screen it out.

CHAIRMAN WALLIS: In other words, today is the sort of things you're thinking about having to consider.

MR. DINGLER: That's correct.

CHAIRMAN WALLIS: You're not really saying that you've resolved the issues.

MR. DINGLER: No, we're not saying we've resolved the issues. I wish we could say that.

MR. ANDREYCHEK: So do I.

CHAIRMAN WALLIS: Well, you could say that.

MR. DINGLER: I wish we could.

MR. ANDREYCHEK: So in summary, considerable work has already been performed, and the available results indicate success in demonstrating long term core cooling is offered for a wide range of conditions.

Additional work has been identified to address the phenomenon in more detail and to refine some analyses while demonstrating there is significant margin for long term core cooling.

I'd like to add also that the work on this

project is going to be done jointly with and between AREVA and Westinghouse. It is going to be a joint effort, and some of the materials that I presented here today is a result of AREVA's efforts they've already undertaken, as well as efforts of Westinghouse performed to date.

MEMBER BONACA: Now, this includes those CE plants?

MR. ANDREYCHEK: That's correct. I consider them Westinghouse at this point since we --

MEMBER MAYNARD: Okay. There are some PWRs that had GE fuel, I believe. Are they --

MR. DINGLER: From what we understand it's only AREVA and Westinghouse now fuel is at the PWRs.

MEMBER MAYNARD: Okay.

MR. DINGLER: Is what we've been told. We're trying to find that out, but the plants have told us that's all they have. There's about a 40-60, 40-60-40 split right now between the two. And I may be wrong, but that's what I was told.

MEMBER MAYNARD: The other thing, I'd like to go back to the flow rates and take a look at those numbers. It does look like what would be in a tech spec would basically boil off rate if you weren't adding any water. There's still valid numbers and

valid trends if your make-up water, and in fact, the cooler you make your make-up water, the less water that you need.

So I think the numbers are still representative of what you need, but I do think that what numbers are coming out of the emergency procedures there is what the boil-off rate is at that point.

MR. DINGLER: Thank you. I apologize for misleading you by then.

MEMBER BONACA: You simulated up to 80 percent blockage.

MR. ANDREYCHEK: That's correct.

MEMBER BONACA: But you would have some boiling probably right above that blockage. I don't understand the hydraulics in the area. You're showing some flow coming through and some of the circulation there.

CHAIRMAN WALLIS: Well, this is a sort of porous media model or is this some sort of a --

MR. ANDREYCHEK: Actually, this was a finite element model. This was -- the blockage was set right here.

CHAIRMAN WALLIS: But what do you about the resistance to cross-flow and the fuel?

MR. ANDREYCHEK: The cross-flow and the fuel is modeled by looking at flow through bundles.

CHAIRMAN WALLIS: So it's something like a porous medium.

MR. ANDREYCHEK: That's correct. And if you take a look at Idel-chek, you can get loss coefficients for flow through bundles of --

CHAIRMAN WALLIS: It's surprising that you get that.

MEMBER BONACA: So what did you get it through D? I mean, RELAP-5 doesn't give you -- see, how did you analyze in 3(d), that part above the blockage?

MR. ANDREYCHEK: Well, this was a pie sector of a model. We took a look and basically used the bisector. We didn't try to model the entire core. And, again, we're using symmetrical blockages starting at 20 percent centered in the middle, then 40, 60, 80 as shown in the previous diagram.

MEMBER BONACA: Oh, I see what you mean.

MEMBER MAYNARD: Even if you had no flow coming in at all, as long as you have water above the core you would get some boiling, but you're going to maintain and stay below your limits of cladding temperatures as long as you've got water. So you're

getting some recirculation and stuff in there.

MEMBER BONACA: What I don't understand is how did they do the prediction. I mean, you mentioned TRACE and RELAP 5.

MR. ANDREYCHEK: For this particular calculation that was used a finite element code, it was not TRACE. It was not RELAP 5. It was a finite element code to look at flow and flow redistribution.

CHAIRMAN WALLIS: Would you go back to that picture you just showed us of the finite element output? Somewhere behind Mo here there's a stagnation point.

MR. ANDREYCHEK: The recirculation pattern here.

CHAIRMAN WALLIS: Where that recirculation pattern meets the main flow, there has to be a stagnation point down on the bottom there.

MEMBER KRESS: Right in the middle.

CHAIRMAN WALLIS: Right in the middle. So presumably particulate matter would come around and go around that vortex and deposit down in that stagnation area just like snow behind the fence or something, the vortex. So it might build up particles by settling in the regions of very low velocity in there.

MR. ANDREYCHEK: It's a possibility,b ut

I would suggest if you've got blockage, Dr. Graham, we did some calculations and we're looking at some boiling here. That becomes a very energetic and very chaotic process.

CHAIRMAN WALLIS: You do have particles in this flow, don't you?

MR. ANDREYCHEK: In this particular calculation --

CHAIRMAN WALLIS: But you don't throw out particles because some of the particles go through.

MR. ANDREYCHEK: That's correct.

CHAIRMAN WALLIS: All right. So that you'd have to consider what they do in this, as well as what the fluid does.

MR. ANDREYCHEK: That's correct.

MEMBER BONACA: That's the point I was trying to make before. It would be very energetic. You would have probably removal or lifting of blockage, too.

MR. ANDREYCHEK: Not only that, but depending on the bubbles and how the bubbles would be moving, there might even be a forcing function down to actually push fibrous debris off the grids and open up the grids again.

CHAIRMAN WALLIS: Dangerous for you to

hypothesize all of these mechanisms because then we will now turn around and 'say, "Well, analyze them."

MR. ANDREYCHEK: I understand. I realize that.

(Laughter.)

MR. DINGLER: That's another reason I'm up here.

MR. ANDREYCHEK: That's right. But this was a calculation we had done several years ago looking at this.

Any other questions?

CHAIRMAN WALLIS: Can we believe these calculations or do we have to do some sort of test?

MR. ANDREYCHEK: I don't think we need to do a test. I think we can believe them, and there is data to --

CHAIRMAN WALLIS: It may be approach to all of the strainers, is to base everything on tests because we really have difficulty predicting.

MR. ANDREYCHEK: Okay.

CHAIRMAN WALLIS: Are you going to say that cores are different and we can predict what happens? We don't need any tests?

MR. ANDREYCHEK: I'd like to say that I've a very strong belief the multi-dimensional

capabilities of advanced codes and there's a sufficient amount of data out there that looks at blockage in the flow paths.

MEMBER MAYNARD: Has there been some testing done with blockage in the past on fuel assemblies?

MEMBER KRESS: There was a lot of testing with the liquid-metal cooled reactors.

MR. ANDREYCHEK: That[s correct.

MEMBER KRESS: Because they expected it there, and of course, it's a different core configuration and a different coolant.

MR. ANDREYCHEK: That's correct.

MEMBER KRESS: But a lot of data there.

MR. ANDREYCHEK: Yes, there is, and in fact, that's what happened in FERMI Unit 1, was a blocked part of the port.

MEMBER KRESS: Yeah, that's what brought it on actually.

MR. ANDREYCHEK: Yes.

MEMBER MAYNARD: Was the recent event at PAKS at all instructive on this?

MR. ANDREYCHEK: PAKS? I'm not familiar with it. So you're going to have to help me, please.

MR. CARUSO: The Hungarian reactor where

they had some bundles isolated in a cleaning chamber overnight and they turned off the cooling to it, and it got very messy.

MR. ANDREYCHEK: I'll be honest with you. I am not familiar with that scenario at all. So if you can give me a reference, I'd be more than glad to look at it, but I'm not familiar with it.

MR. CARUSO: P-A-K-S. Happened about two years ago.

MEMBER MAYNARD: It had water over it, and it was still --

MR. ANDREYCHEK: I've got it. I am not familiar with it. I'll be more than glad to take a look at it. I'll talk to our fuels people.

CHAIRMAN WALLIS: Of course, you don't know where the blockage is going to be, do you either? You've got an 80 percent blockage that you sort of have at a certain place.

MR. ANDREYCHEK: You're correct, yes.

CHAIRMAN WALLIS: So one would have to do, I suppose, a whole lot of sensitivity calculations about where the blockage might be and so on.

MR. ANDREYCHEK: That's entirely possible. Again, we were looking at what we had available to help guide us to say does this look like a reasonable

success path. We believe we have sufficient data and sufficient capability to find a success path.

CHAIRMAN WALLIS: You're not looking at bypass flows coming in in some way? There was some talk earlier about even if you've got 100 percent blockage, you get have got water in there.

MR. ANDREYCHEK: That is correct. There are some designs that have the capability of doing that, yes.

MR. DINGLER: And we may use that yet. We're seeing if we can take the next step and then we may have to take the next step on down.

MR. ANDREYCHEK: This appears to represent a limiting configuration to look at. If we can be successful here then the rest is margin.

CHAIRMAN WALLIS: Well, its' still work in process and interesting to see how it comes out.

MR. ANDREYCHEK: Thank you, and I appreciate the insights on the PAKS, Ralph. Thank you.

Any other questions?

CHAIRMAN WALLIS: I assume there will be some sort of WCAP or something at the end of it all.

MR. ANDREYCHEK: There will be a report, yes.

CHAIRMAN WALLIS: Is there some time schedule for that? Do you have a plan?

MR. DINGLER: We're working with the staff to work through that right now.

CHAIRMAN WALLIS: But it will be some time, won't it?

MR. ANDREYCHEK: Yes.

MR. DINGLER: We have been requested by the staff to work very closely with them as we develop this to make sure we're not far off when we get done.

MR. SCOTT: Mike Scott again.

Obviously the publication date of that document is of great interest to us, given the December 31st, '07 goal for resolving the generic letter.

CHAIRMAN WALLIS: Well, it will be January 1st, 2008.

MR. SCOTT: We are pushing. They're probably saying we're pushing them pretty hard to get busy on this and get a product out as soon as they can.

MR. DINGLER: And we figure this probably won't be the last time we're up in front of you to discuss this either.

MEMBER MAYNARD: At this point is there

any international cooperation going on with your plants or is this primarily --

MR. ANDREYCHEK: It's primarily U.S. plants.

Any other questions?

CHAIRMAN WALLIS: Then we're finished. Thank you very much.

MR. ANDREYCHEK: Well, thank you. We appreciate the attention and the questions. Thank you.

PARTICIPANT: Do you want to keep going?

CHAIRMAN WALLIS: I think we should keep going. We've been going for less than an hour. Is staff ready? Do you have your reg. guides and SRPs and everything all ready for this problem?

PARTICIPANT: We're working on it.

(Whereupon, the foregoing matter went off the record at 1:53 p.m. and went back on the record at 1:54 p.m.)

MR. SCOTT: Before the staff begins their presentation I wanted to just make a few introductory remarks.

The subject matter for the next hour or so is licensing activities related to GSI-191. The activities that we're planning to discuss with you are

actually two types. One is license amendment requests that are before the staff or have been, and the other is extension requests to resolve the issues in Generic Letter 2004-02.

So Ruth Reyes, who is sitting at the front there of the SSIB staff in NRR, is going to present to you a summary of all of the license application requests except one, and that one being Palisades in which you all had expressed particular interest, and for that one Mark Padovan to your right here is going to present the Palisades license amendment request after Ruth has summarized the others.

There are about eight license amendment requests that she's going to talk about, and most of those involve a considerable cast of NRC reviewers, and I'd like to thank that considerable cast who are mostly present in the room with us right now, but because of the number of involved parties, it is possible that you may have a question that we're not prepared to answer because that particular individual may not happen to be here.

Should that happen to be the case, we'll provide you additional information as soon as it becomes available.

The other presenter that you see in front

of you is Leon Whitney, also of the SSIB staff, and Leon will be talking to you towards the end of Ruth's presentation about the extension request that the staff has be reviewing and some of which the staff has approved in recent months.

So that's what we're going to be discussing with you.

And with that, Ruth.

CHAIRMAN WALLIS: Okay. Thank you.

MS. REYES: Good afternoon, everyone. My name is Ruth Reyes from NRR in the Safety Issue Resolution Branch.

The purpose of this presentation like Mike said is to inform about the license amendment request that address in SSIB 191, and we're also going to discuss the staff's review of licensee request to extend completion of Generic Letter 2004-02, corrective actions beyond December 1st, 2007.

In response to the GSI-191 and the Generic Letter 2004-02, the licensees -- sorry. Like I was saying, in response to the GSI-191 and the Generic Letter 2004-02, the licensees reanalyzes the containment sump, and as a result of the analysis some licensees determined that they had to make some changes on their technical specifications, and there

was one licensee that identified that they had to make some changes on the evaluation methodology that they have in their UFSAR.

The license amendment request that I will be discussing are the Millstones, Fort Calhoun, Surry, Sequoyah, Robinson --

CHAIRMAN WALLIS: I'm not quite sure what's going on here. I thought this entire process was a change in evaluations. The whole way of analyzing sumps has been changed as a result of this GSI, hasn't it?

It used to be that you were allowed to assume that half of the screen was blocked and all of that sort of thing. The whole regulation has changed, hasn't it?

MR. SCOTT: The regulation has not changed. In most cases the methodologies that are involved here are not described or at least the licensees have not identified them as being described in the FSAR, which of course is one of the criteria that triggers a license amendment request. That's why we have 69 plants that are out reevaluating this issue, but we only have eight or nine license amendment requests so far.

We're likely to get others.

CHAIRMAN WALLIS: It's a kind of technical question really, isn't it? It's regulatory technical, whether or not something happens to be -- an FSAR needs to be changed, and so on.

MR. SCOTT: It's in accordance with 10 CFR 5053.

CHAIRMAN WALLIS: In general, all of the plants are reevaluating everything.

MR. SCOTT: Absolutely.

CHAIRMAN WALLIS: Okay.

MR. SCOTT: And excuse me. I understand one more thing. To the extent that some plant modifications end up being implemented, for example, to change out a pH blocker, if that's described and they make the decision that they need to change out their pH buffer, then we're going to be getting potentially a large number of LARs related to that.

MS. REYES: So the last ones are Robinson, Comanche, Catawba, McGuire and Palisades.

The first one that I'm going to talk about is Millstone. This last summer request proposed to delay the initiation of the (unintelligible) gray system pumps. With this change they want to increase the NPSH margin.

Currently the Millstone --

CHAIRMAN WALLIS: How does it increase the NPSH margin?

MS. REYES: Through the (unintelligible) spray pumps.

MEMBER KRESS: Is that spray on automatic actuation?

MS. REYES: Right now what they have is based on after they get the containment high pressure signal, and there's a delay timer. They want to change it to start the pumps --

MEMBER KRESS: Change the delay timer.

MS. REYES: They want to change the delay timer. They don't want to use the delay timer. What they want to do, automatic after they get the containment high pressure signal and the RWST low level signal.

MEMBER KRESS: It will still be on automatic.

MS. REYES: It will be on automatic, yes.

CHAIRMAN WALLIS: Now, I'm trying to get the connection between the first bullet and the second.

MEMBER KRESS: It allows the containment temperature and pressure to increase more.

CHAIRMAN WALLIS: Well, the increase in

temperature decreases your MPSH. Unless you get containment credit, you don't get any pressure.

MEMBER KRESS: Yeah, but the pressure goes up.

CHAIRMAN WALLIS: Unless you get containment pressure with it.

MR. LOBEL: this is Richard Lobel from the staff.

I wasn't the reviewer, but judging from the way subatmospheric containments work and Millstone is slightly atmospheric and they were designed that way; delaying the recirculation spray pumps would allow more time for the level to increase. The recirculation spray pumps start very early.

CHAIRMAN WALLIS: So it's the -- that increases the NPSH.

MR. LOBEL: Yes.

CHAIRMAN WALLIS: Okay. It's not a temperature and pressure effect at all.

MR. LOBEL: Probably not.

CHAIRMAN WALLIS: We don't know.

MR. LOBEL: Most likely it's just waiting longer until you have more water on the floor and in the sump. That's the effect.

CHAIRMAN WALLIS: But it might be altered

by then. So it's not clear which way things will go.

MR. LOBEL: It's not going to be too much colder. I don't know. Maybe Westinghouse has something to add.

CHAIRMAN WALLIS: There's some data we can't tell.

MR. LOBEL: I would say it's a pretty good bet that that's what it is.

MEMBER KRESS: It's hard to believe they're (unintelligible).

CHAIRMAN WALLIS: It's going to make the temp and pressure higher, isn't it?

MEMBER KRESS: Right. Wait longer to turn the sprays on.

MR. SCOTT: Now, correct me if I'm wrong here. This reactor has two spray systems, right? They have an injection spray systems, right?

MS. REYES: Yes.

MR. SCOTT: They have an injection spray system and they have a recirculation spray system. So you're spraying the whole time.

MS. REYES: There's another set up containment spray pumps that are going to start right after the containment high pressure signal.

MEMBER KRESS: Okay. I take it all back

then.

MR. LOBEL: The recirculation pumps are taking suction from the floor of -- the other spray system is taking suction from the RWST.

MEMBER KRESS: That makes a lot of sense.

CHAIRMAN WALLIS: Okay, okay.

MS. REYES: So there's no adverse impact on containment temperature or pressure expected with this change.

CHAIRMAN WALLIS: Well, just wait a minute. If you turn the pumps on it doesn't necessarily change the level very much. The water goes up and comes back down again.

MR. LOBEL: You're just allowing more water to accumulate.

CHAIRMAN WALLIS: Before you turn them on, before you stop. Okay, and that comes from the RWST then.

MR. LOBEL: From the RWST and from the break.

MS. REYES: The second license amendment request is Fort Calhoun. They propose to reduce the required number of containment spray pumps, and with this they're going to increase the NPSH margin. Right now the Fort Calhoun containment spray system pumps

consist of three pumps, and two of those three pumps share the same suction line. So they want to disable the activation signal for automatic start for one of those two pumps.

And again, there's no significant adverse impact on either containment temperature or pressure expected with this change.

For Surry, they want to change the method for starting the inside and outside recirculation spray pumps. Currently what they have is like Millstone has. They have delay timer after they get the high pressure in the containment. They want to wait until they get the high pressure in containment, also a low level signal for RWST.

And there's no significant adverse impact on containment temperature or pressure expected with this change.

CHAIRMAN WALLIS: Well, are those the only things that are getting impacted by this sort of thing?

MR. SCOTT: Well, now, here again, the license amendment requests are going to have narrow scope related to what appears in the SR. Surry turning in this particular discussion or this application here does not in any way mean that there

aren't myriad other issues associated with this. It's just that they don't come up as FSAR items.

CHAIRMAN WALLIS: Presumably you have to evaluate all of the consequences of this change, not just the effects on containment, temperature and pressure.

MR. SCOTT: Okay. I misunderstood your question. Are we implying by these limited slides here that these are the only considerations taken? No.

CHAIRMAN WALLIS: Well, there was other things.

MR. SCOTT: Yes, that's right. Again, we had a relatively short presentation time here, and so we attempted to identify what the key point is that's being made here, and as was pointed out, each of these license amendment requests involves a number of reviewers, some of whom are here.

So if you have a particular question about a consideration, we can answer it.

One other thing to bear in mind is most all of these are still under review.

CHAIRMAN WALLIS: Now, are they asking to be able to make these changes before or after they install the new strainers?

MR. SCOTT: I don't know for each one of these. In general, they are asking to do these changes in conjunction with installing the new strainers.

CHAIRMAN WALLIS: Did it go along with the change in the strainers or do they want to do it now before they change anything because there's a benefit?

MR. SCOTT: It depends. It varies from request to request.

CHAIRMAN WALLIS: But it's not a consequence of having new strainers that they want to do this?

MR. SCOTT: In some cases it is.

CHAIRMAN WALLIS: It might be.

MR. SCOTT: That's right.

CHAIRMAN WALLIS: -- in with how the strainers work. So you have a lot of work to do to evaluate it.

MR. SCOTT: In some cases they are independent of the strainer activities and in some cases they're not. As we go through the rest of them, I think you'll see it's kind of a mixed bag.

The ones that you see, most of the ones that Ruth has discussed so far related to what has been loosely referred to as water management, that

these are good things to do regardless of the presence or absence of a new strainer.

CHAIRMAN WALLIS: Well, you're telling us all of this. Is there any input from us that you would expect or which we could possibly give you which might be useful?

MR. SCOTT: If you --

CHAIRMAN WALLIS: Were you aware that these things are happening?

MR. SCOTT: This was meant to update you on what's going on with these. Obviously we're always interested in hearing your input on these. If there's something that we need to discuss, we can.

CHAIRMAN WALLIS: -- what's going on, we can't really give you much feedback.

MR. SCOTT: Maybe a good way to leave this is because we're going over eight of them actually in a half an hour period and we don't have a lot of time for in depth discussion of any one of them, if there is a particular aspect that piques your interest or concern, then we can come back to you another day and speak to that in more detail.

CHAIRMAN WALLIS: It might be a concern that you have with some of them you could tell us about.

MR. SCOTT: Okay. I would suggest we go through the rest of the presentations.

MEMBER MAYNARD: So far it has primarily been a water management issue and NPSH. Do any of these have any chemical injection with their containment spray or is this all just water?

I'm looking at any radiation effects. Some of the containment spray systems do more than just cool.

MR. LOBEL: This is Richard Lobel of the staff.

Usually there's chemicals in the spray water for the PWRs.

MEMBER MAYNARD: And my question kind of gets back to we talk about pressure and temperature effects. I take it that there's no adverse exposure consequences either.

MR. LOBEL: That's one of the things that's addressed by the licensees in these. They would have to address any changes in their dose methodology or calculations or conclusions.

MR. KLINE: Paul Kline.

I think one of the amendments that Ruth will get to in a minute here relates to a change of request also that has to do with a potential change in

a buffering agent

MS. REYES: The next one is Sequoyah. Sequoyah requested a license amendment to change an evaluation methodology on their UFSAR. This revised analysis includes development of a three dimensional CFD model of the debris transport in the sump pool. This three dimensional model sizes the flow area for an advanced sump strainer design which will replace the Sequoyah's original sump intake structure.

CHAIRMAN WALLIS: I thought from everything we heard in the last few days that these blenders were mixing up everything to make sure everything got to the strainer, to be conservative, and this whole business about how much stuff got transported was irrelevant.

Now you're saying that here are these folks who want to make it a key part of their strainer design.

DR. LU: Shan Lu from NRR.

Actually a lot of licensees are using the CFD to reduce certain fraction of the debris transport to the sump. Some of them are taking or using conservative assumptions.

CHAIRMAN WALLIS: They want to take credit for this.

DR. LU: Yes, they do. In this particular plant, the licensee does, takes credit.

CHAIRMAN WALLIS: But the people that we heard from the last couple of days seemed to make great efforts to stir everything up and make sure nothing settled out and everything went to the screen.

MR. SCOTT: That's partly because the staff has been pressing them if they are making assumptions about what doesn't get to the screen to justify it, and in some cases, as they stated, it's easier to just dump it all on the screen rather than justify the amount that doesn't get there.

So you have a mixed bag here. Some are trying to take credit for it. Others are not.

MR. LEHNING: This is John Lehning from the NRR staff.

I just wanted to point out that the process of doing evaluation of what gets to the sump is a little bit different than this head loss testing. So when you're doing this evaluation, you'd calculate the amount of debris generated and then you'd calculate what gets to the sump screen, and that's what the CFD part is form.

When you do the head loss testing, it's taking that amount of debris that you calculated in

your calculation as transporting and then when you do that head loss testing if you take credit for settling, it's crediting settling again after you already did this analytical credit for it. So it's like a different issue. It's not this near field settling issue.

CHAIRMAN WALLIS: So far all we see is this is something they're applying for. We don't see a presentation of how good it is or how bad it is or anything. You're just being informed that this is what they're doing.

DR. LU: Yes, that's right.

CHAIRMAN WALLIS: And do you want us to say that we think it's a great idea or not?

MR. SCOTT: Which is a great idea? Any particular item on here?

CHAIRMAN WALLIS: To do this kind of thing.

MR. SCOTT: Like the last one here for Sequoyah?

CHAIRMAN WALLIS: Yeah.

MR. SCOTT: Well, the staff views that as not an item of particular concern, that particular one that you just did.

CHAIRMAN WALLIS: Do you feel confident

that you can review this application and make a proper decision?

MR. SCOTT: Yes.

CHAIRMAN WALLIS: Without presenting anything to us?

MR. SCOTT: Yes.

CHAIRMAN WALLIS: Okay. Shall we move on then?

MR. SCOTT: I guess I'd have to take slight issue with your wording. We are presenting it to you, but again, the constraints of this type of presentation is there are a large number of applications.

CHAIRMAN WALLIS: I know. I'm just wondering how we add value to this whole process. If you're going to say we have some concerns about this 3D calculations and so on and we'd like to bring it to you guys for advice. Are you going to do that or are you just going to go ahead?

MR. SCOTT: We're going to show you one that we do have concerns with here in a minute.

CHAIRMAN WALLIS: So that's where we can help you. If there's something you are concerned about and we can be of use.

MR. SCOTT: Okay. Fair enough. Thank

you.

CHAIRMAN WALLIS: We don't particularly like to raise concerns that you don't have. We don't particularly like to do that.

MS. REYES: The next one is Robinson. Robinson (unintelligible) strainer, and this license amendment is requesting to replace the phrase "trash racks and screens" in the tech specs with the term "strainers."

CHAIRMAN WALLIS: I'm going to need about an hour's discussion on this.

(Laughter.)

MR. SCOTT: Well, this one is not trivial if you think about it. Go ahead, Ruth.

MS. REYES: And the staff review for this license (unintelligible) to insure that replacement strainers are functionally equivalent to existing trash racks and screens.

Other plants that have applied or plan to apply, the replacement of the phrase "trash racks and screens" are Oconee, which has already been approved, Wolf Creek, Calloway, and Comanche Peak.

MR. SCOTT: To expand on that one a little bit, trash racks, the existing trash racks have a definite role in protecting the existing strainers.

If the trash racks are going to disappear and they're not going to be providing that role for the new, very different strainers that are going to replace the screens, then we're expecting the licensees to show that the strainers are able to handle the various issues related to the absence of the transracks, such as materials impinging on the strainers that would have been blocked by the trash racks had they been there.

CHAIRMAN WALLIS: Now, the word "screen" has bene used in all of this as far as I can remember for the last year or two while we've been writing all of these letters and we've had all of these meetings. Suddenly they're being called strainers. That's the big change.

MR. SCOTT: There seems to be use of both words in discussing both the new and the old configurations, and if all it says was we're changing our screen to a strainer, that would largely be semantics, but there's more to it than that.

First of all, you do have the presence and the existing configuration of trash racks, which won't be around for some of the new configurations, and of course, the screen, the way we kind of thought of it was the screen is the mesh sort of, well, screen --

PARTICIPANT: Perforated plate.

MR. SCOTT: Well, the strainer is the perforated plate. So but is that defined in Webster's somewhere? I'm not so sure.

CHAIRMAN WALLIS: I think strainer is an attempt to make this more culinary.

(Laughter.)

MR. SCOTT: Well, I don't have a better explanation.

MEMBER BONACA: You may have addressed it already, but it is confusing to me. I mean we have seen over a day and a half of presentations, plus, that a lot of these issues are not closed yet. I mean there are still elements to be brought in, chemistry effects, other effects.

And now you're presenting us changes to these plans and making the tech specs or whatever to reflect already some changes for GSI 181. I would expect that they may still have to make additional changes.

MR. SCOTT: Absolutely correct.

MEMBER BONACA: So this is just interim changes for the tech specs to address things they have done or want to do, not necessarily closure on GSI-181 on their part, right?

MR. SCOTT: That is absolutely correct. As we have said in past briefings to the committee, the staff believes that, of course, GSI-191 is a very complex issue. As you have heard, we are not near the finish line of this issue. However, if the choice is to wait until we get to the finish line and then enlarge the strainers or enlarge the strainers and reduce the risk and then get to the finish line, we've chosen the latter.

And so everybody going into this knows that the larger strainers may not be the complete end state. As you all were talking about, there may be changes in the pH additive. There will likely be additional plant modifications to remove problematic materials. There's a long way to go here, but we believe that, again, the right answer is to increase the strainer size, and these amendments that you see here are likely -- you know, if we're going to approve them, it's because we believe that they are the right thing to do regardless of how this issue turns out.

MEMBER BONACA: So, I mean, this is because they are a regulatory requirement that says if you want to implement this change, though it may not be the final one, okay, you have to submit an amendment request and do that now. Okay?

MR. SCOTT: Right.

MEMBER BONACA: That's the reason why it's happening. All right.

MR. SCOTT: Right. This is per 10 CFR 5059, and they want to make a change to the plant. they have to review it for these various considerations, and the ones you se here have come up with, you know, -- the gate has sent them to they need to ask the NRC for approval to make the particular change they have in mind.

MR. WHITNEY: This is Leon Whitney, NRR.

However you define strainer or screen, if you're installing what you believe is a strainer in place of trash racks and a screen, I don't think you legally can come out of your outage having done that without getting this change.

MEMBER MAYNARD: Right. That's what to me some of these may seem somewhat I won't say trivial, but they're more than that. If it's part of your license you have to have that change before you can actually implement. Some of the modifications, as long as it's improvement in the overall safety, can be implemented, but if there's other things that are part of the license involved i it, that license amendment has to be submitted and approved before you can do it.

MR. WHITNEY: To the extent that the sum total of all the concerns about water management come out positive, you'd want to go ahead regardless of whether you have the old screen or the new one.

MEMBER BONACA: I understand that. In some cases like this one here, you know, the guy has replaced the strainers. So I understand. He has to submit an amendment, thought it may not be the final solution, but still.

In other cases, it seems to me they could have waited to propose the change until they had the full solution, but they chose to, I guess, implement -- I was looking at the minutes on LAR.

MR. SCOTT: Well, remember if you look at this one, for example, I don't know when Robinson is putting in their new strainer, but let's assume they're putting it in in spring '07. Then as Leon said, they need this change in place before they start up after that outage.

Also, please recall that starting this fall, we're going to see a significant number of installations of new strainers. The bulk of the new strainers are going to happen in fall '06, spring '07, and fall '07. So there are going to be a lot of these that are going to need to come in well in advance of

the December 31st, '07 deadline for resolution of the generic letter.

CHAIRMAN WALLIS: They're all going to come in and say, "Please change the word 'screen' to 'strainer'"?

MR. SCOTT: I don't believe we're going to get any like that. We don't have any. Again, if somebody just came in and said "screen to strainer," then I would likely -- my inclination would be to say that that was semantics unless they described what "screen" meant.

CHAIRMAN WALLIS: It says "trash racks and screens."

MR. SCOTT: If it says "trash racks," then you have a component that's no longer there.

CHAIRMAN WALLIS: Okay.

MS. REYES: The next one is Comanche Peak. This LAR proposes to lower the value of the low level set point in the RWST, and it also revised (unintelligible) requirements to allow use of alternative containment spray bulkers (phonetic).

The staff is currently discussing scope of this LAR with the licensee.

MR. SCOTT: And this is one that we do have some questions about because it seeks to allow

use of alternate containment spray buffers unspecified, to be decided in the future, and so as Ruth said, we're currently discussing this one with the licensee.

MS. REYES: The next one --

CHAIRMAN WALLIS: Well, it can't go much further usually on the low, low level set point per RWST, which is pretty close to the point where they suck in air and stuff. Usually there's not much flexibility with the low, low level, is there?

DR. LU: That's right, and that's one of the issues we are looking into as a part of the review related to the war taxing.

MS. REYES: The next one is the Catawba/Mcguire. They want to implement an additional manual operator action that would allow operators to manually start one air return fin. With this they preclude the use of containment spraying for many small break LOCAs.

MR. CARUSO: Could you explain that?

MS. REYES: Okay. Well, if they start the air fins before they normally do, you are lowering the temperature and pressure.

CHAIRMAN WALLIS: What does the air return fan connect to?

MR. HAFERA: Excuse me. It's Tom Hafera from staff.

This is an ice condenser containment. So starting the air return fan will drive more flow through the ice condenser and, therefore, you reduce containment temperature and pressure.

MR. LOBEL: This is Richard Lobel.

What Tom said, it increases the amount of ice melt.

CHAIRMAN WALLIS: Right. That's right, but it wouldn't apply to another kind of plant at all, would it?

MR. LOBEL: No. Well, no other plant has these fans. There aren't the fan coolers. These are special fans in an ice condenser.

CHAIRMAN WALLIS: Thank you.

MR. WHITNEY: Leon Whitney, NRR.

I'd like to give you a survey or summary for your information on extension requests under 4 GSI 191. Generic Letter 2004-02 corrective actions are due by 12/31/07.

SECY-06-0078 provided new extension criteria. One, the licensee must have a plan for resolution of outstanding technical issues with margins. It must have mitigative measures, and

provide temporary improvement to sump or containment materials.

And eight requests have been approved out to spring --

CHAIRMAN WALLIS: On the mitigated measures, mitigated measures sounds like a sort of catch all thing. Is this --

MR. WHITNEY: I can discuss what one --

CHAIRMAN WALLIS: -- some criterion about what they have to achieve to be acceptable or something?

MR. SCOTT: Leon, these would be consistent with the bulletin, right?

MR. WHITNEY: Well, the bulletin and other things. One of the rationales the licensee gives is that we have done the bulletin mitigated measures, for example, but they give many others.

CHAIRMAN WALLIS: But then they have to achieve something with those measures which is acceptable.

MR. WHITNEY: Yes, and I happen to have a listing of representative ones for you, which I'll give you.

CHAIRMAN WALLIS: How do you decide if they're enough? That's my question.

MR. WHITNEY: This is a qualitative review. It is not a quantitative review. We thought of having strict quantitative reviews and found it to be much too cumbersome and we thought we could do an adequate job on a qualitative basis.

CHAIRMAN WALLIS: Well, there isn't something which says at the risk of failure long term quilting (phonetic) must be reduced to a certain --

MR. WHITNEY: It's not risk based or risk informed.

MR. SCOTT: Let me speak a little bit to management's views on this. The requests that have come in to date are asking for basically extending their full completion of generic letter actions out a matter of two to three months, out into the spring '08 outages. In essentially all of the cases, and Leon will talk about this some more, but in essentially all of the cases these plants are telling us, "We're installing our strainers now in fall '06." These are mostly fall '06 outages plants. "We're going to have our new strainers in in fall '06, but there's some other issue out there," which Leon will talk about, "that we won't be able to get to in fall '06. So we are 90 percent of the way there."

The staff's view on it is that having the

strainer installed in '06 and waiting until spring '08 to get to the finish line is better than saying no to these requests and having somebody wait until December '07 and then shut down and do the whole thing.

CHAIRMAN WALLIS: All right. So it really is just tied in with a particular outage schedule at the plant is what is driving this.

MR. SCOTT: Certainly that's true, and what's also driving it is the staff's view that we need to encourage the utilities, even though who have fall '067 outages to get these strainer installations done.

CHAIRMAN WALLIS: In order to be fair to the people who are actually doing it on time, too, so that they can't say, "Well, how did those guys get away with waiting and we weren't allowed to?"

MR. SCOTT: Well, they actually are waiting longer because they're not installing their strainers until spring '07 or fall '07.

CHAIRMAN WALLIS: In that sense they're behind. Well, as long as they put these things in in fall 2006, you feel comfortable allowing them to delay?

MR. SCOTT: Well, there's more than that. I mean, as Leon went over, we're looking for other

features, mitigative measures, et cetera, that provide us a high confidence that this plant can operate safely until that spring '08 outage, but --

CHAIRMAN WALLIS: Just like confidence relates to my saying there's little risk of it not working. It's the same thing really.

MR. SCOTT: Without a rigorous quantitative risk evaluation that's true.

MEMBER BONACA: Okay. Installing them now, it doesn't mean that the component isn't operable. It would be operable, but --

MR. SCOTT: I'm not sure where you're going with that. Can you --

MEMBER BONACA: I'm trying to understand. You're saying that they're asking for approval to move to spring 2008.

MR. SCOTT: Right.

MEMBER BONACA: And by installing the new equipment now in 2006 --

MR. WHITNEY: Some of the new equipment, the strainers.

MR. SCOTT: Here's the way it works.

MEMBER BONACA: I'm trying to understand how the equipment would work in the interim period. Will it work as it was before?

MR. SCOTT: Yes, let me speak to that. When a plant puts in the strainer, let's say they put their strainers in in fall '06. Then when they start out from the fall '06 outage, they have to be operable in accordance with their present licensing basis, and then they have to be operable in accordance with their revised licensing basis to meet the generic letter at whatever the agreed date is that we provided them, which will be February, March '06.

MEMBER BONACA: They may install it, but not connect it yet.

MR. SCOTT: No, no, no. They're installed. They're connected. I mean, there's no way to install these things without removing the old ones. Okay? So the new strainers are installed, and most of the plants have a nonmechanistic licensing basis which is that their strainer should survive 50 percent blockage. Okay?

And I think you can imagine that's not going to be difficult to show for these huge strainers. So they're going to show that they're in compliance with their existing licensing basis until either December 31st, '07, when they need to show they're in compliance with using a mechanistic basis per Generic Letter 2004-02, or until early spring '08

if we've agreed to that for these few plants that have extension requests.

CHAIRMAN WALLIS: This 50 percent blockage thing is going to be expunged once and for all.

MR. SCOTT: That's correct.

CHAIRMAN WALLIS: It will disappear from the record.

MR. SCOTT: That's correct because they will be replaced by a mechanistic basis, yes.

MR. CARUSO: So these plants don't have any drawings of their sump screens in their licensing basis.

MR. SCOTT: If they do, then they will clearly have to turn in an amendment request. We haven't seen one like that.

MR. WHITNEY: Just to correct the record --

MR. CARUSO: That's the functional definition that it has to work at 50 percent blockage.

MR. SCOTT: And even that's not always in their licensing documents, but yes.

MR. WHITNEY: Some of these approved extensions are into April and one, to my recollection, is May to correct the record.

Okay. Licensee reasons for requests,

design, testing and fabrication time. Many times they'll be talking about their throttle valves and related orifices.

Technical issues not resolvable by the 2006 outage, again, this might be related to a component and they need to study design, et cetera.

Complexities approach. A number of licensees were thinking about going with active strainers, which require redundancy and power and control boards and stuff, and they wanted time to work on a complex approach like an active strainer, and by the way, to our knowledge all licensees have decided not to go with active strainers at this time.

Expense of installing insulation twice. One licensee was going to replace their steam generators in spring '08. So if in the fall they had removed offending insulation, they would have had to put in expensive, engineered, custom insulation and then rip it out again for the new generator.

The circulation pump start signal change turned out to be quite complex in one case.

Now, to answer your question about what we're basing the approvals on, examples. Larger strainers plus interceptors, that's typical. They may not be the full, complete, final size, but they're

significantly larger, an order of magnitude usually at least.

Removal of problematic materials or chemicals from containment can be a rationale for approval.

Favorable plant characteristics, minor things like curbs around the -- and slopes preventing debris from getting to the strainers or something else about their design, their flow paths, et cetera, that may be very favorable.

The bulletin compensatory measures which they've already placed in their plan.

Existing LOCA analytical margins. We don't take credit for containment over pressure, for example, and yet we know it's going to be there, et cetera. Those kinds of arguments.

And reduction in LOCA frequency from NRC approved leak before a break would be another rationale for saying there's a low probability of an event in the interim time period.

And if you have any questions, I'd be glad to answer.

CHAIRMAN WALLIS: Relatively few licensees are doing this.

MR. WHITNEY: I have three or four on my

desk that are beyond the eight that have been approved to be studied and adjudicated.

MR. SCOTT: it is conceivable that, depending on how issues such as chemical effects play out, we could see significantly more of these sorts of things.

MS. REYES: A summary for this presentation. NRC has received nine (unintelligible) requests related to the General Letter 2004-02. Additional submittals expected for plants that change buffers and eight extension requests to spring 2008 approval.

MR. SCOTT: if you all have no questions, we'll go straight to Mark Padovan's presentation.

CHAIRMAN WALLIS: We don't have questions, but I think we should thank the presenters.

MR. SCOTT: Thank you.

MR. PADOVAN: Good afternoon. My name is Mark Padovan. I'm the NRR project manager for Palisades. Also I've asked people from our tech staff who are preparing safety evaluations on Palisades, the license amendment request move TSP to be here. They're in the audience as well, and I'll ask them for help to answer some questions that I can't.

The purpose of the presentation is to tell

you about NMC's amendment request to remove trisodium phosphate from the containment at Palisades, and then to give you a status of where we are on review of that LER.

As I understand it, there's six plants that have TSP in containment, along with calcium silicate. Palisades is the lead plant to remove this from containment, and as far as I know, there are no other applications in at this time.

I understand Fort Calhoun is close by, but not in house as of yet.

In response to Information Notice 2005-26 and Supplement 1, NMC submitted this license amendment request to revise the technical specifications to remove TSP from the containment at Palisades, and this would be for one operating cycle.

CHAIRMAN WALLIS: Are you going to put it back again after one operating cycle?

MR. PADOVAN: No, they're having a different program to use an alternate buffer at that time. Removal of the TSP would be until the next refueling outage in the fall of 2007.

Their application also included interim compensatory measures using sodium hydroxide injection for their post LOCA sump pH control. In our review

we've sent out a number of RAIs. We've collected the RAIs from various staff branches, put them in to one, sent them out, got a reply, but based on that replay we've got further RAI communications ongoing at this time.

Key review considerations that we're looking at are dose analysis, containment performance, and chemical effects. The dose analysis evaluates both the on site dose consequences and off site, with the on site being the dose of the control room operators.

Sump screen blockage and pH control, hydrogen generations are items under the containment performance consideration, and regarding chemical effects, we're looking at things such as corrosion, formation of calcium phosphate. I'll address each of these in the following slides here.

Under dose analysis, the Accident Dose Branch analyzed off site dose consequences and dose to the control room personnel without TSB being available in containment during the LOCA.

MEMBER KRESS: Now, when they do this nine basis calculation of trisodium phosphate, they're assuming the iodine in containment is (unintelligible)?

MR. PADOVAN: I will ask Michelle, but it's both elemental and the other.

MS. HART: Right. This is Michelle Hart from the NRR staff.

They are currently under the old TID source term, and so they have kept that speciation. So it's mostly elemental and organic.

MEMBER KRESS: Elemental.

MS. HART: Yeah.

MR. PADOVAN: And in the analysis that both utility and our staff is doing, it's very, very conservative. It assumes that iodine in the containment sump instantaneously reevolves into containment, and that the containment sprays would not remove any iodine.

CHAIRMAN WALLIS: So if they replace this trisodium phosphate with sodium hydroxide, doesn't that control the pH just as well? Doesn't it have the same effect on the iodine or not?

MS. HART: This is Michelle Hart again. They did not want to take credit for sodium hydroxide replacement for purposes of pH control for dose analysis for the radiation reduction.

CHAIRMAN WALLIS: They still want to use it for something else?

MS. HART: Right, and it's not being injected right away. It's not being injected until later in the event.

MEMBER KRESS: The trisodium phosphate enhances the spray remove of iodine. I don't think the sodium hydroxide will do that. So you lose that aspect of it.

MS. HART: Right.

MEMBER KRESS: But it still would remove some iodine. Indeed, we put some water.

MR. PADOVAN: This very conservative analysis done by staff and the utility showed that if you remove the TSP from containment, the NRC could not meet control room habitability criteria. Thus, they are implementing the compensatory measures which would be the introduction or use of potassium iodide control with control room operators and use of self-contained breathing apparatus as well.

Now, based on that, we have determined that the utility's estimates of off site and control room doses do meet our criteria with control room operator use of potassium iodine.

Regarding containment performance review considerations, we're assessing the impact of removing TSP on sump screen blockage, pH control and hydrogen

generations during these DBAs. I'll discuss that in each of the following slides here.

Regarding sump screen blockage, as previously mentioned, you're aware that the Information Notice 2005-26 and Supplement 1 that formation of the calcium phosphate precipitate is created on the sump. It could create enough blockage to become --

CHAIRMAN WALLIS: Excuse me. They're doing this because this is a CalSil plant?

MR. PADOVAN: Correct.

CHAIRMAN WALLIS: It's not just the concrete debris and stuff --

MR. PADOVAN: Correct.

CHAIRMAN WALLIS: -- that provides the calcium.

MR. PADOVAN: TSP-calcium --

CHAIRMAN WALLIS: It is the CalSil which is the problem.

MR. PADOVAN: Right.

CHAIRMAN WALLIS: Right.

MR. PADOVAN: And they found that this phosphate precipitation is a failure mechanism for the emergency core cooling system and containment spray during some LOCAs. Thus, if they reduce the potential

for the pump screen blockage due to this calcium phosphate, then you could reduce the risk of ECCS and containment spray failure during recirculation.

Regarding pH control and hydrogen generation, they have an existing Tech Spec 355 which gives the LCLs for pH control of the sump water. What it says is that there are these screened TSP baskets in containment and you have to have between 8,300 and 11,000 pounds of trisodium phosphate. If you don't, then you have 72 hours to correct that situation.

They're proposing deleting that tech spec basis on an interim basis, but as an alternate -- on a temporary basis.

CHAIRMAN WALLIS: What material is being attacked to produce this hydrogen?

MR. PADOVAN: Staff?

PARTICIPANT: Probably aluminum would be one of the major contributors to hydrogen generation, but also galvanized surfaces.

CHAIRMAN WALLIS: That actually produces hydrogen also when you go to the high pH, isn't it?

PARTICIPANT: We saw in the ICET tests with the IR pH, we did see hydrogen levels that were detectable.

MR. PADOVAN: Now, they are proposing to

delete this tech spec on an interim basis until the next outage in the fall of 2005 (sic). At that time they're going to institute an alternate buffer program.

Also, NMC concluded that removing this TSP from containment would have a negligible impact with respect to design basis hydrogen challenges the containment integrity, and we are presently reviewing that pH control and hydrogen generation issues and still ongoing.

Regarding chemical effects, we have, as I mentioned earlier, some RAIs out to them right now regarding the NaOH spray pH and aluminum in containment.

Removing the TSP and delayed introduction of the sodium hydroxide has potential advantages. There is no immediate formation of calcium phosphate. Formation of precipitates will occur when pump NPSH margins are higher, and that the spray containing sodium hydroxide will be at a lowered temperature, thus reducing aluminum corrosion rates.

In summary, our evaluation is nearly complete, but again, we're waiting for these RAI responses. We have some preliminary conclusions about removing TSP from the Palisades containment, and they

are that the estimates of the off site control room doses are will they meet our criteria if the control room operators use potassium iodide.

Risk of a sump blockage following a design basis accident in containment is decreased. Formation of precipitates will occur when pump NPSH margins are higher, and spray containing NaOH will be at a lower temperature, thus reducing the aluminum corrosion rate.

CHAIRMAN WALLIS: Well, isn't NaOH more effective at corroding aluminum than the TSP? TPS doesn't particularly corrode aluminum, does it?

PARTICIPANT: That's correct. There will be higher aluminum corrosion rates, but if you go back to what we learned from the ICET with the calcium silicate insulation and TSP, we saw immediate precipitate formation within 20 minutes of when they were combined. So expectation is in this case the sodium hydroxide would not be sprayed until either within seven days or within 20 hours of a loss of fuel integrity.

CHAIRMAN WALLIS: There are two bad things. One is calcium silicate. The other one is this aluminum oxihydroxide. So there's some trading off one against -- one is phosphates. The other one

is this aluminum oxihydroxide. Trading off one against the other in a way.

PARTICIPANT: Yes. In a way you're trading off precipitates, but the advantage is you're getting a much more delayed introduction.

MR. ARCHITZEL: This is Ralph Architzel from the staff.

A comment on the hydrogen. It's really the whole hydrogen recombiner issue, and it's a non-issue because it does come in for seven says. The original application was just talking about addition of seven days for EQ, and I forget what the other issue was. It was general corrosion of the material. So the hydrogen is a non-issue for this amendment.

MEMBER KRESS: The control room, is it normally stocked AI or will that be something new?

MR. PADOVAN: I believe it's something new for that plant.

Michelle, do you know?

MS. HART: I'm not sure. I thought that they had said it was currently a program that they already had.

MR. PADOVAN: Well, then I would defer to you on that one.

MS. HART: But we would have to check on

that to make absolutely sure.

MEMBER KRESS: Does that also include donning gas masks, SCBA?

MR. PADOVAN: The self-contained breathing apparatus?

MEMBER KRESS: Yes.

MR. PADOVAN: Are you familiar with that?

MS. HART: The only credit they took in their dose analysis was for the KI.

MEMBER KRESS: KI?

MS. HART: Yes.

PARTICIPANT: One other consideration. One of the things we observed in both the ICET tests and testing at ANL. Calcium silicate itself will have an effect on pH. It will raise the pH sine there are sodium silicates that will dissolve into the water. In this case the licensee took no credit for that during their dose considerations.

MR. PADOVAN: Any other questions?

MEMBER KRESS: Does that control room dose include other things besides iodine?

MS. HART: Yes, it does. It also includes the SHINE (phonetic) doses, is included in there, as well as the noble gas dose.

MEMBER KRESS: Noble gases and cesium?

MS. HART: Right, right. Because they're in the TID 14-844 source term, they have both the whole body and thyroid dose reported to meet GDC-19.

CHAIRMAN WALLIS: Well, these preliminary conclusions seem to point to the conclusion that you don't have here, which is that it would be a good idea to remove this.

MR. PADOVAN: We're still formulating that opinion. We've got more information to gather. I don't think we've reached that point just yet.

MS. HART: One of the things to note is that this particular plant had a lot of margin to the dose analysis limit in the control room. So some other plants may not be able to counteract the increased of dose in the control room by using KI.

MR. ARCHITZEL: Yes, Architzel. I'd like to make a comment on that good to do thing or not to do thing.

I guess that was one of the RAIs we did ask. It wasn't crystal clear that this was a risk positive thing to do. So we did ask questions, and that's one of the reasons we've got a double situation with adding the buffer. So there is a 20 hour time frame to add the buffer, which makes it more easy to make that conclusion it's the right thing to do.

CHAIRMAN WALLIS: So what it does is it reduces the risk of failure of long term cooling, but it increases the consequences of the curve; is that right? You've now got more dose consequence?

MS. HART: If the design basis accident would occur, yes.

CHAIRMAN WALLIS: You can't evaluate just on the basis of frequency of the event. You've got to also look at what you've done to the consequences.

MS. HART: Right, yes.

MR. PADOVAN: Anything else?

CHAIRMAN WALLIS: Okay.

MR. PADOVAN: Thank you.

CHAIRMAN WALLIS: Thank you.

Mike, do you want to make a concluding statement?

MR. SCOTT: Well, I did want to mention one thing, and I'll probably get in trouble with Bob Dennig for this, but we talked about water management. I don't know to what extent you all are aware of this, but the staff is working with NEI and the industry to encourage water management initiatives, and I would suggest that that might be something the committee might want to weigh in when it's a little further along.

We're actually talking to two utilities to potentially be pilot plants for pursuing water management initiatives. So it's pretty early in the process, but I think there might well be a stage where you all might want to get involved.

And I say Bob Dennig because he's the lead for that with the staff.

CHAIRMAN WALLIS: What you mean by water management, I think, is if you have water, you want to conserve it to cool the core if you possibly can rather than using it to do other things which might not be necessary. Is that water management mostly?

MR. SCOTT: I'd state it slightly differently. It is taking actions to management the inventory of water you have in the RWST.

CHAIRMAN WALLIS: The clean water that you have.

MR. SCOTT: Right. To minimize the amount of times you demand from the sump.

CHAIRMAN WALLIS: Right, but in principle if you could you'd like to conserve it to cool the core.

MR. SCOTT: Right. So you're talking about changes might be to containment spray.

CHAIRMAN WALLIS: You do need water to

cool the core.

MR. SCOTT: Right.

CHAIRMAN WALLIS: There's a minimum requirement there.

MR. SCOTT: Right. So that's something you all might want to think about.

CHAIRMAN WALLIS: Well, most of this we probably don't have much to say. We're being informed about this. It's interesting. A lot of it is in regulatory space. We don't go too much into regulatory space.

MR. SCOTT: Right. There are some technical issues here related to water management and some other odds and ends.

The pH buffer, of course, is a big consideration. As you saw, the staff is looking at that for a couple of these, and we may see more like it or similar to it.

CHAIRMAN WALLIS: So when do we meet with you again and what are we going to hear? When is the next step where something substantial has happened that we ought to hear about it?

MR. SCOTT: Tom, step up here and remind me what the schedule said.

MR. HAFERA: Well, Ralph and I just talked

about that yesterday. We were originally proposing an update for you in November on our audit activities. However, from what I understand, you as a committee are very busy with some other higher priority items.

CHAIRMAN WALLIS: Some of your colleagues have started to snow us with some other requests.

MR. HAFERA: And we're graciously willing to postpone --

(Laughter.)

MR. HAFERA: -- to defer to our colleagues and give them the more valuable time.

CHAIRMAN WALLIS: Is that the way it worked or did you somehow get in league with them?

(Laughter.)

MR. HAFERA: No. To be perfectly honest, I was asked. We were requested. The ACRS has some other very high priority items and --

CHAIRMAN WALLIS: Well, we were told by the Commission to make this sump blockage question a major priority. They don't usually tell us to prioritize something, and they did ask us to prioritize this one. So I think if you had something substantial to bring to us, we would make space for it.

MR. SCOTT: Well, let me tell you where

we're going to be if the subject is the audits. We are right in the process of doing Audit No. 2. We did an audit of Watts Bar that we're just about ready to finalize the report on, and we are in the middle of auditing San Onofre.

CHAIRMAN WALLIS: Watts Bar is interesting because I think they are taking credit for settling out of some of the debris before it gets to the strainer.

MR. SCOTT: No, no. Watts Bar is pretty much --

CHAIRMAN WALLIS: That's what they told us or maybe you told us the last time you presented to us.

MR. SCOTT: Well, one thing about Watts Bar is they don't have much debris.

PARTICIPANT: They don't have any fiber.

DR. LU: It's an RMI plant, and they assume 100 percent of transport role of the RA coating debris. So they took the credit from the CS-3D CFD calculation for the RMI.

CHAIRMAN WALLIS: Take credit?

DR. LU: Yes, they did. They did take credit, but not too much, but ten percent or 15 percent. I cannot remember the exact number. So we

are pretty much done with Watts Bar. That's what Mike says.

CHAIRMAN WALLIS: Watts Bar is actually assuming a large amount of paint comes loose.

DR. LU: That's right. The entire containment.

CHAIRMAN WALLIS: Right.

MR. SCOTT: But even so, they are a low susceptibility plant.

So we're finishing that one up. We're in the middle of San Onofre. We're planning to visit Prairie Island in the fall. So were we to come back to you in the November-December time frame, we'd have some information on those three audits. A lot of it would still be preliminary. You might actually benefit more. We might actually benefit more from an interaction in -- let's see. You all don't usually meet in January, if I recall correctly -- maybe in the February time frame on that?

CHAIRMAN WALLIS: Like that, sure. Okay.

MEMBER KRESS: Thank you.

CHAIRMAN WALLIS: Anything else we need to do today?

MEMBER MAYNARD: I've just got a couple of comments.

CHAIRMAN WALLIS: Yes, please.

MEMBER MAYNARD: First of all, I found the presentations all very informational and I really appreciate it. I think everybody did a good job.

One thing that I didn't see that I think perhaps needs to be address in some of this testing, and that's temperature effect on some of the debris. Is there a point someplace below boiling but above 100 degrees where some of these tests were being done where some of the debris may have a significant change in its characteristic?

And what I'm thinking of is maybe a paint chip or something like that. Is there some point where it significantly softens or whatever?

I doubt that there is, but I just didn't see any explanation that said it doesn't significantly change characteristics.

MEMBER KRESS: It looked like that would be an easy thing to look at.

MEMBER MAYNARD: Yes.

MEMBER KRESS: You wouldn't have to do a blockage. You could just look at what happens to the paint chips after they got hot.

CHAIRMAN WALLIS: but you might want to also see if there's any effect on the strainer.

MEMBER KRESS: Yes, if there was any effect on it.

CHAIRMAN WALLIS: Suppose the paint chip does get softer. Does it make any difference?

MEMBER KRESS: Then you run a blockage test.

MR. HAFERA: Excuse me. Tom Hafera again from staff.

If you recall when we presented some research that was done, Irv Geiger is not in the room right now, but we did do some testing on paint chips with Carderock, and they did heat the chips up to 140 degrees at that time.

CHAIRMAN WALLIS: They were all pretty stiff.

MR. HAFERA: Yes, yes.

CHAIRMAN WALLIS: They didn't soften.

MR. HAFERA: Yes. If you recall, they said that they created curled chips, right? And they heated them up, and as they heated, they softened and flattened out and sank. So there was a tendency for the curled chips to actually flatten and sink at around 140 degrees.

MEMBER MAYNARD: And I just think that from what I heard that either the staff or the

licensee, somebody needs to address it. It sounds like you may have the information for that, but it still --

CHAIRMAN WALLIS: Well, a flat chip if it landed across some poles on a string, it would be more effective at blocking it than a curling chip.

MR. HAFERA: Yes, but again, what they found was then they sink and sit on the floor and don't transport.

MEMBER MAYNARD: One other general comment I have. It looked like in my opinion NRC may be forcing more conservatism than necessary on the transport, trying to get everything out. It looks like all of these test facilities had to do a lot of work to get the debris suspended into the screen, and my concern is that we may end up with overly conservative, much larger screens than what's really needed and may have some other consequences, additional dose in containment doing work. It's going to be harder to do work.

There's a number of other things that could factor into this if we make these screens significantly larger than what they need to be. So just kind of as a general comment there.

But I did enjoy the presentations. It

looks like a lot of good work is going on.

MR. SCOTT: If I can interject one thing on that, one point to consider is that the chemical effects which are as yet unresolved may drive them larger. We may be glad at the end of the day we had that extra space. It's not predictable at this point.

MEMBER MAYNARD: I understand.

CHAIRMAN WALLIS: Well, what we missed today and yesterday was the utility's point of view, and we heard from the people who are selling strainers, and they seem to be interested in understanding what's happening. The utility is interested in what's good for the plant. That gets a bit to your topic here, and what's optimum for the plant may be somewhat different than what the vendor of the strainer thinks is appropriate.

Is there any prospect of hearing from the utilities some time down the road?

MR. SCOTT: Well, you did hear from the owners group a little bit today. You heard from Mo, right?

CHAIRMAN WALLIS: But you have to hear something really specific. I think you have to have sort of a case history of what happened to the particular place, why they chose certain strainers,

how they made the decisions and so on. That really is quite a technical thing.

MR. BUTLER: Dr. Wallis, I of course cannot volunteer someone, but if there is a strong interest in hearing a licensee perspective maybe at the appropriate point in their design plan --

CHAIRMAN WALLIS: Maybe we should.

MR. BUTLER: -- I think we could probably find or force a volunteer.

(Laughter.)

CHAIRMAN WALLIS: Is there any interest in the committee in hearing from licensees?

MEMBER KRESS: Yes, I think that would be great.

CHAIRMAN WALLIS: Maybe we should think about that, Ralph, next time, which will perhaps be next year.

MR. DINGLER: Do you want to look at the January-February time frame? That gives us time.

CHAIRMAN WALLIS: It's much easier to travel. No thunderstorms.

MR. DINGLER: No snow on the ground and stuff like that.

CHAIRMAN WALLIS: Okay. Anything else?

I agree with you. The presentations were

well prepared and presenters were very responsive to questions and so on. What was, as we said, lacking was data, but the overall impression was a good one, I think.

Okay. It's nice to finish on the hour. I'd like to finish at three o'clock. Are we ready to do that?

The words are adjourned. I adjourn the meeting. Thank you all very much.

(Whereupon, at 3:00 p.m., the meeting was adjourned.)

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 Thermal Hydraulics

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.

Katherine Sykora
Official Reporter
Neal R. Gross & Co., Inc.

PWR Owners Group
Long-Term Core Cooling Project

ACRS Meeting

August 23, 2006

Where We Are Today

Fuel Evaluations

- Method presented in WCAP 16406-P used to evaluate collection of fibrous debris on fuel components
  - Assumed a large capture efficiency of fibrous debris on first fuel component in flow stream
  - Assumed fibrous debris "mats" like those formed on a flat screen or perforated plate
  - NUREG/CR-6224 head loss correlation used to conservatively assess head loss across this fuel/fiber bed
  - Based on this evaluation approach, small amounts of fibrous debris result in prediction of "thin bed effect" pressure drops
- Method used to evaluate all PWRs for fuel blockage

Path Forward

Project Objective

- Develop methods and evaluations to show the acceptance criteria are met
  - Blockage of Normal Core Flow Paths
    - Assess flow needed to remove decay heat
  - Localized buildup of debris and hot spots
    - At grid spacers and due to plate-out
  - Chemical effects
    - Precipitants
    - Plate-out

Schedule of Tasks

- Tasks have been scheduled to:
  - Address areas of uncertainty and vulnerability
  - Confirm long-term core cooling capability
  - Take advantage of "lessons learned" from previous work
- Schedule of the PWROG work:
  - Blockage of normal core flow paths
  - Localized buildup of debris and hot spots
  - Chemical effects on long-term core cooling capability

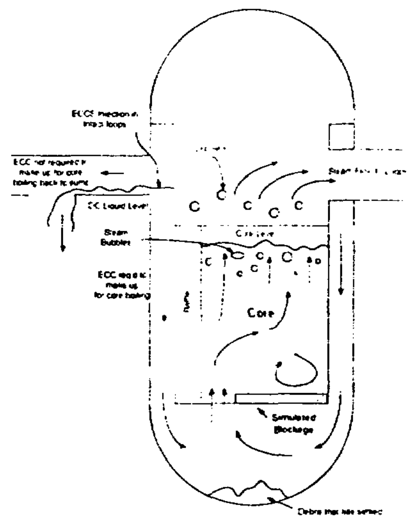
Cold Leg Break Scenario

Considerations

- Earliest time for blockage formation is at switchover from injection to recirculation
  - ~20 minutes for large break LOCA
- Flow rate is determined by density difference between downcomer and core inventory
  - Decay heat is low, decreases with increasing time
  - Flows are low
- No flow through alternate paths

Current Evaluation

- Limited ability to lift debris up to fuel
- Limited ability to compact debris lifted to bottom fuel component



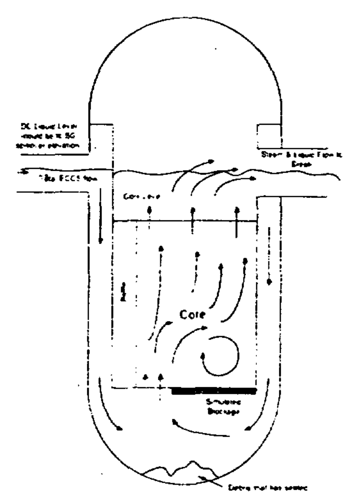
Hot Leg Break Scenario

Considerations

- Earliest time for blockage formation is at switchover from injection to recirculation
  - ~20 minutes for large break LOCA
- Flow rate is determined by ECCS pump capability
  - Flow exceeds that needed for decay heat removal
  - Limited / no boiling in core
- No flow through alternate paths

Current Evaluation

- Some ability to lift debris up to fuel
- Still insufficient ability to compact debris lifted to bottom of fuel component



Current Core Blockage Study

- Current results for assumed 80% blockage
  - The majority of the core is minimally affected
    - Some boiling would begin just above the blockage
    - As the steam rises, cooler fluid from the periphery would be drawn in laterally
    - This behavior is observed to be limited to the lower portion of the core
  - A bounding calculation of superheat at the fuel rod surface was performed
    - The most severely blocked region of the model were used
    - An upper bound of about ~400° F was evaluated which, in turn, was correlated to a clad surface temperature of ~600° F
    - This is well below 2200° F PCT limit

Additional Core Blockage Studies

Using RELAP 5

- Used a W 4-loop reactor core, reactor vessel flow areas and loss factor data
- Double-ended cold leg breaks analyzed - limiting condition for water supply to the core
- Initial results - no core reheat for blockages up to 99% (0.153 ft^2) at the beginning of sump recirculation

Using TRACE

- Used core inlet strainer inputs from industry
- TRACE model description
  - Core divided into 8 radial segments, with 4 rings and 14 elevations
  - No bypass flow between core and volume outside baffles
  - Double ended cold leg break assumed
  - Recirculation starts at 1200 sec
- Initial Results are comparable to those obtained from RELAP 5

Task Description

Localized Build-up of Debris and Hot Spots

- NEA/CNSI/R (95)11
  - Fibrous collection on fuel grids – Section 5.4.2.3
    - Test Conditions
      - ➢ Unheated BWR bundle 3 meters long (3 spacer grids)
      - ➢ Flow rate was typical of post-LOCA natural circulation for BWRs
      - ➢ Rockwool debris used
        - » Thermally treated to drive off binder
        - » Disintegrated by small steam jet
    - Observations
      - ➢ Fibrous debris did collect in spacer grids
      - ➢ Some head loss increase observed
      - ➢ However, flow continued to be provided through fiber bed

Task Description

Localized Build-up of Debris and Hot Spots

- Local flow blockage in rod bundles has been studied extensively
  - Full Length Emergency Core Heat Transfer Test (FLECHT) Program (1970, 1971)
  - Thermohydraulic Tests with Bundles of Ballooned Rods Simulating the Reflood Phase of a LOCA, reported at 1977 ANS Meeting
  - FEBA (Flooding Experiments with Blocked Arrays) in Partially Blocked 25-Rod Bundles (1980)
- Initial conditions
  - Start of core quench; high decay heat, heater rod temperatures ≥ 1100° F
  - Various blockage configurations and flooding rates
- Observations
  - Presence of up to 90% blockage improved heat transfer downstream of blocked area due to:
    - Increasing turbulence and mixing
    - Break-up of liquid phase and increasing liquid surface area

Task Description

Chemical Effects

- Demonstrate techniques to perform sensitivity analyses for pH and temperature effects on solubility of chemical precipitates to identify the influence of these parameters on key chemical interactions
- Demonstrate Long-Term Core Cooling is maintained
  - May be plant-specific (uses plant-specific inputs for chemical interactions)
  - Identify methodologies to predict precipitation and deposition on relevant core components
  - Perform sample evaluations to guide plant-specific use of recommended evaluation tools

Program Summary

- Considerable work already performed
  - Available results indicate success in demonstrating Long-Term Core Cooling for a wide range of conditions
- Additional work identified to:
  - Address phenomena in more detail
  - Refine analyses while demonstrating significant margin for Long-Term Core Cooling

Licensing Activities Related to Generic Safety Issue (GSI)-191

Presented to: ACRS Subcommittee on Thermal Hydraulics

Presented by: Ruth C. Reyes

Leon Whitney

Safety Issue Resolution Branch

Division of Safety Systems

Office of Nuclear Reactor Regulation

August 24, 2006

Purpose of Presentation

- Inform the Subcommittee about License Amendment Requests (LARs) that address Generic Safety Issue (GSI) 191 resolution

- Discuss the staff's review of licensee requests to extend completion of Generic Letter (GL) 2004-02 corrective actions beyond December 31, 2007

Introduction

- In response to GSI-191 and GL 2004-02, licensees reanalyzed the containment sump
- As a result of the analysis, some licensees identified technical specification changes that are required
- One licensee identified the need for a license amendment based on a change in an evaluation methodology described in the updated final safety analysis report (UFSAR)

GSI-191 – Related License Amendment Requests (LARs) under Review

- Millstone Power Station Unit 3
- Fort Calhoun Station
- Surry Power Station Units 1 & 2
- Sequoyah Nuclear Plant Units 1 & 2
- Robinson
- Comanche Peak Units 1 & 2
- Catawba Nuclear Station Units 1 & 2, and McGuire Nuclear Station Units 1 & 2
- Palisades

UNITED STATES NUCLEAR REGULATORY COMMISSION

Millstone LAR

- Delays initiation of the recirculation spray system pumps
- The proposed change increases net positive suction head (NPSH) margin
- No adverse impact on containment temperature and pressure expected

Fort Calhoun

- Reduces the required number of operable containment spray pumps
- Reduction of flow in the common suction line will increase NPSH margin
- No significant adverse impact on containment temperature and pressure expected

Surry

- Changes method for starting the inside and outside recirculation spray pumps in response to a design basis accident
- The proposed change starts the recirculation spray pumps by coincident containment high pressure and refueling water storage tank low level signals
- No significant adverse impact on containment temperature and pressure expected

UNITED STATES NUCLEAR REGULATORY COMMISSION

Sequoyah (SQN)

- Revised analysis methodology includes development of a three-dimensional computational fluid dynamics model of the debris transport in the sump pool
- The three-dimensional model sizes the flow area for an advanced sump strainer design, which will replace SQN's original sump intake structure
- Different evaluation method from that described in UFSAR

Robinson

- The amendment request is to replace the phrase “trash racks and screens” in the Technical Specifications with the term “strainer(s)” to reflect new design and terminology

- Staff review intended to ensure that replacement strainers are functionally equivalent to existing trash racks and screens under the current licensing basis

Comanche Peak

- This LAR proposed to reduce the allowable value for refueling water storage tank low-low level setpoint and to revise surveillance requirements to allow use of alternate containment spray buffers

Catawba/McGuire

- Implementation of an additional manual operator action that will allow plant operators to manually start one air return fan
- May preclude use of containment spray for many small-break LOCAs
- No adverse impact expected

GSI-191 Extensions

- GL 2004-02 corrective actions due 12/31/07
- SECY-06-0078 extension criteria
  - plan for resolution of outstanding technical issues (with margins)
  - mitigative measures, and
  - temporary improvements to sump or containment materials
- 8 requests approved to spring 2008

GSI-191 Extensions

- Licensee reasons for requests
  - design, testing, and fabrication time
  - technical issues not resolvable by fall 2006 outage
  - complexities of approach
  - expense of installing insulation twice (spring 08 SG replacement)
  - recirculation pump start signal change

Summary

- NRC has received 9 LARs related to the GL 2004-02
- Additional submittals expected for plants that change buffers
- 8 extension requests to spring 2008 approved

License Amendment Request to Remove TSP from the Containment at Palisades

Presented to: ACRS Subcommittee on Thermal Hydraulics

Presented by: L. Mark Padovan
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

August 24, 2006

Purpose of Presentation

- Inform the Subcommittee about the Nuclear Management Company's (NMC's) license amendment request (LAR) to remove trisodium phosphate (TSP) from the containment at Palisades, and give the status of NRC staff's review of the LAR.

Palisades' LAR

- In response to IN 2005-26, "Results of Chemical Effects Head Loss Tests in a Simulated PWR Sump Pool Environment," and Supp. 1, "Additional Results of Chemical Effects Tests in a Simulated PWR Sump Pool Environment," NMC submitted a March 20, 2006, LAR to remove TSP from the containment at Palisades (for one operating cycle).

- LAR includes an interim compensatory measure to use sodium hydroxide (NaOH) injection for post-LOCA sump pH control.

- The NRC issued requests for additional information (RAIs) to NMC and is still receiving responses.

Key NRC Review Considerations

A. Dose Analysis

B. Containment Performance

C. Chemical Effects

A. Dose Analysis Review Considerations

Radiological consequences of design-basis accidents (LOCA)

- Modeling of impact of loss of pH control in containment sump
  - Bounding assumptions for re-evolution of iodine in sump
- Use of potassium iodide (KI) as compensatory measure for control room habitability

B. Containment Performance Review Considerations

- NRC staff is assessing the impact of removing TSP on sump screen blockage, pH control, and hydrogen generation during design-basis accidents (DBAs).

B.1. Impact on Sump Screen Blockage

- Containment sump blockage from formation of calcium phosphate precipitate is a credible failure mechanism for the emergency core cooling system (ECCS) and the containment spray system (CSS) during some loss-of-coolant accidents (LOCAs).

- Thus, reducing the potential for sump screen blockage due to the formation of calcium phosphate reduces the risk of ECCS and CSS failure during recirculation.

B.2 Impact on pH Control and Hydrogen Generation

- Technical Specification (TS) 3.5.5 establishes limiting conditions for pH control of the sump water.

- LAR proposes deleting TS 3.5.5 on an interim basis.

- NMC concluded that removing TSP from containment would have a negligible impact with respect to design-basis hydrogen challenges to containment integrity

C. Chemical Effects Review Considerations

- NRC staff is waiting for NMC's response to remaining RAIs related to NaOH spray pH and aluminum in containment.
- Removal of TSP and delayed introduction of NaOH has potential advantages:
  - No immediate formation of calcium phosphate.
  - Formation of precipitates will occur when pump NPSH margins are higher.
  - Spray containing NaOH will be at lower temperature, thus reducing the aluminum corrosion rate.

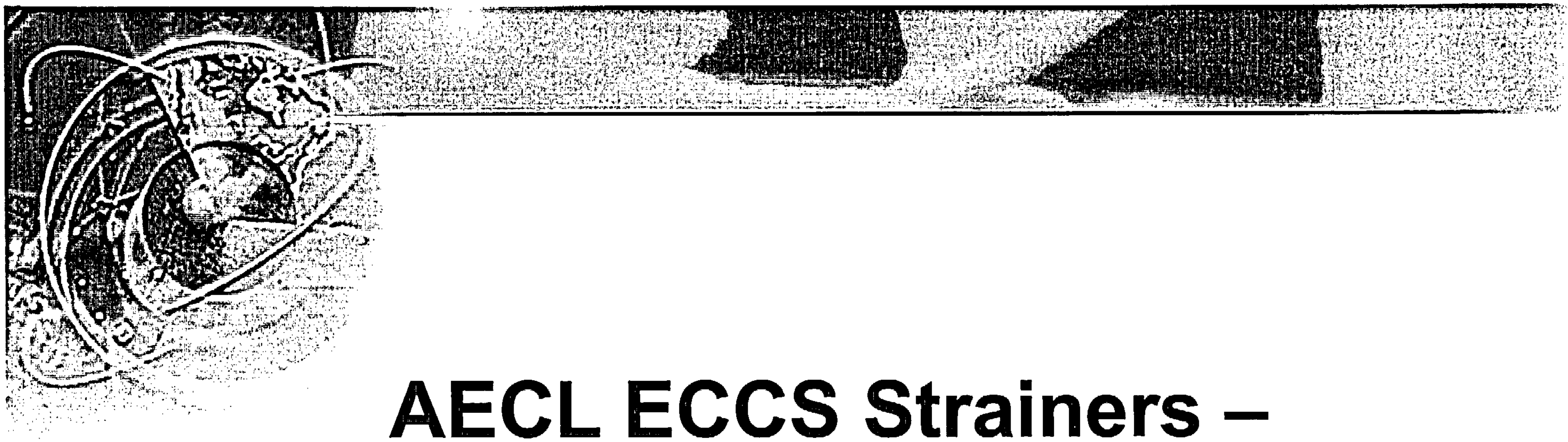
Summary

- NRC staff evaluation is nearly complete, but awaiting RAI responses.

- Preliminary NRC staff conclusions:

  - Estimates of offsite and CR doses meet NRC criteria with CR operator use of KI.
  - The risk of sump blockage following a DBA in containment is decreased.
  - Formation of precipitates will occur when pump NPSH margins are higher.
  - Spray containing NaOH will be at lower temperature, thus reducing the aluminum corrosion rate.

UNITED STATES NUCLEAR REGULATORY COMMISSION



AECL ECCS Strainers – Testing for Dominion and SCEG

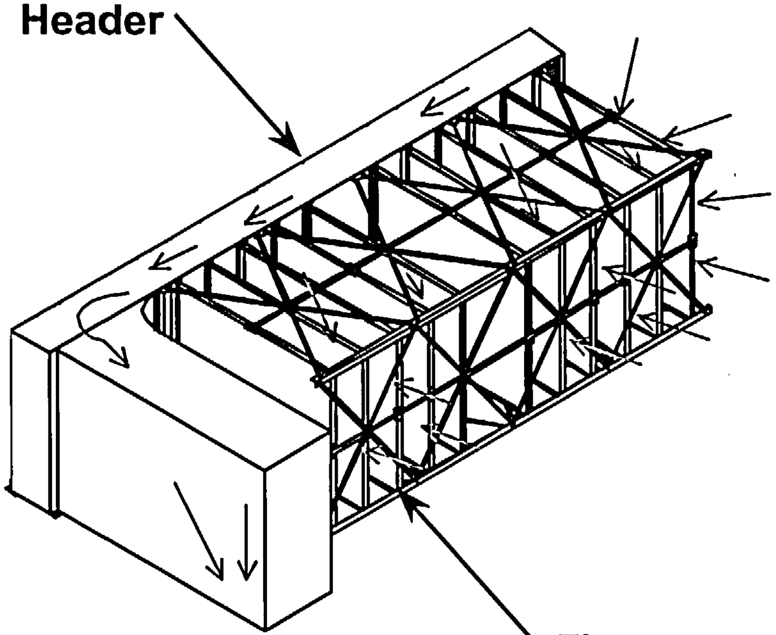
2006 August 24

AECL

Outline

- Overview
- Scaling Methodology
- Debris Preparation Methodology
- Debris Introduction Methodology
- Head Loss due to Chemical Effects
- Screen Bypass Testing
- Termination Criteria
- Reduced-Scale Results
- Large-Scale Results

Overview of Design - *Finned Strainer®* Concept



- **Strainer module consists of a set of perforated fins attached to a common header**
- **Water passes into fins, then through header towards pump intake**

®*Finned Strainer* is a Registered Trademark of AECL

Overview of Facilities

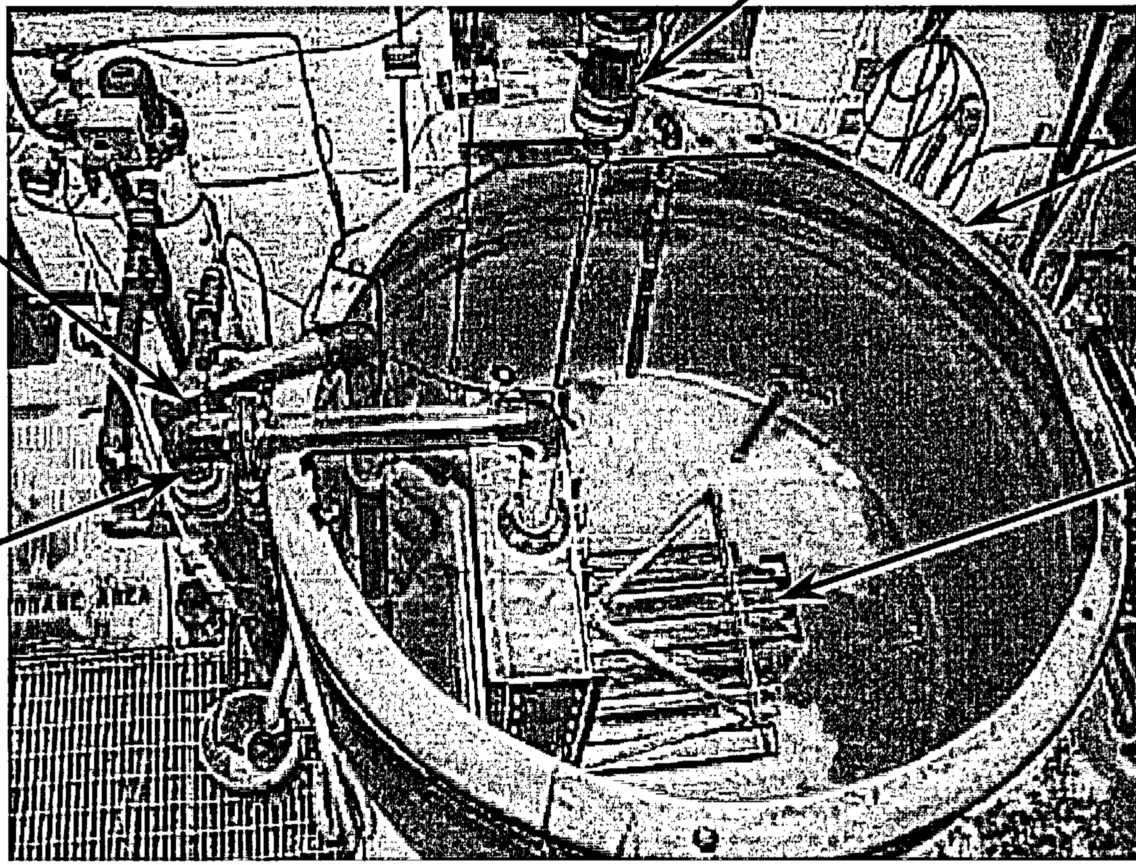
Reduced-Scale Facility

- Test 2 or 3 fins
- Optimize strainer area
- Optimize fin pitch
- Determine head loss due to chemical effects

Large-Scale Facilities

- Test 1 module (8 to 16 fins)
- Verify head loss performance for each strainer design

Reduced-Scale Facility

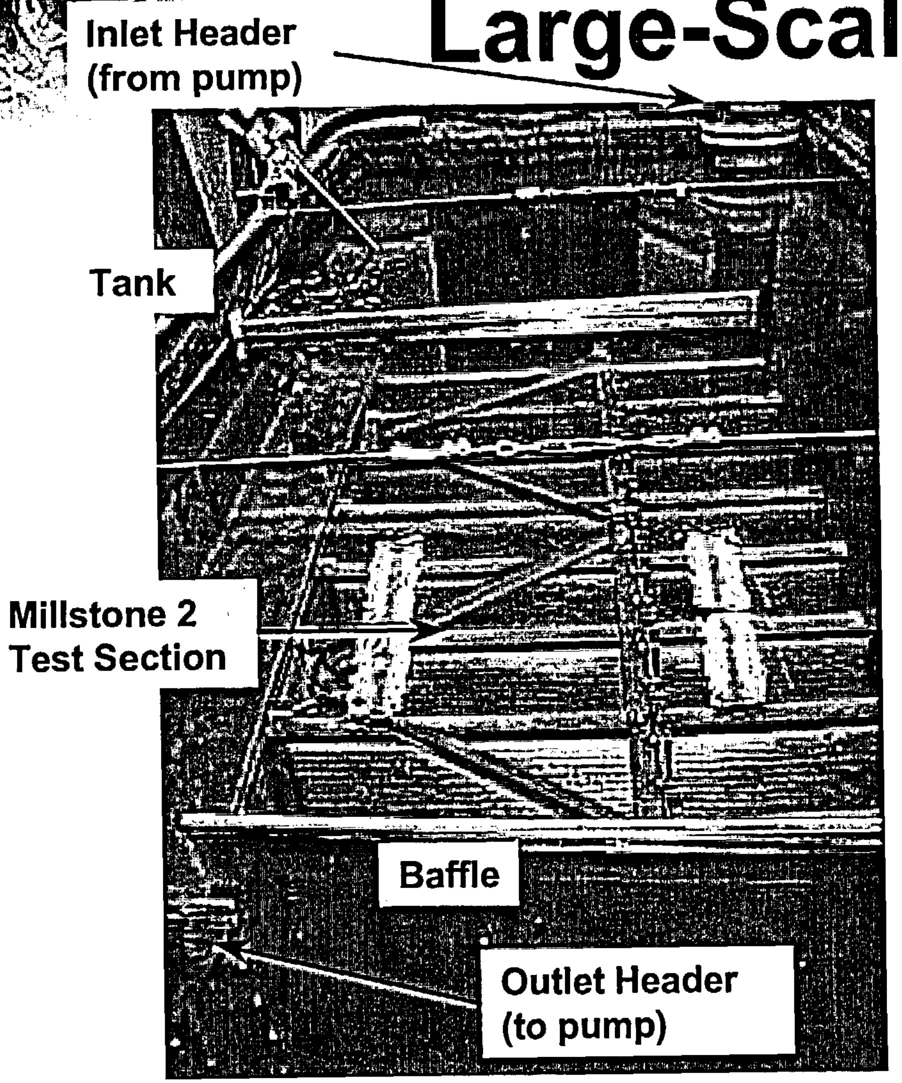


Rig 33

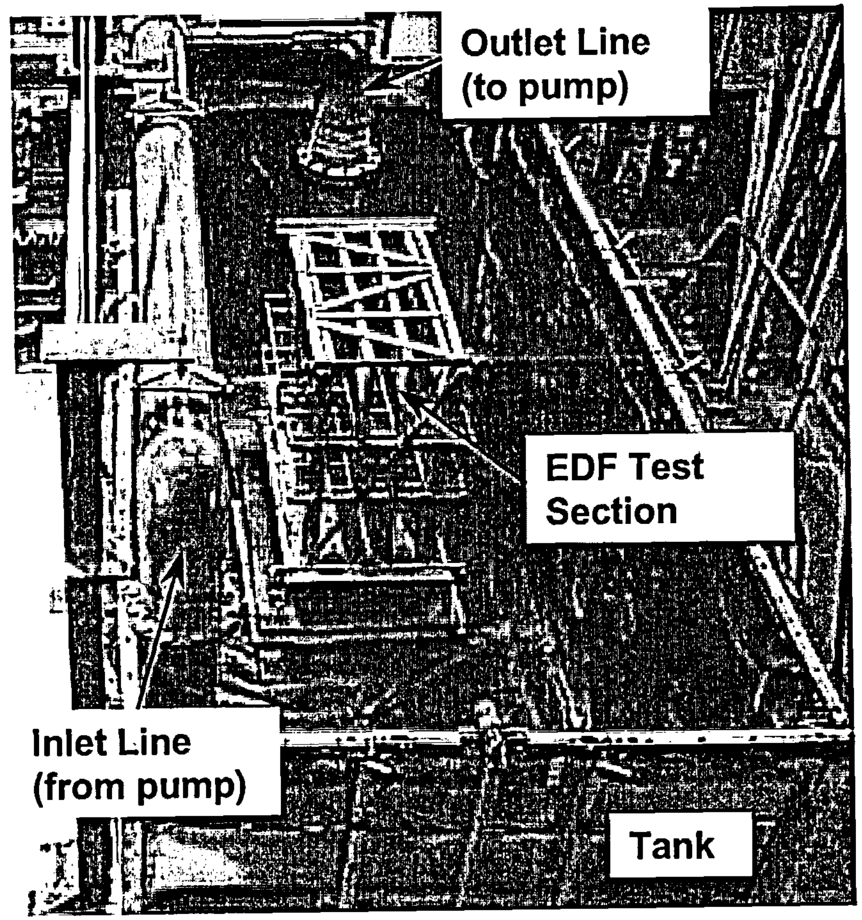
Reduced-Scale Facility

- Tank dimensions: 90” dia., 56” height, 1500 gal.
- Instrumented with thermocouple (temperature), flow meters (flow rate through test section), and differential pressure transmitter (debris bed head loss).
- Flow rates from 2 to 115 GPM.
- Water temperatures from 50 to 120°F.
- Use service water from river (samples analyzed for suspended solids)
- Stirrer used to mix water, maintaining suspension of debris.

Large-Scale Facilities



Rig 42



Rig 85

Large-Scale Facilities

Rig 42

- Tank dimensions: 6' deep, 8' wide, 19' long, 6500 gal.
- Instrumented with thermocouple (temperature), flow meters (flow rate through test section), and differential pressure transmitter (debris bed head loss).
- Flow rates from 80 to 3000 GPM.
- Water temperatures from 60 to 120°F.
- Use service water from river (samples analyzed for suspended solids)

Rig 85

- Tank dimensions: 7.5' deep, 8' wide, 18' long, 8000 gal.
- Instrumented with thermocouple (temperature), flow meters (flow rate through test section), and differential pressure transmitter (debris bed head loss).
- Flow rates from 300 to 3000 GPM.
- Water temperatures from 50 to 120°F.
- Use service water from river (samples analyzed for suspended solids)

Overview of Licensees

		RS	LS	CE
Dominion –	Millstone 2	✓	✓	fall
	Millstone 3	Sep	Oct	winter
	Surry 1 & 2	✓	Sep	fall
	North Anna 1 & 2	Aug	Oct	winter
SCEG –	V.C. Summer	N/A	Aug	N/A

RS = Reduced-Scale

LS = Large-Scale

CE = Chemical Effects

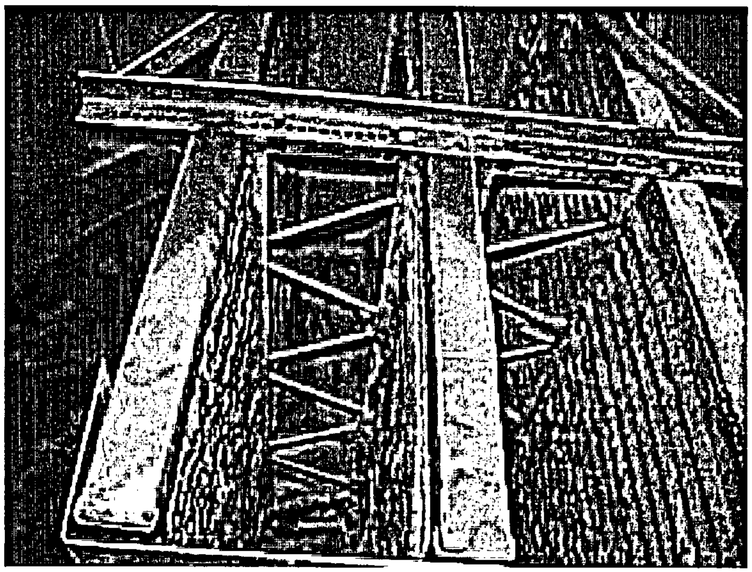
Overview of Design Parameters

Plant	Debris Mix	Hole Size (in.)	Available NPSH Margin (ft)	Area (ft^2)	Approach Velocity (ft/s) (mm/s)
Millstone 2	Fiber/Part.	1/16	2.3	6250	0.0024 (0.74)
Surry 1 & 2	Fiber/Part.	1/16	4 6.4	6150 2200	0.0046 (1.4) 0.0034 (1.0)
North Anna 1 & 2	Fiber/Part.	1/16	5 8.5	4360 ~2050	0.0065 (2.0) ~0.0044 (~1.3)
Millstone 3	Fiber/Part.	1/16	7.3	~4760	~0.0039 (~1.2)
V.C. Summer	RMI	1/16	6 to 11	2380 & 2940	0.0075 (2.3)

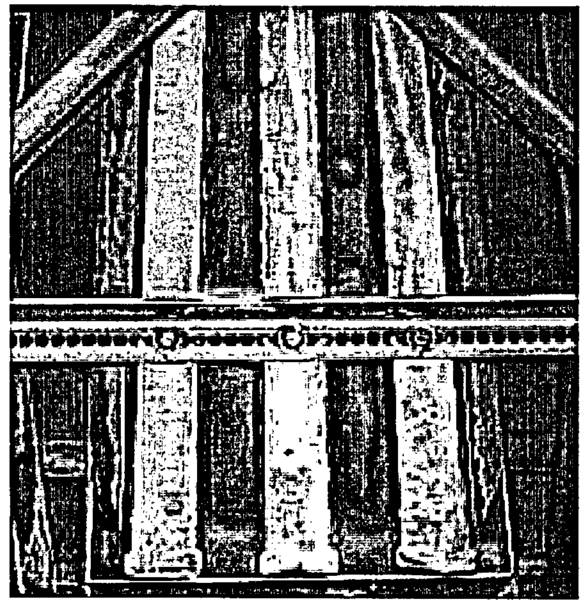
Scaling Methodology - Geometry

Test geometry and procedure are designed to minimize debris settlement outside of test section:

- **Stirrers used to add turbulence**
- **Tank bottom brushed to re-circulate debris**



Millstone 2 Thin Bed Test – 70% of debris volume on test section



Surry RS Thin Bed Test – >95% of debris volume on test section

Scaling Methodology - Temperature

Tests conducted at 104°F (40°C):

- Debris bed head loss measured at 104°F,
- Allowable head loss at sump temperature "viscosity-corrected" to test temperature:

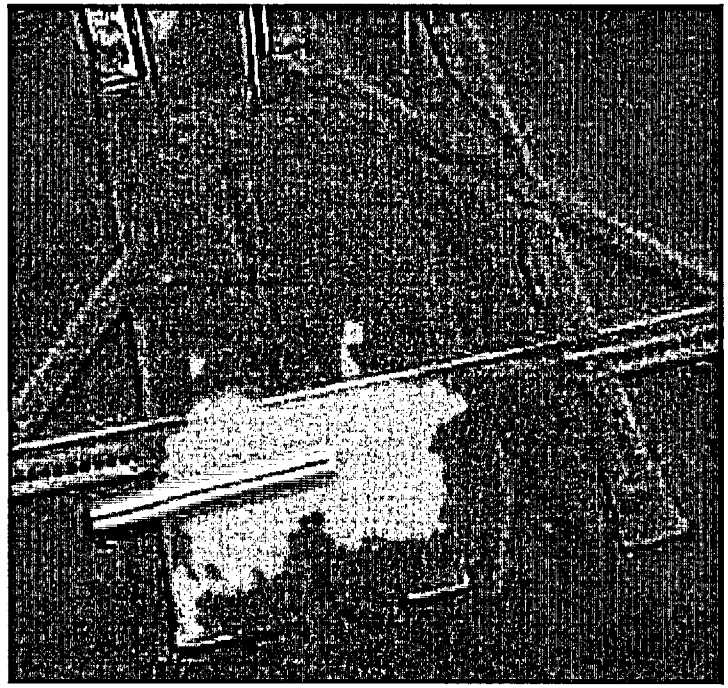
$$\Delta H_{vc} = \Delta H_{a}\left(\frac{\mu_t}{\mu_s}\right)$$

- Measured head loss compared to "viscosity-corrected allowable.

Scaling Methodology – Modular Strainer Set Up

Tests conducted under full debris loading conditions for designs where encapsulation is allowed to occur

Millstone 2 Full Debris Load Test



North Anna RS Full Debris Load Test

Debris Preparation Methodology

Debris Types

- RMI – Transco RMI Foil
- Fiber – Mineral Fiber/Knauf, Mineral Wool (Fibrex, Paroc), Fiberglass (Nukon, TempMat, Cerafiber, Thermal Wrap)
- Particulate – Calcium Silicate, Marinite, Microtherm
- Coatings – Qualified and Unqualified Coatings

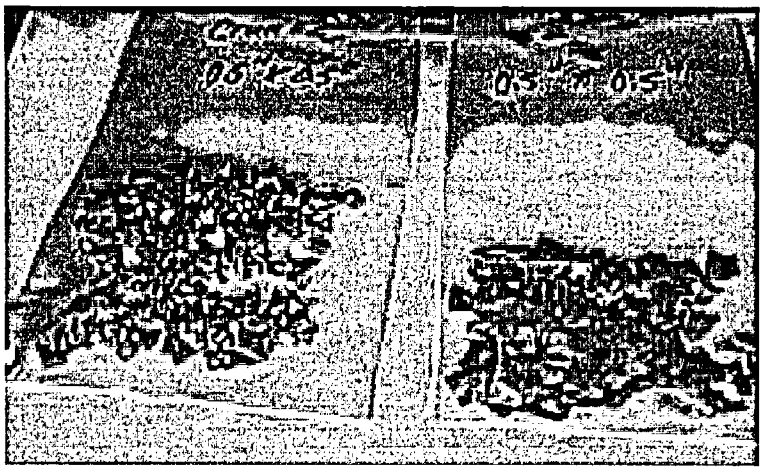
Surrogates

- Coatings as Particulate – Walnut Shell Flour (-325 Mesh)
- Asbestos – Fiberglass (Cerafiber)
- Latent Fiber – Fiberglass (Nukon, Thermal Wrap)
- Latent Particulate – Walnut Shell Flour

Debris Preparation

Preparation of RMI Debris for non-RMI Plants

- Cut RMI foil into pieces ranging from ½" x ½" to 6" x 6" according to specified distribution
- Slightly crumple (bend) one-half of pieces in each category
- Crumple (into loose ball) one-half of pieces in each category



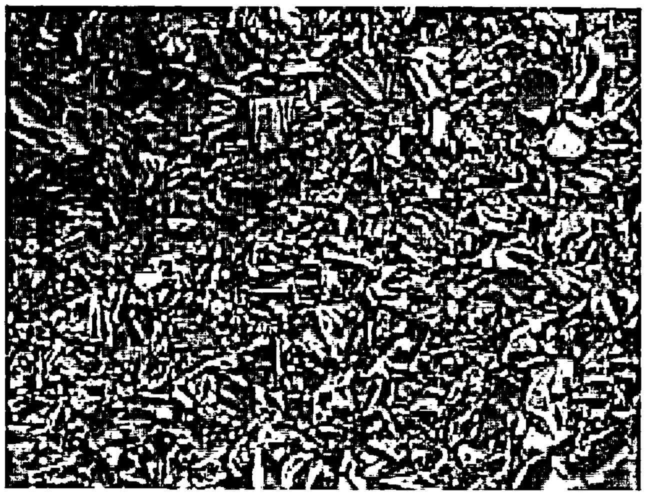
½" x ½"

4" x 4"

Debris Preparation

Preparation of RMI Debris for RMI Plants

- Purchase pre-cut RMI foil in pieces ranging from ½" x ½" to 6" x 6"
- Mechanically crumple pieces in each category
- Weigh-out quantities of each category according to specified distribution



1" x 1"

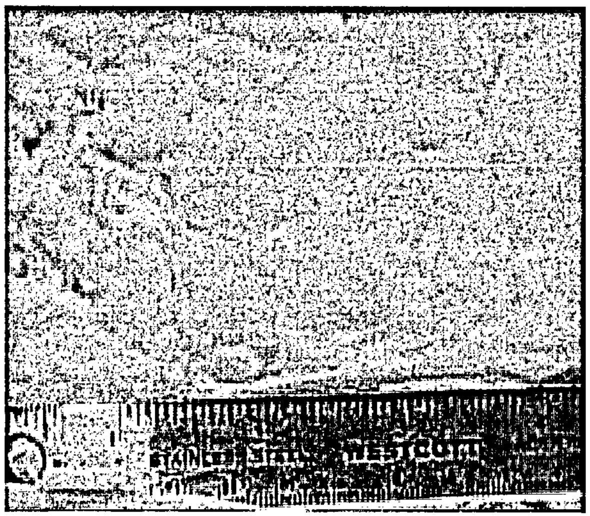
4" x 4"

Debris Preparation

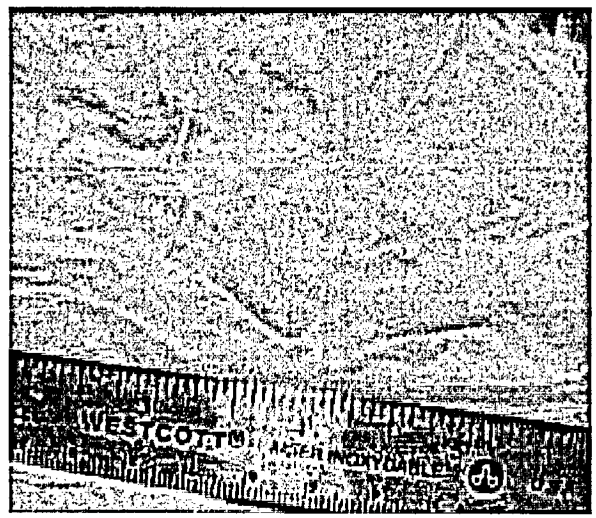
Preparation of Fibrous Debris

- Cut fiber batts into small pieces
- Shred pieces using a leaf shredder
- Mix weighed quantities of fiber with water
- Agitate mixture for ~2 min. with water jet from pressure washer to separate fibers

Paroc



Cerafiber

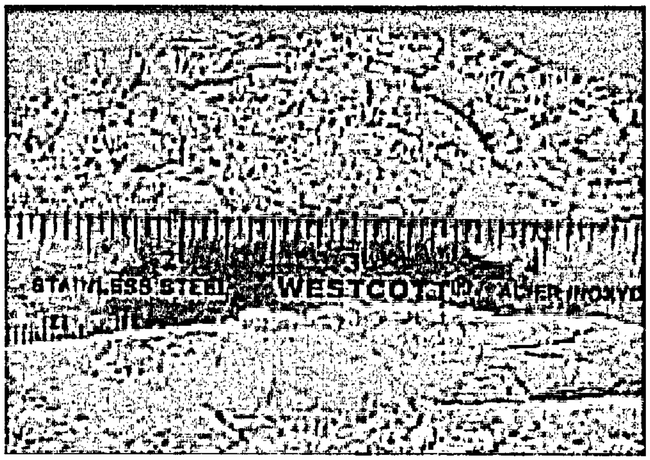


TempMat

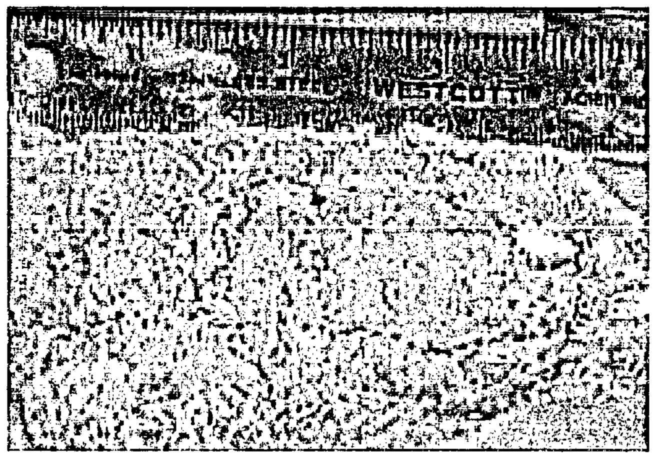
Debris Preparation

Preparation of Particulate Debris

- Crush particulate using a hammer mill (if required)
- Weigh quantities for each addition



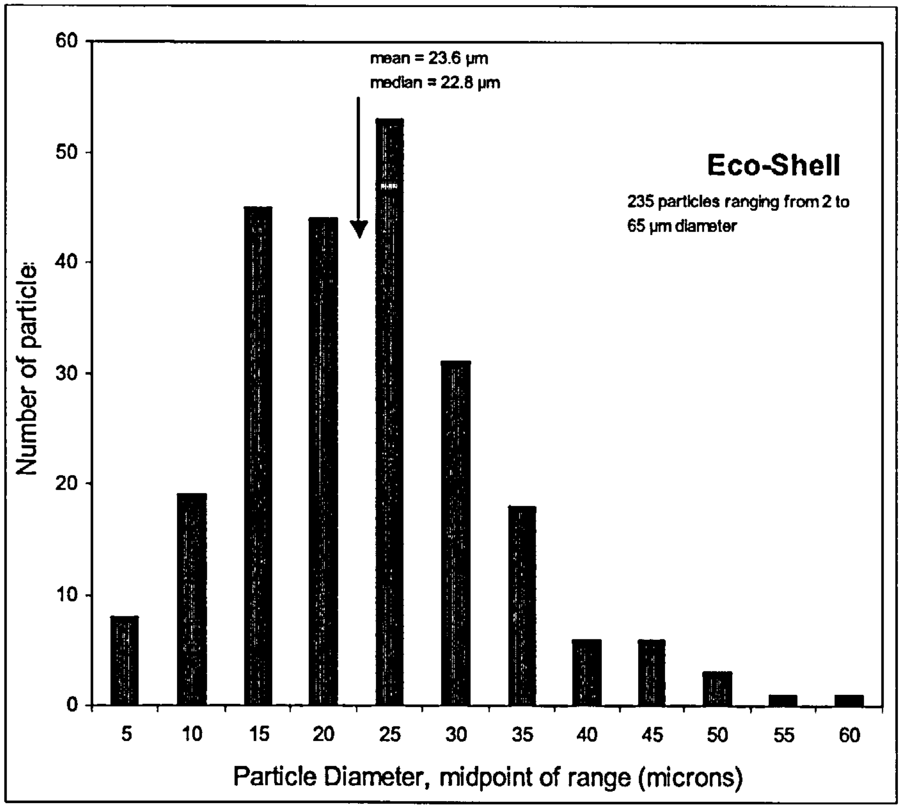
Walnut Shell

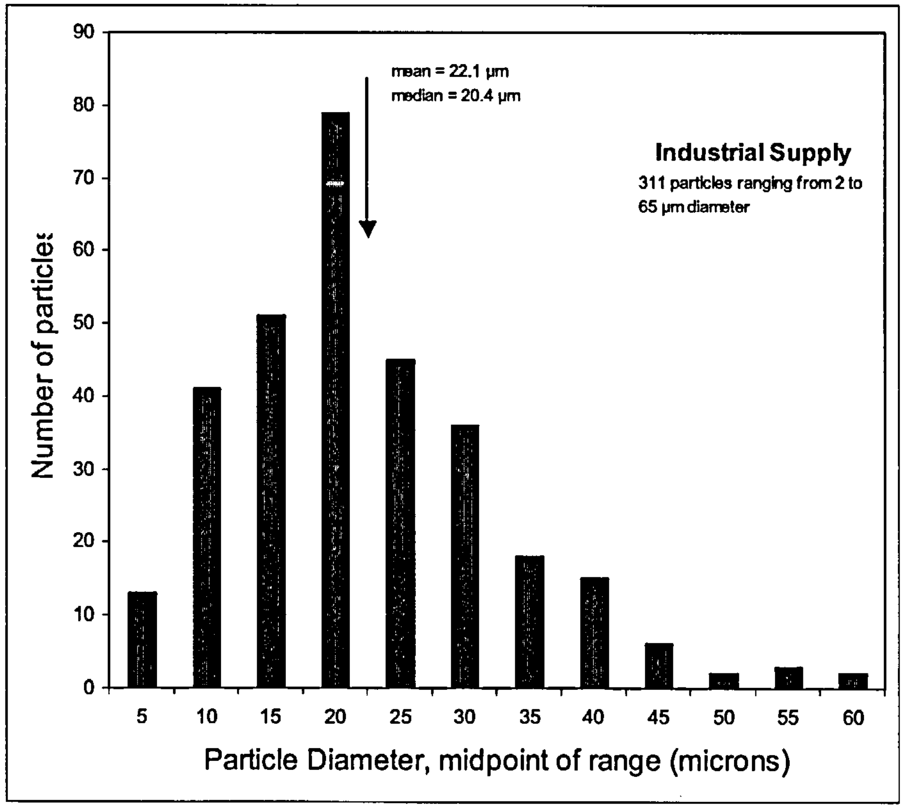


Calcium Silicate

Debris Preparation

-325 Mesh Walnut Shell Flour Particle Size Distributions



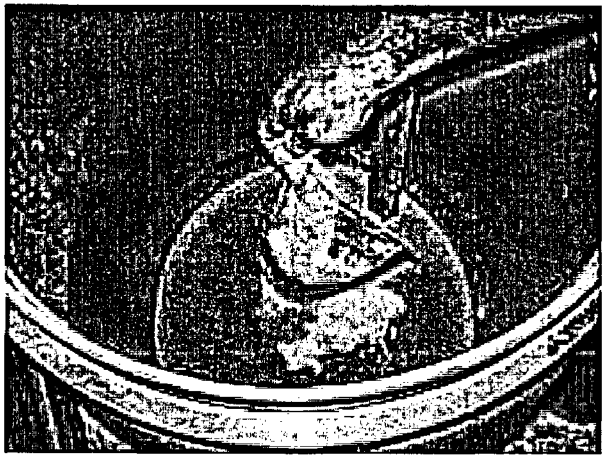


Debris Introduction Methodology

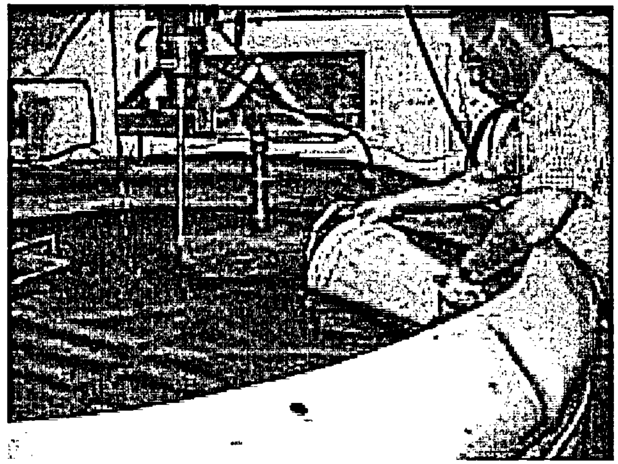
Debris Additions (Thin-bed Tests)

1. Mix particulate
2. Add particulate
3. Pressure wash fiber in batches (1/16" theoretical bed thickness per batch)
4. Add fiber in batches, waiting between additions for pressure stabilization for that fiber quantity

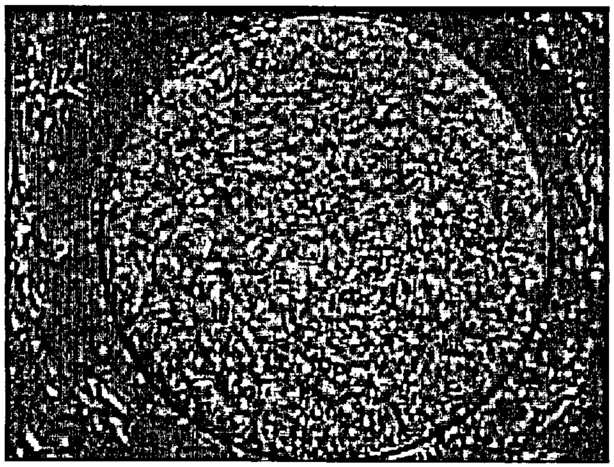
Debris Introduction – Reduced-Scale



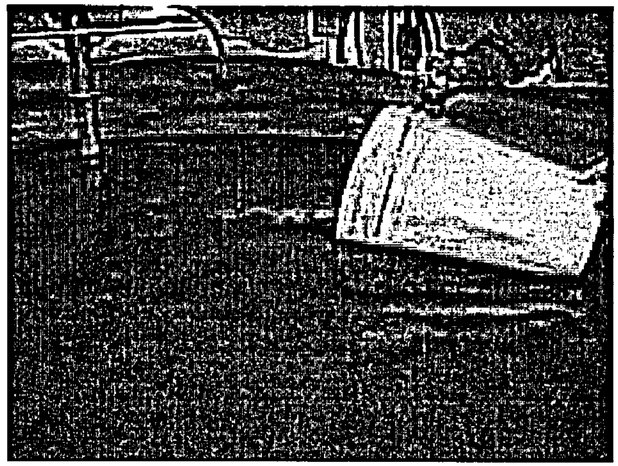
1. Mixing particulate



2. Adding particulate



3. Pressure washing fiber



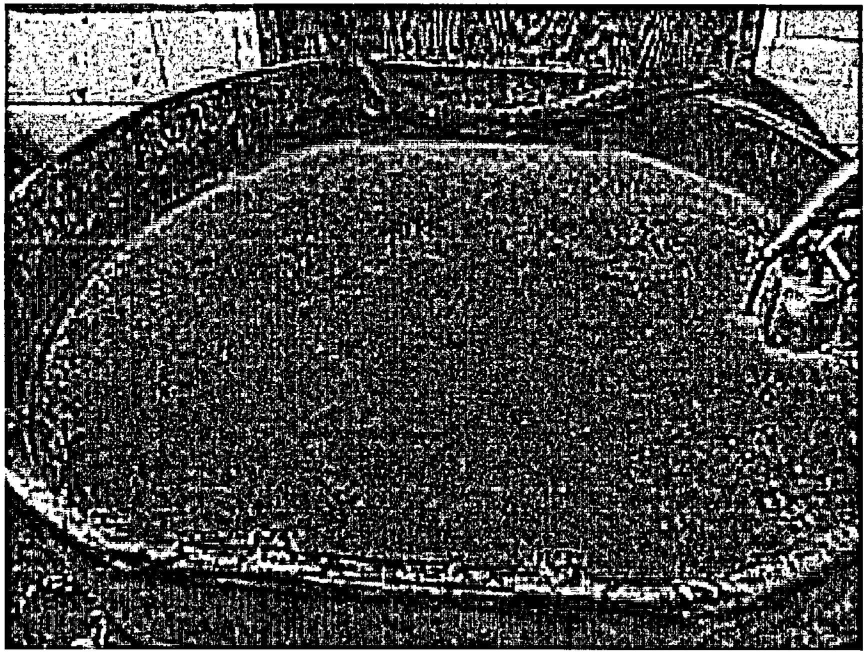
4. Adding fiber

Debris Introduction

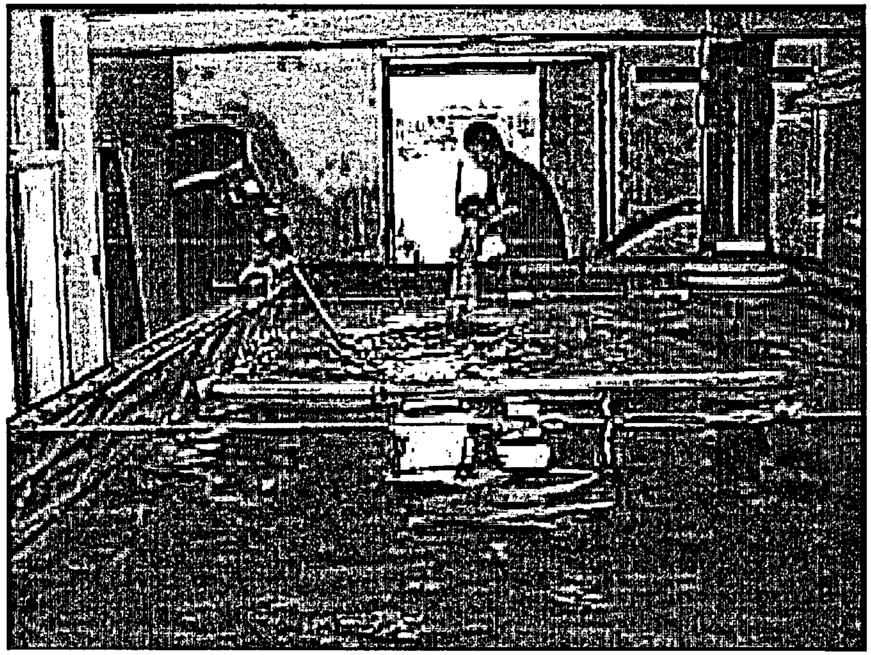
Debris Additions (Full Debris Load Tests)

1. Drop large pieces of RMI between fins
2. Mix particulate, fiber and small RMI in batches (10 to 25% of total)
3. Add batches to tank
4. Brush bottom of tank between additions and periodically after all additions to encourage debris transport to the test section

Debris Introduction – Large-Scale



1. Mixing and pressure washing debris



2. Adding debris

Head Loss due to Chemical Effects

- **Purpose – to determine the increase in debris bed head loss due to chemical reactions that form precipitates**
- **Will do testing for each strainer design in reduced-scale facility with appropriate pH and boron concentration**
- **Methodology under development with Dominion and Sargent & Lundy using WCAP-16530-NP as guidance**
- **Will start with a bench-top program to show that appropriate precipitates can be produced**
- **Proposed reduced-scale test methodology:**
  - **Form thin-bed on test section in tank,**
  - **Produce precipitate in smaller tank,**
  - **Add precipitate to test tank, and**
  - **Observe increase in head loss.**

Screen Bypass Testing

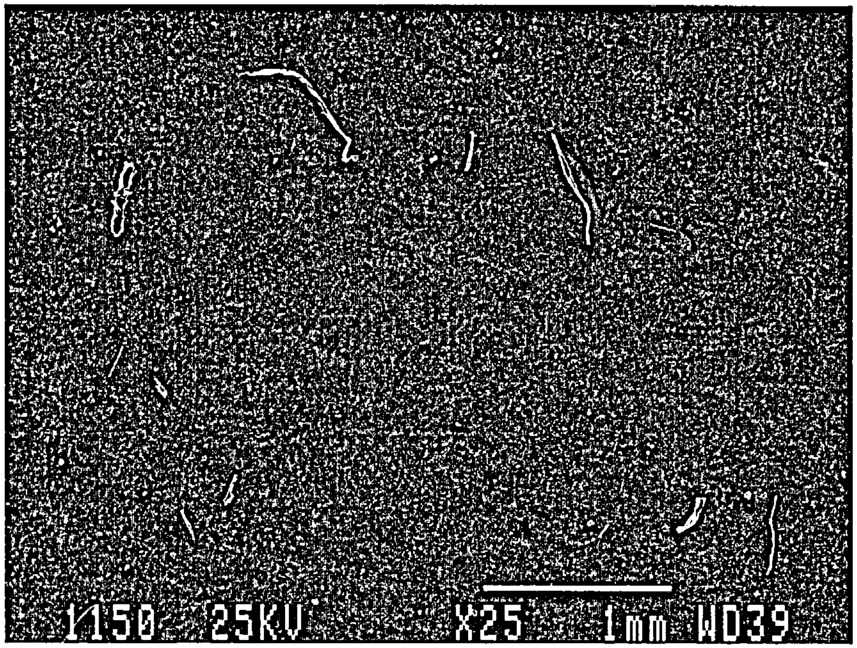
Separate Fiber and Particulate Bypass Testing

- Fiber only tests to assess fiber bypass
- Latent fiber and particulate tests to assess particulate bypass
- Samples filtered and weighed to determine total bypass
- SEM/EDX to identify types and sizes of debris

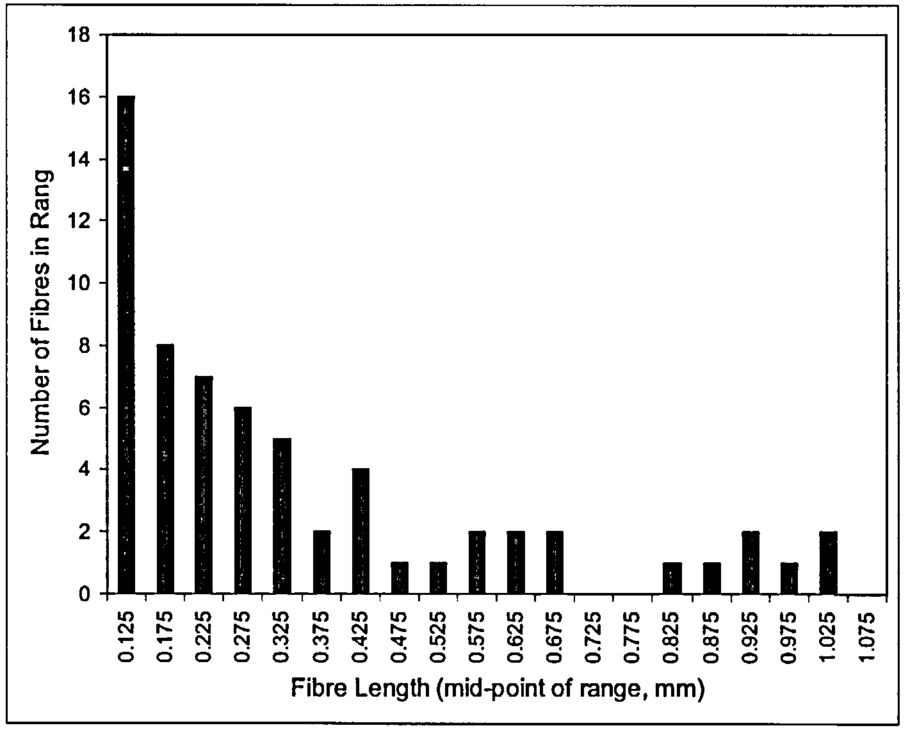
Screen Bypass Testing

Millstone 2 Fiber Bypass Results

1/2 of 3rd Turnover



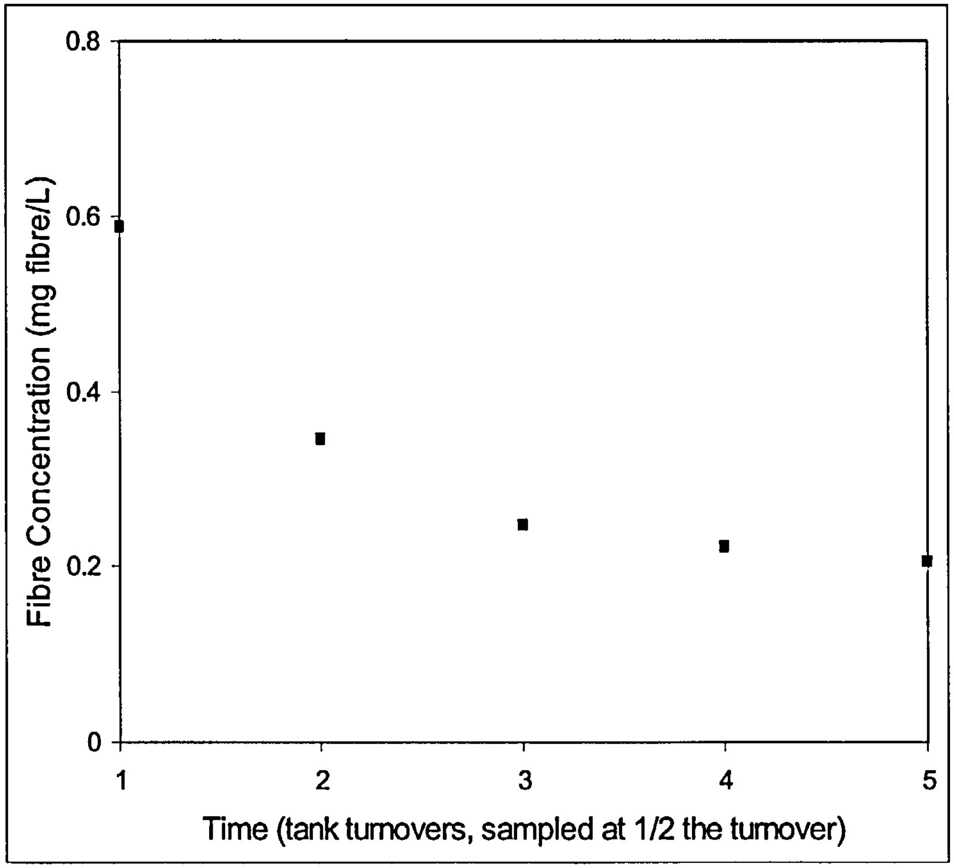
Typical SEM Micrograph



Distribution of Fiber Lengths

Screen Bypass Testing

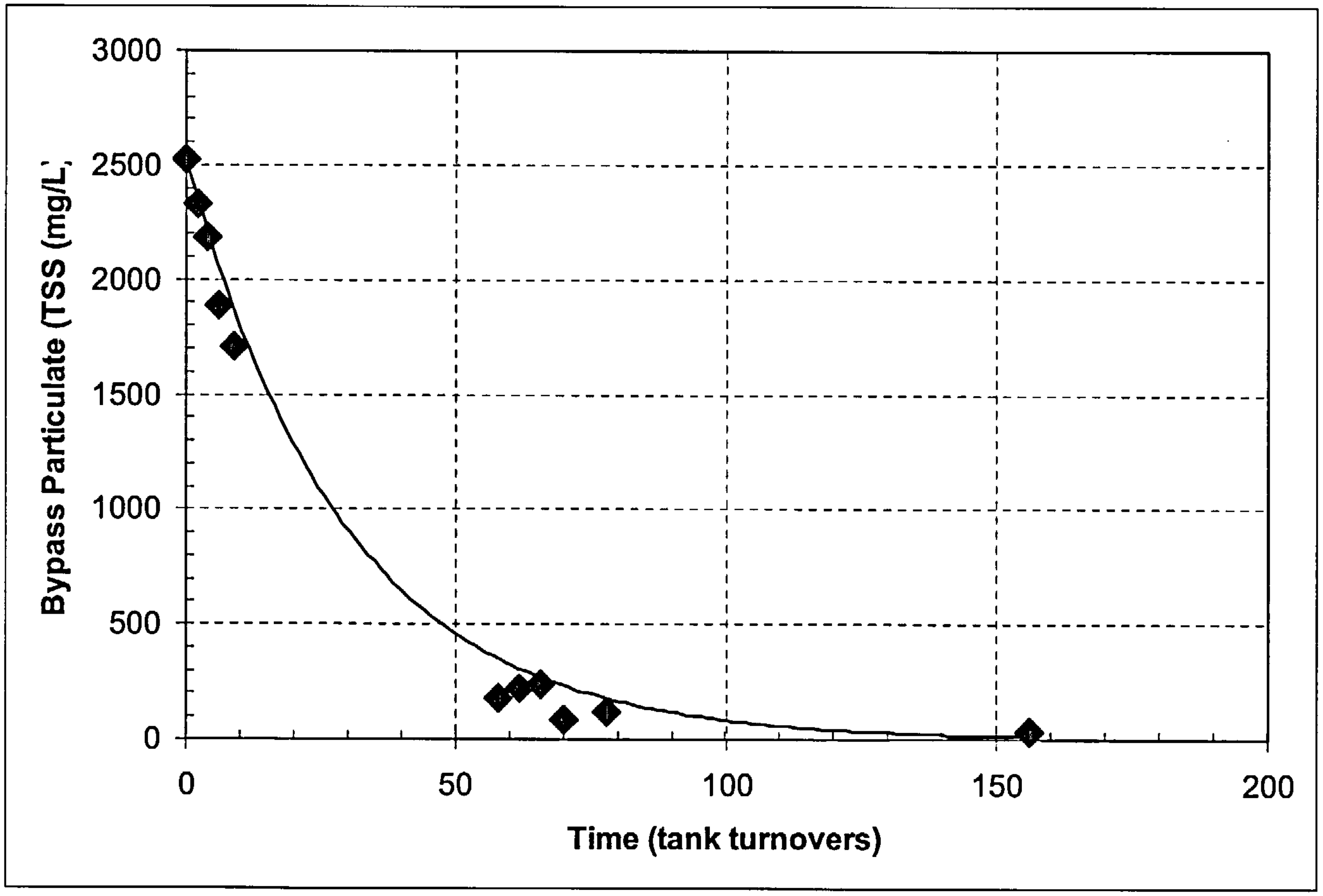
Millstone 2 Fiber Bypass Results



Fiber Concentration with Time

Screen Bypass Testing

Millstone 2 Particulate Bypass Results



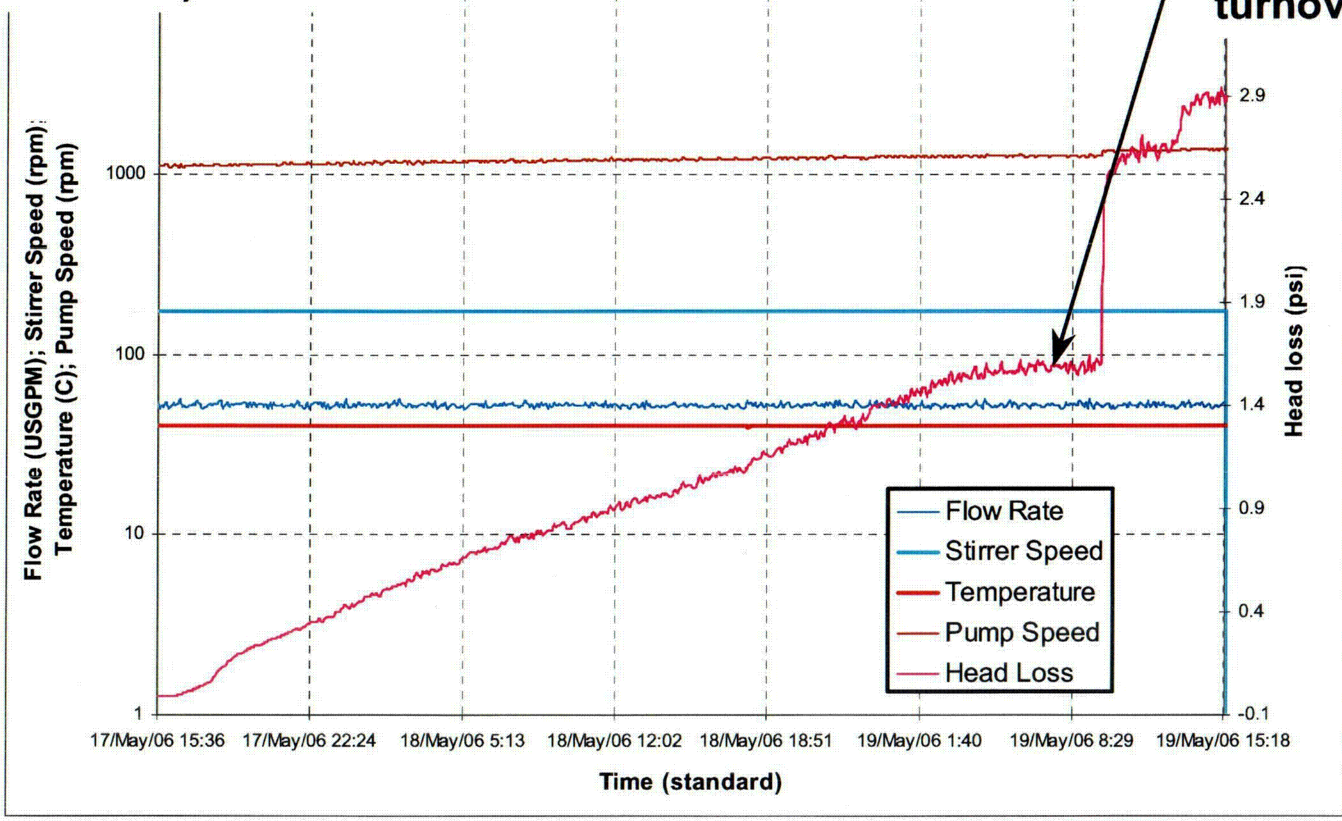
Particulate Concentration with Time

Termination Criteria

Surry Thin-Bed Test

Test duration of 48 h (~96 turnovers)

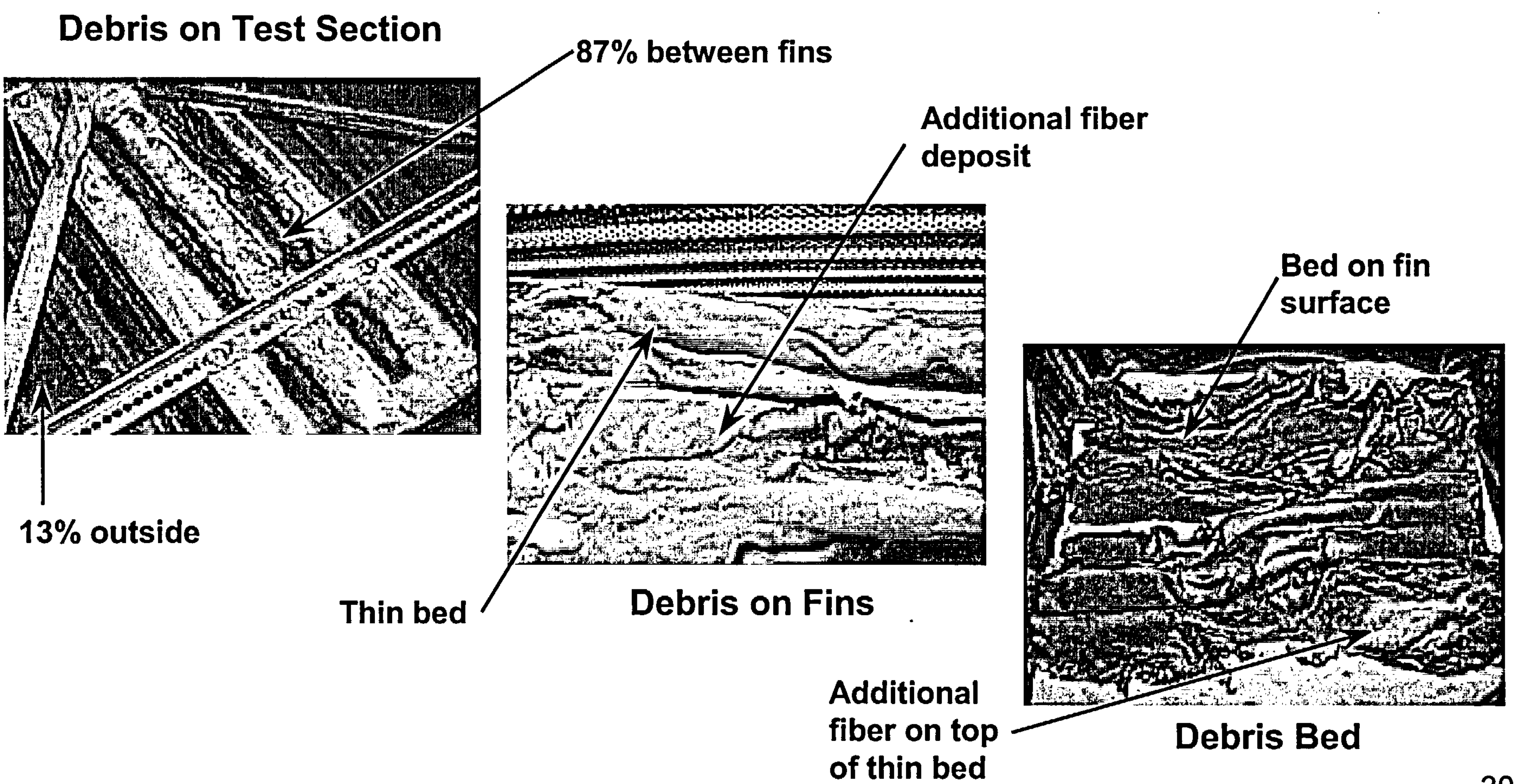
Stability = < 5% change and no general increasing trend within 3 tank turnovers (~1.5 h)



C-01

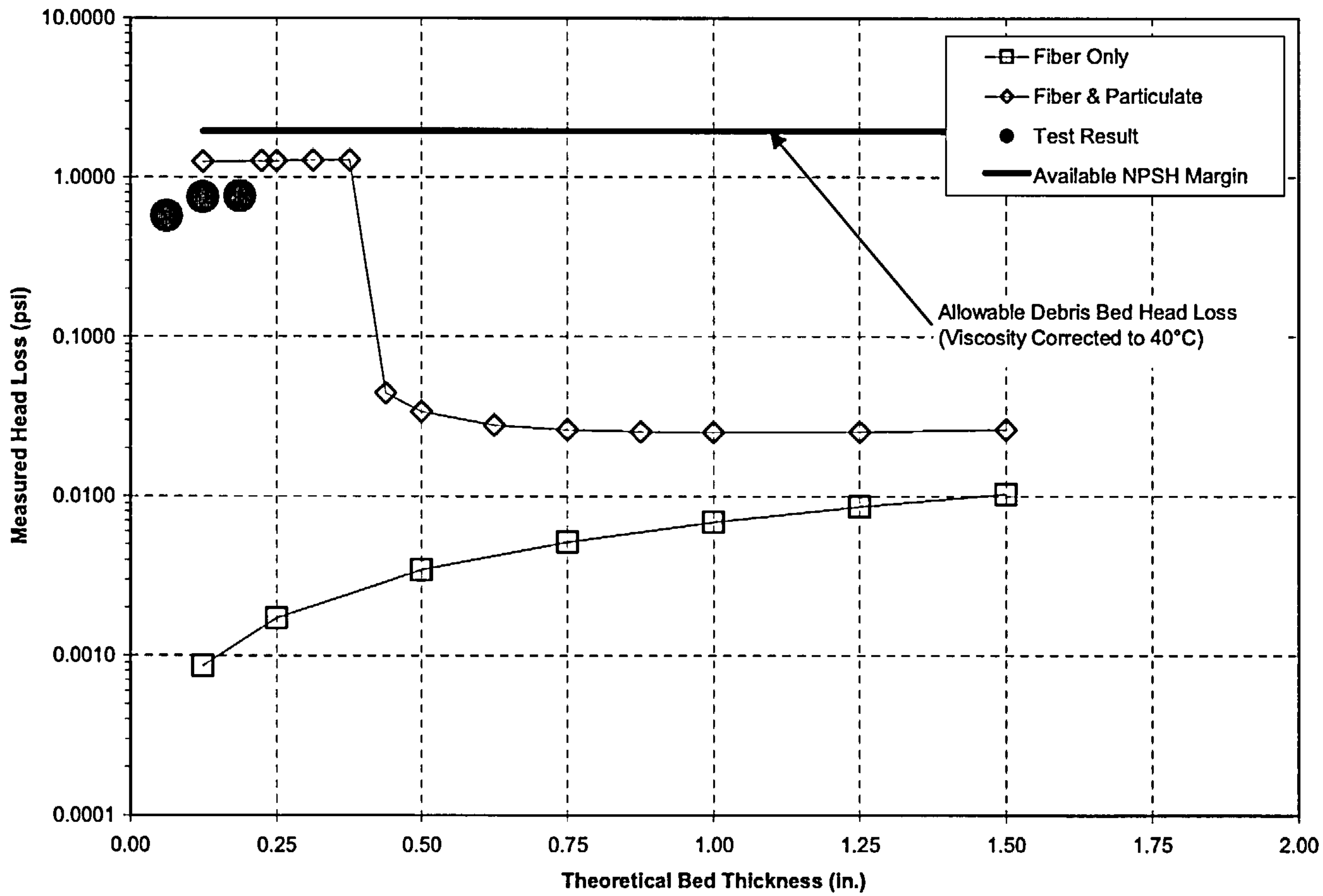
Reduced-Scale Results

Surry Thin-Bed Test



Reduced-Scale Results

Millstone 2 Thin-Bed Test



Reduced-Scale Results

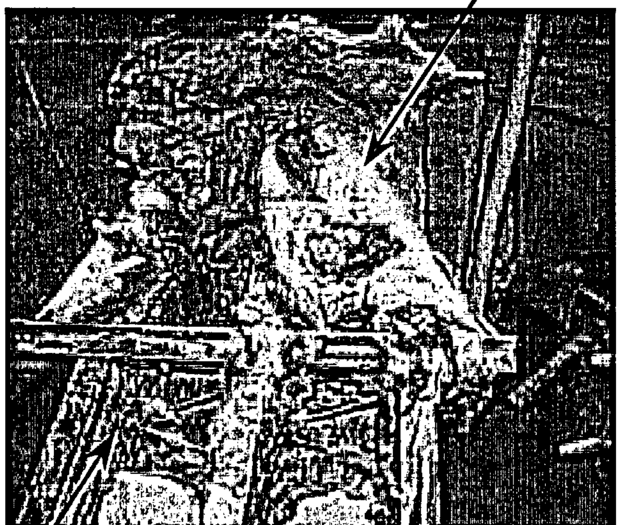
Millstone 2 Full Debris Load Test

Debris on Test Section

Encapsulation on top of fins

Packed between fins

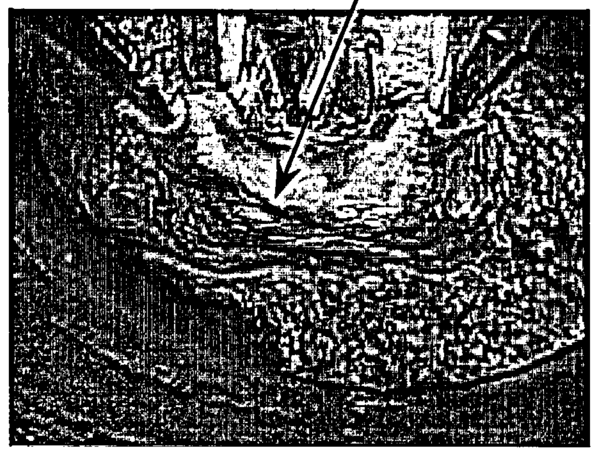
Fluffy bed between and on top of fins



Thin layer on fin surface

Debris on Fins

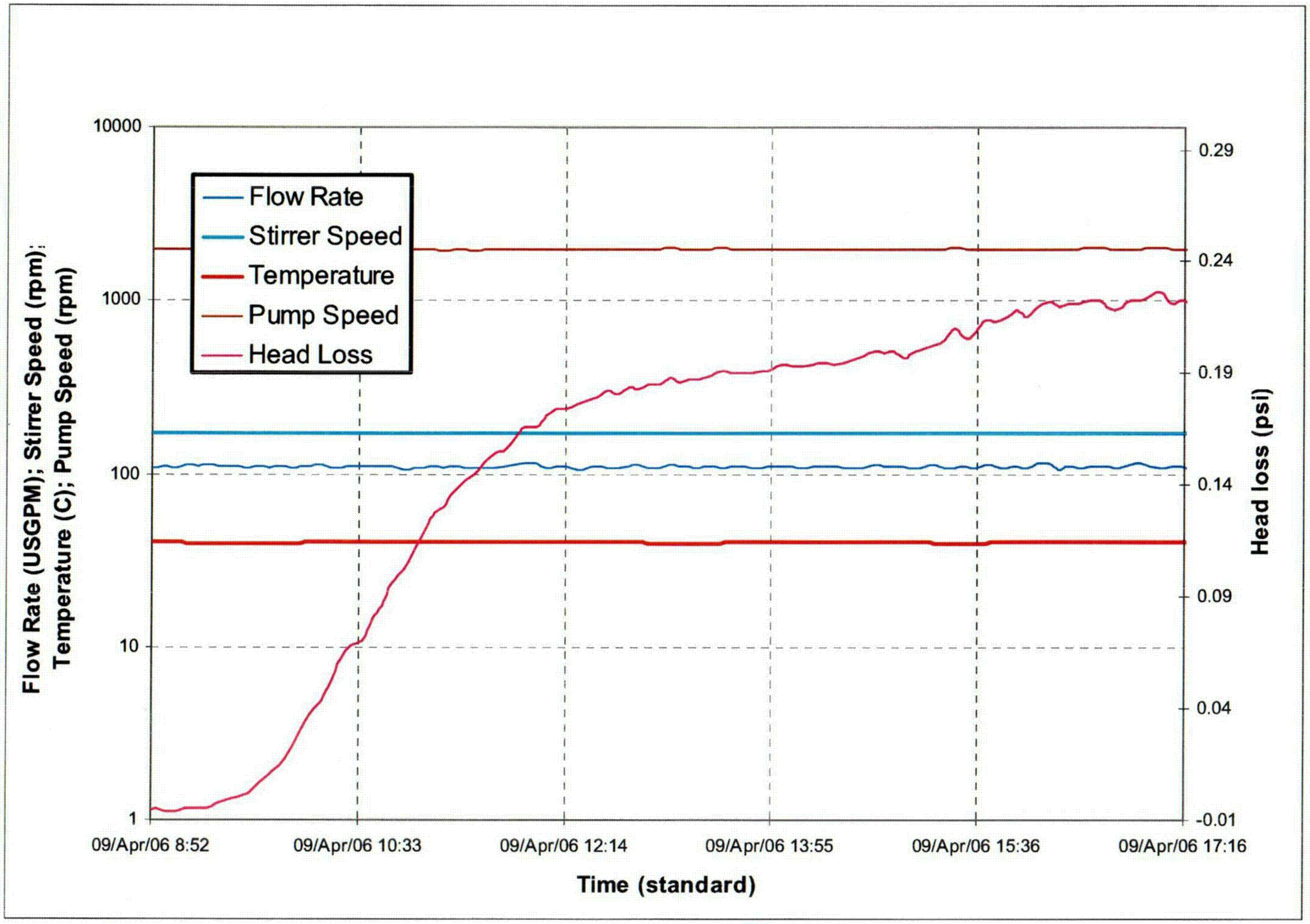
Debris allowed to accumulate in front of fins



Debris in Front of Fins

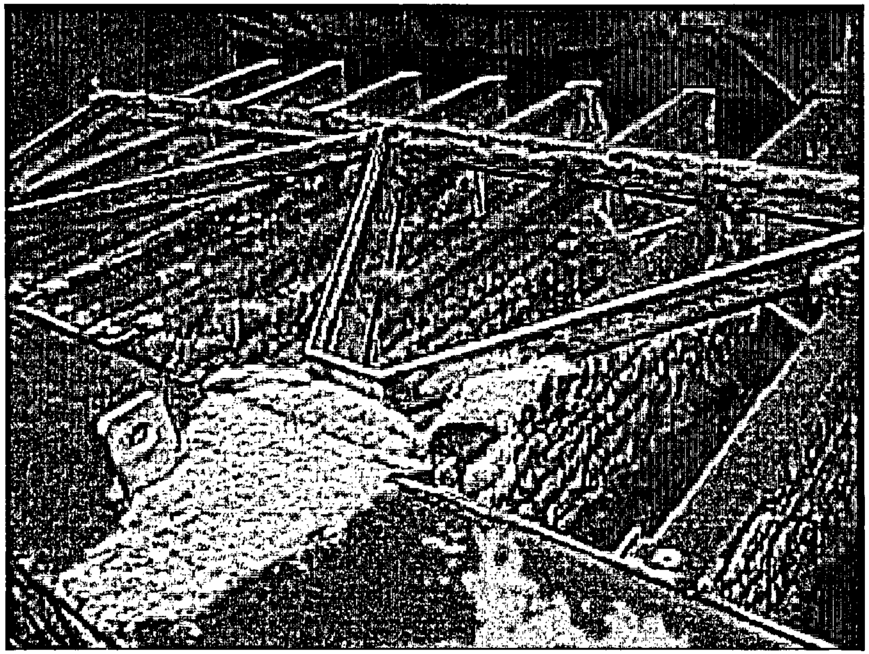
Reduced-Scale Results

Millstone 2 Full Debris Load Test



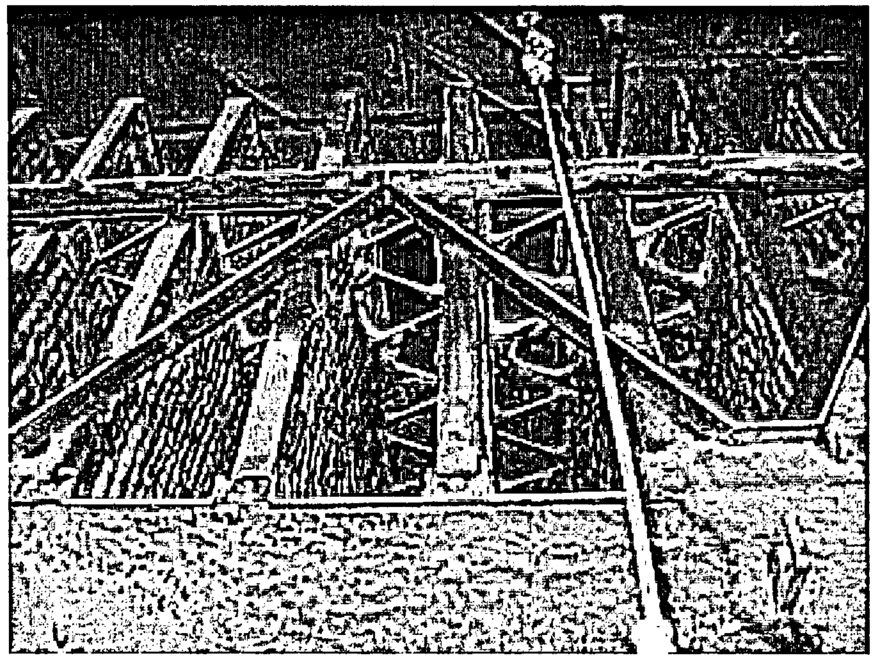
Large-Scale Results

Millstone 2 Thin Bed Test



Water Drained to ~12" Below Top of Fins

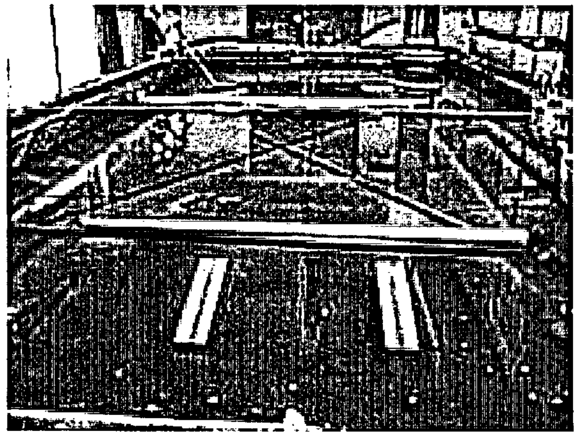
Water Drained Completely Below Fins



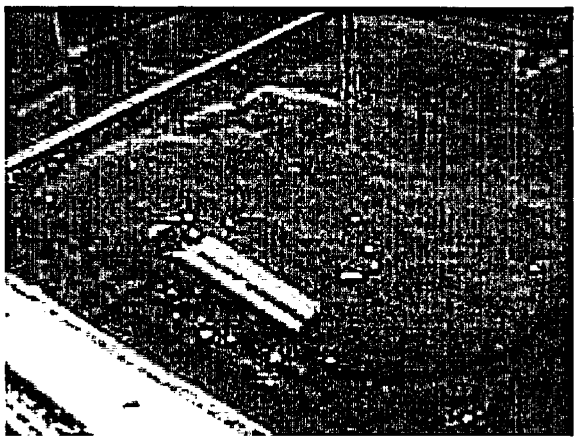
Large-Scale Results

Millstone 2 Full Debris Load Test

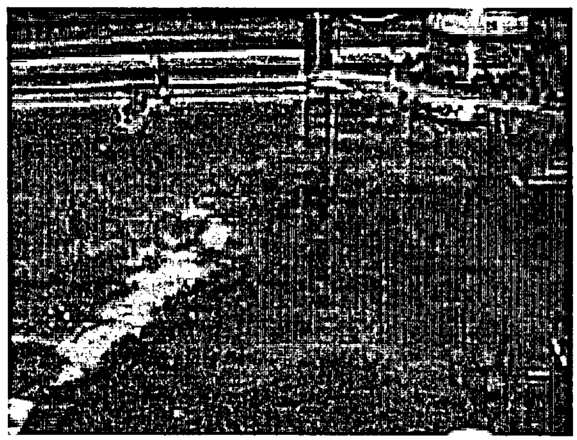
End of Test – Cover On



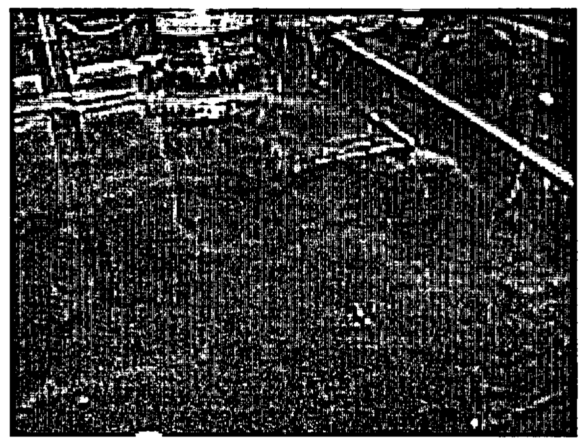
Cover Removed



Left



Centre



Right

Summary of Key Observations

- **Strainer surface area determined by thin bed head loss**
- **Strainer pitch (hence, footprint) determined by encapsulation under full debris load**
- **Measured head loss is comparable to NUREG/CR-6224 predictions**
- **Theoretical bed thickness required to form thin bed increases with decreasing approach velocity**

Summary of Key Observations

- Fiber bypass is composed of short fibers less than 0.08" (2 mm) long
- All particulate bypasses if no fiber bed present
- Once a fiber bed forms, particulate is slowly captured, resulting in decreasing particulate concentration but increasing head loss

AECL

Technology MATTERS™

CCI ECCS strainer

ACRS Meeting, August 24, 2006

Resolution of GSI 191

Presented by:

Deane C. Beck
Business Unit Manager
DBeck@ccivalve.com

Tobias E. Zieger
Deputy Director Nuclear Division
tobias.zieger@ccivalve.ch

Content

- General Topics
  - ECCS strainer replacement project
  - Design features of CCI strainers
  - Test facilities
  - Strainer design parameters
  - List of licensees and related testing
  - Key observations during testing
- Specific Topics
  - Scaling methodology of Test results
  - Debris preparation Methodology
  - Debris Introduction Methodology
  - Head Loss due to Chemical Effects
  - Screen Bypass Test
  - Termination Criteria

ECCS Suction Strainer Replacement Projects

1) Debris Generation Study

- What kind of debris will be generated ?
- How much of each debris ?
- What are the characteristics
  - *density as fabricated*
  - *sludge density*
  - *Surface-to-volume ratio Sv*

2) Debris Transport Study

- How much of the generated debris will reach the sump ?

3) Strainer Layout Footprint

- How much filter area could be installed in the existing space ?

ECCS Suction Strainer Replacement Projects (ctd.)

4) **Headloss calculation**
- Clean Headloss
  - *Based on common hydrodynamic calculation methods resp. tests*
- Fibrous Debris Bed Head Loss
  - *NUREG / CR-6224 Head Loss Correlation*
- RMI Debris Head Loss
  - *NUREG / CR-6808 Head Loss Correlation*

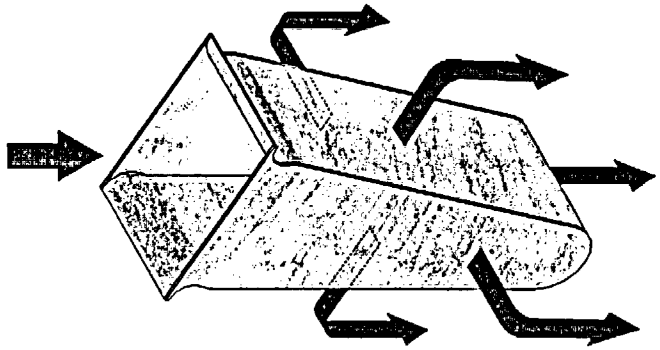
5) **Headloss verification by test**
- Small scale tests
- Large scale tests
- Chemical tests (optional)

→ will prove how much margin is available compared to NPSH allowable

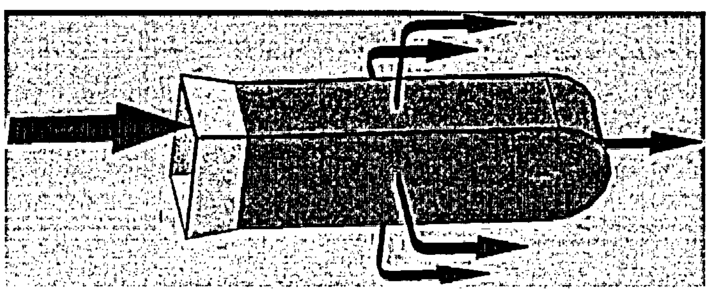
6) **CCI provides Design, Test and Calculation Reports for approval of the strainer sizing**

7) **Strainer fabrication, delivery and installation**

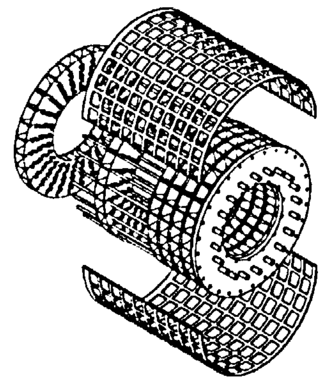
Design features of the patented CCI Cassette strainers →Pocket principle



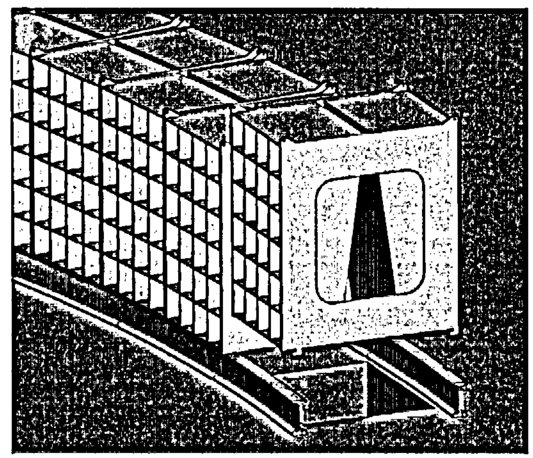
5 PATH OUTFLOW AREA



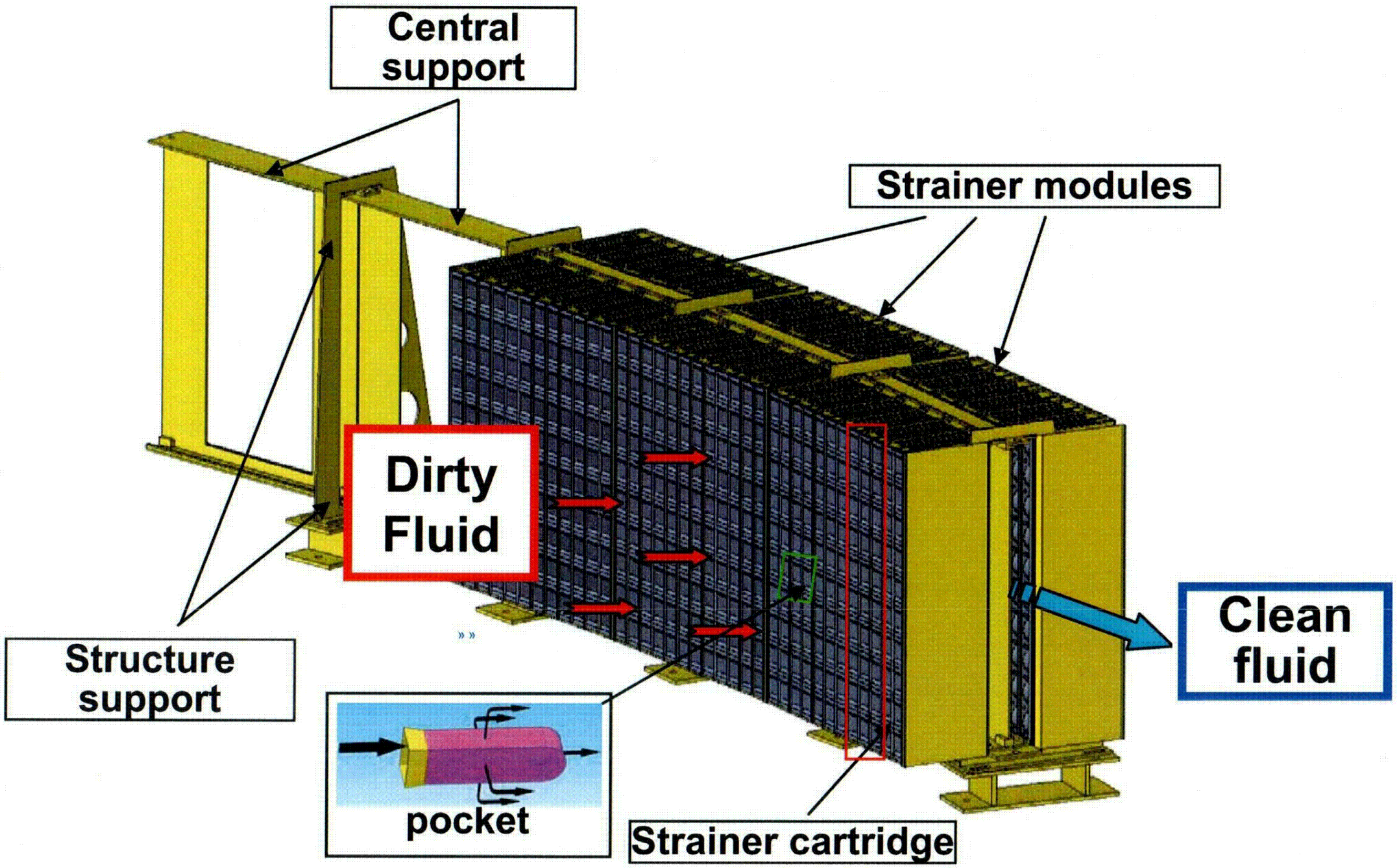
BWR



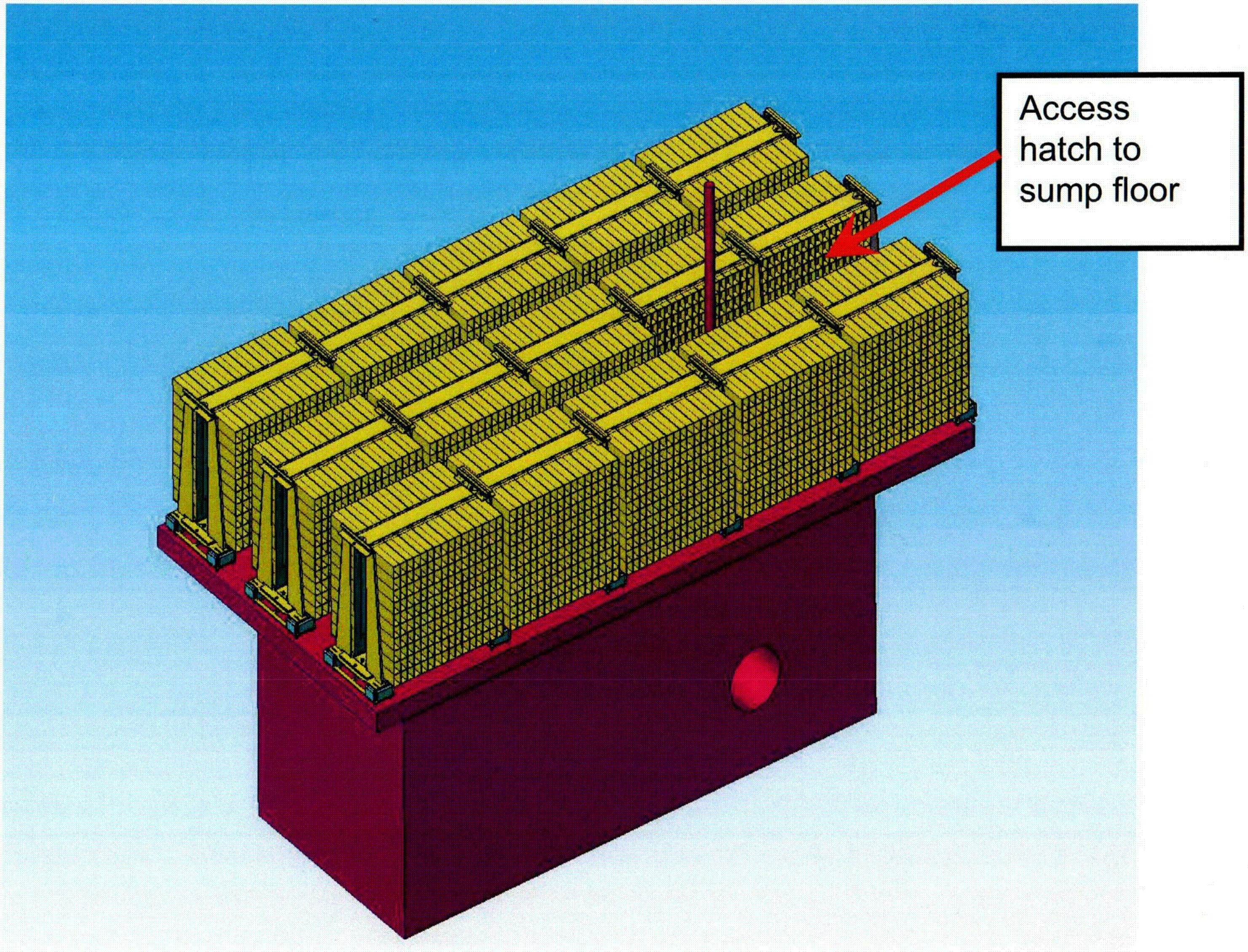
PWR



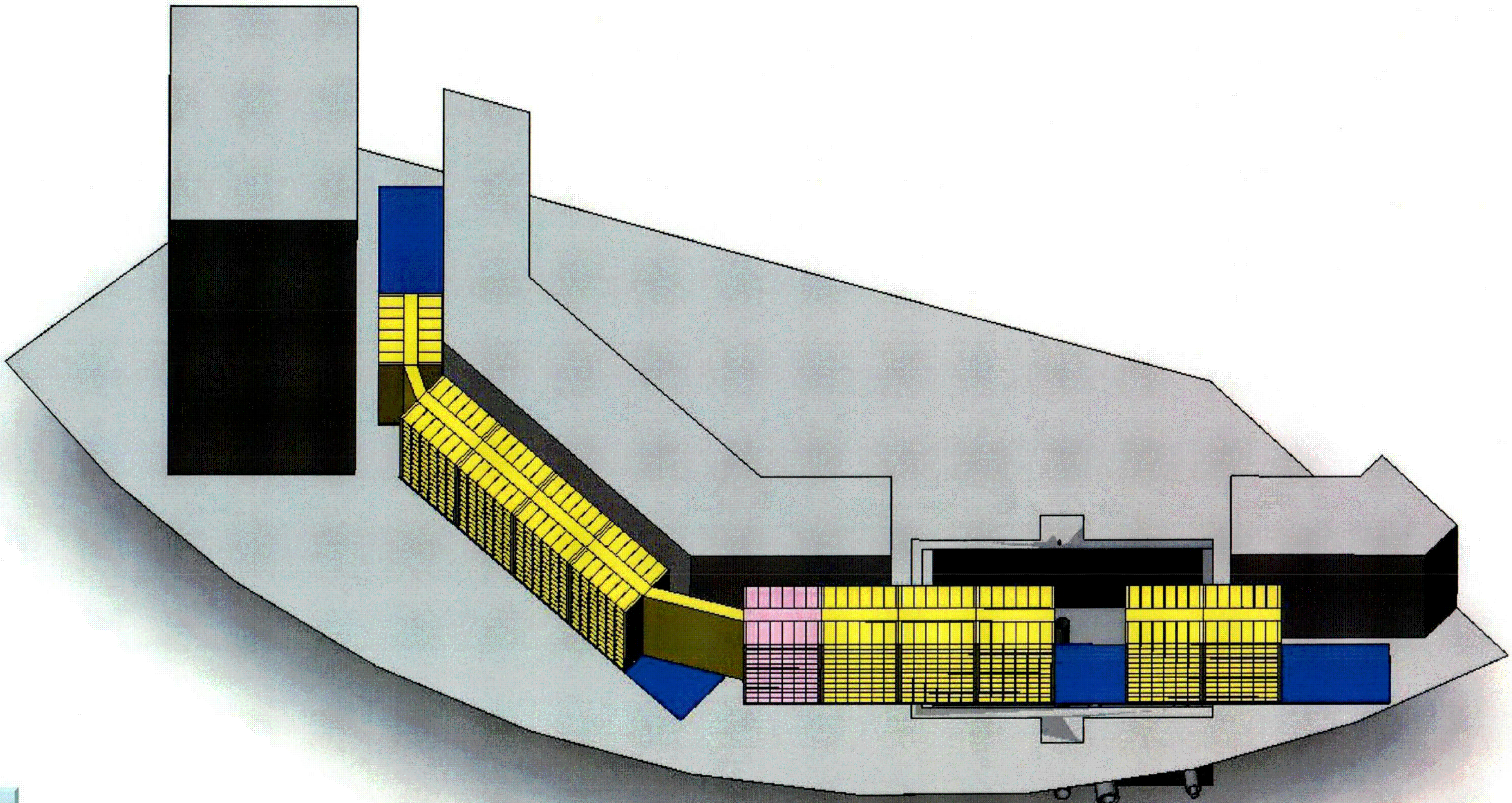
Design features of the patented CCI Cassette strainers →Modularity with cartridges



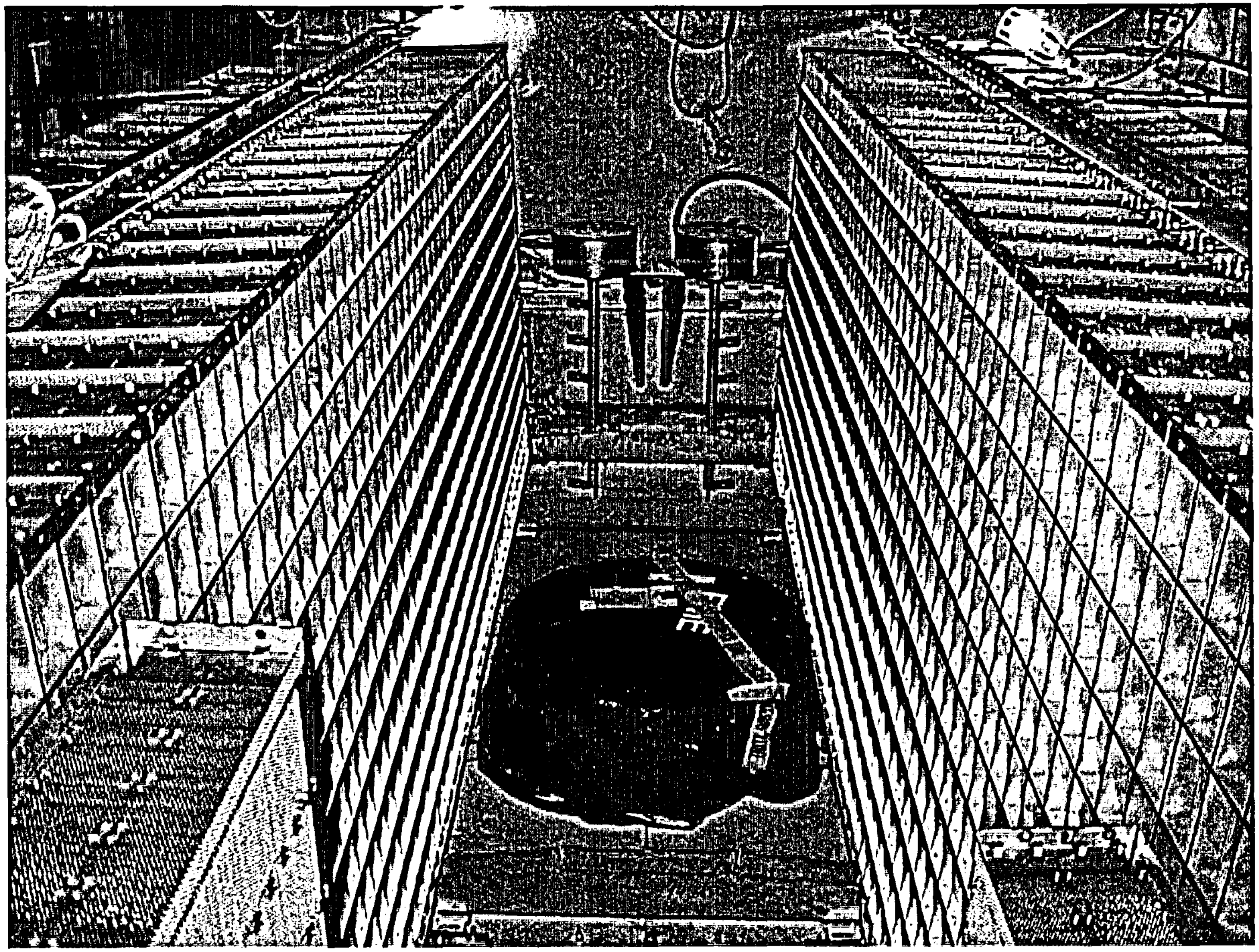
Layout for strainer on top of sump pit



Strainer Layout on Containement floor



Strainer inside of sump pit



Testing strategy for CCI strainers

- Input supplied by utility :
  - Debris quantities after generation and transport
  - Flow rates
  - Water temperatures
  - Allowable head loss
  - Chemical environment (pH, etc.)
- Preliminary sizing by NUREG/CR-6224
- Definition of type of test verification (loops and arrangements)
- Surrogate materials, if appropriate
- Scaling of real plant conditions for each test run, considering sacrificial surface areas

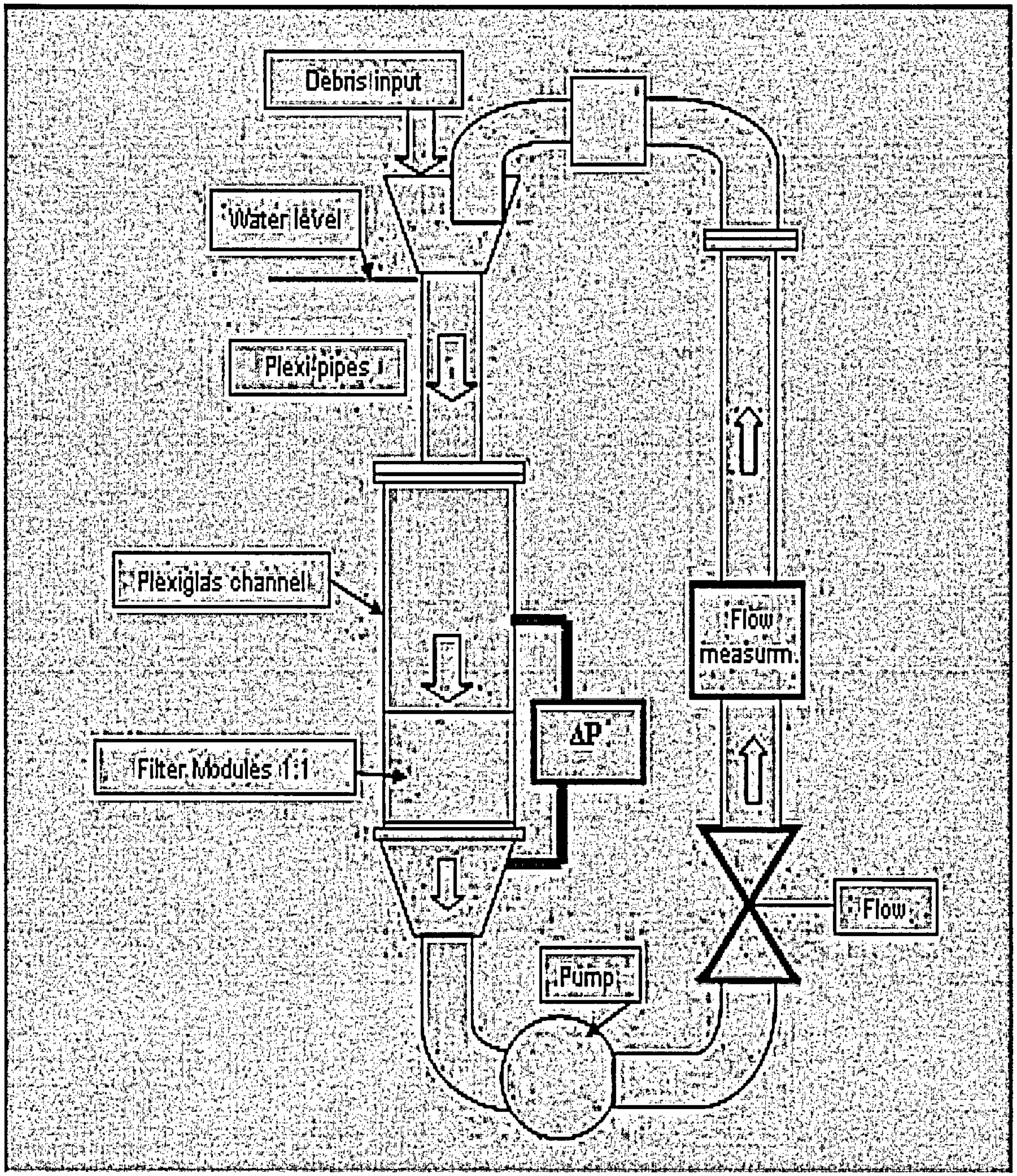
Features of Test Loops
Small Scale Test Loop SST

- Vertical flow with no sedimentation
- Uniform debris cake formation
- Suitable for Parametric studies
- Identification of relevant parameters
- Derivation of theoretical head loss correlations (NUREG/CR-6224)
- Justification of any surrogate materials

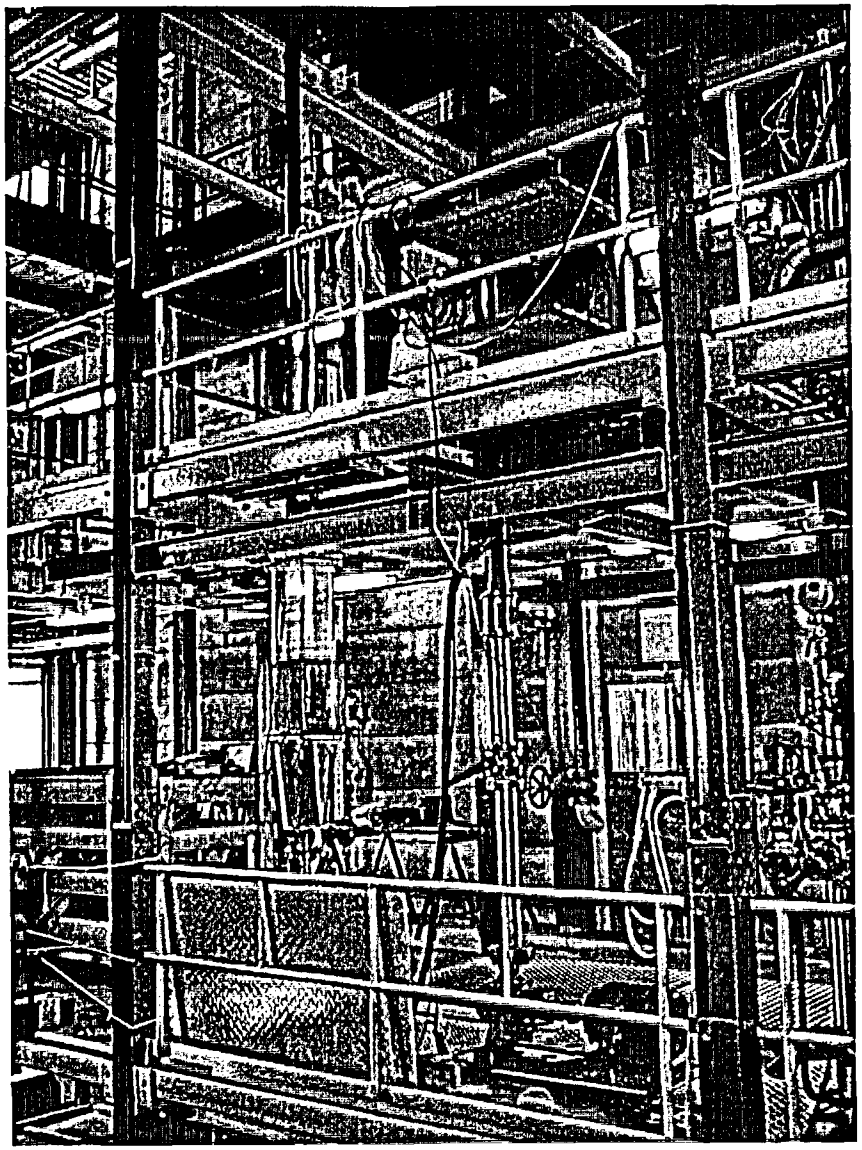
Small Size Test loop SST

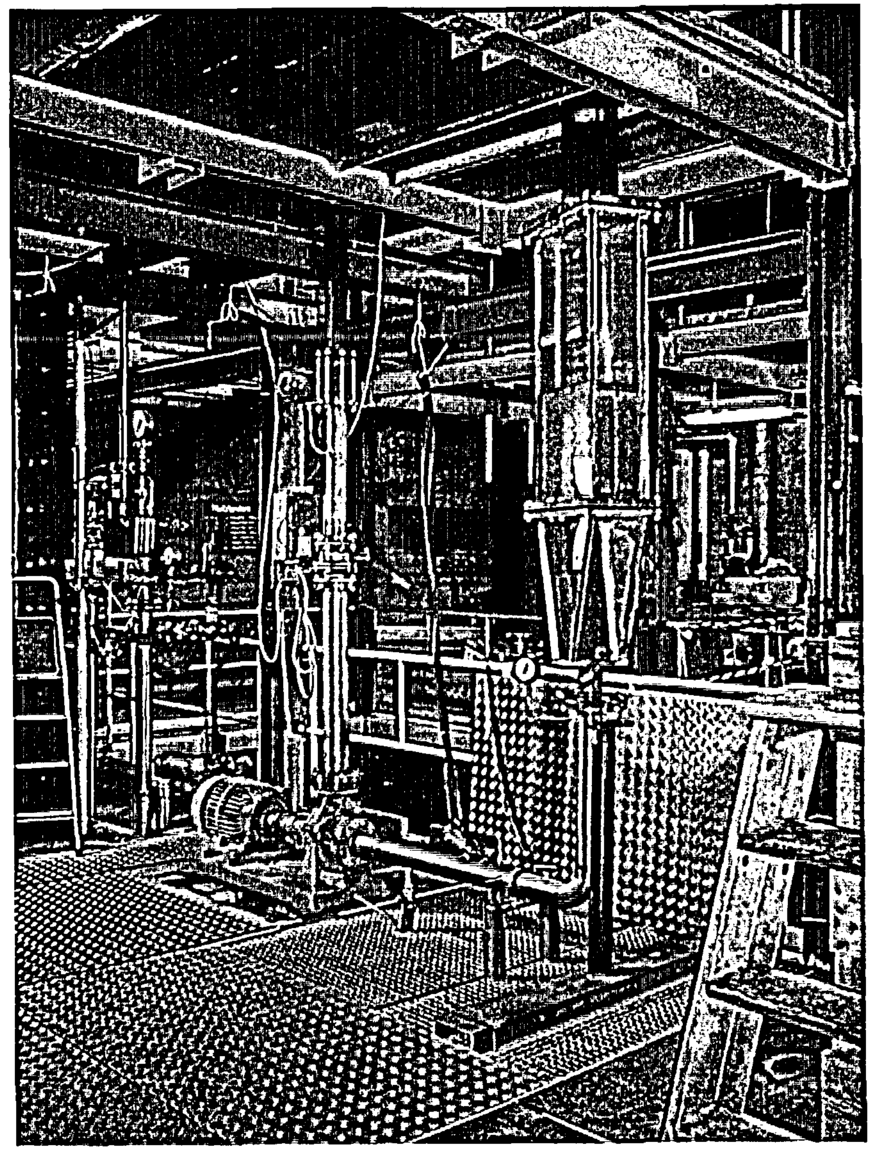
for few representative pockets

~ 2200 runs performed



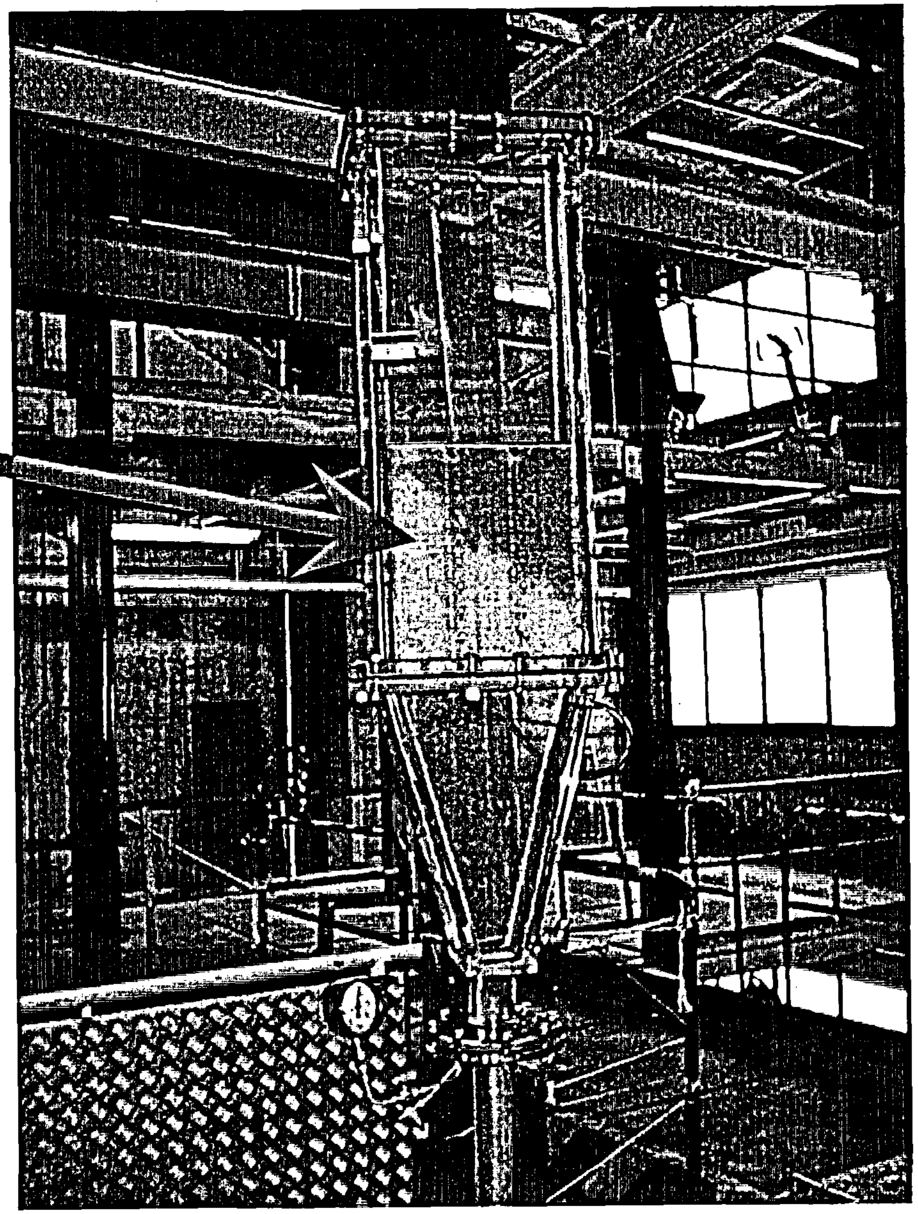
Small Size Test loop





Small Size Test loop

Plexiglas channel with **PWR test module** installed

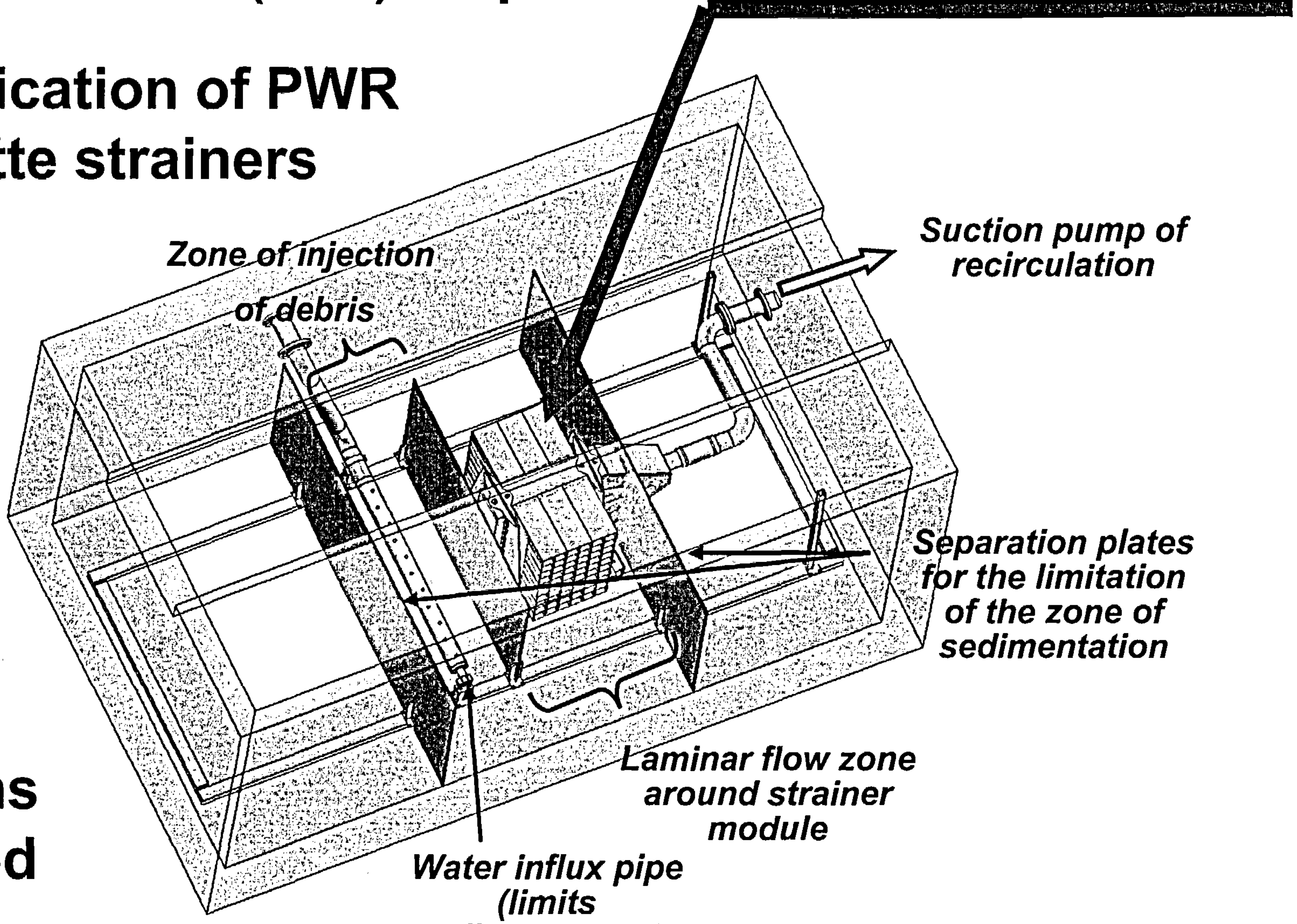


Features of Test Loops
Large Scale Test Loop LST

- Horizontal flow with gravity effects
- Realistic conditions of overall 3D behavior
- Realistic debris bed formation
  - Non-uniformity over strainer module height
  - Non-uniformity inside individual pockets
- Identification of real vs. theoretical (NUREG) head loss behavior

Large Size Test (LST) loop for an entire strainer module

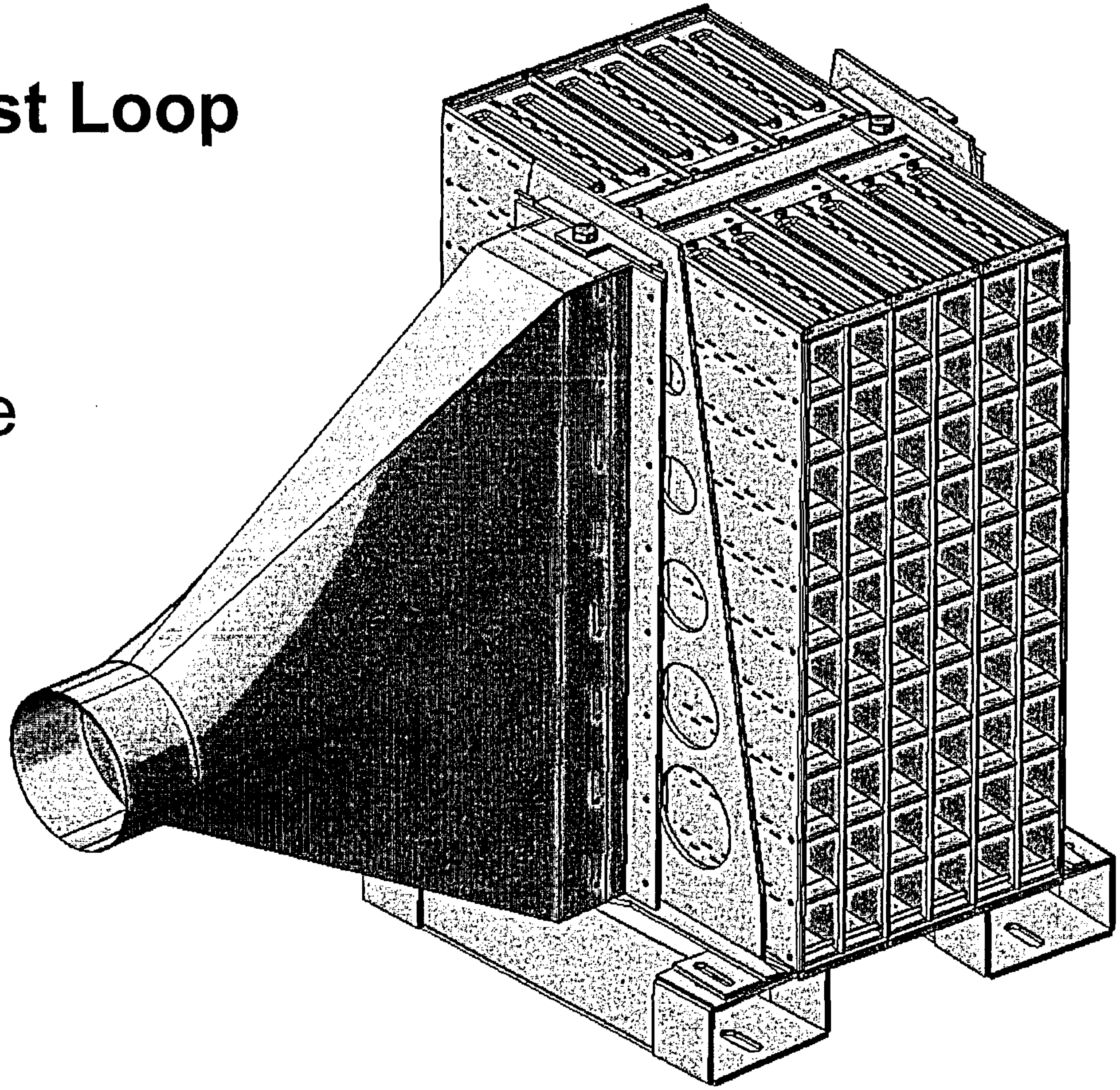
→ **Qualification of PWR cassette strainers**



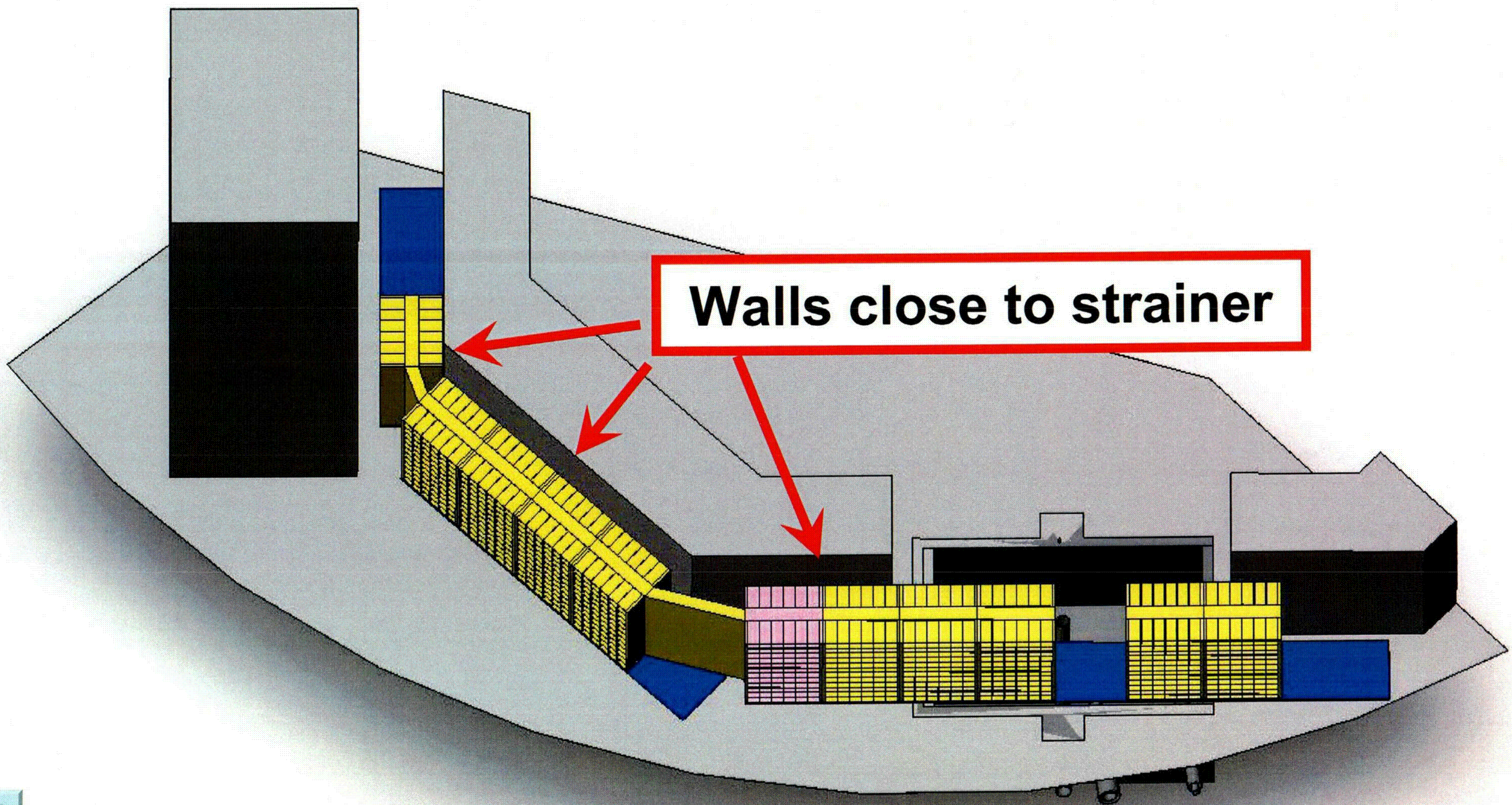
~ 200 runs performed

Large Size Test Loop

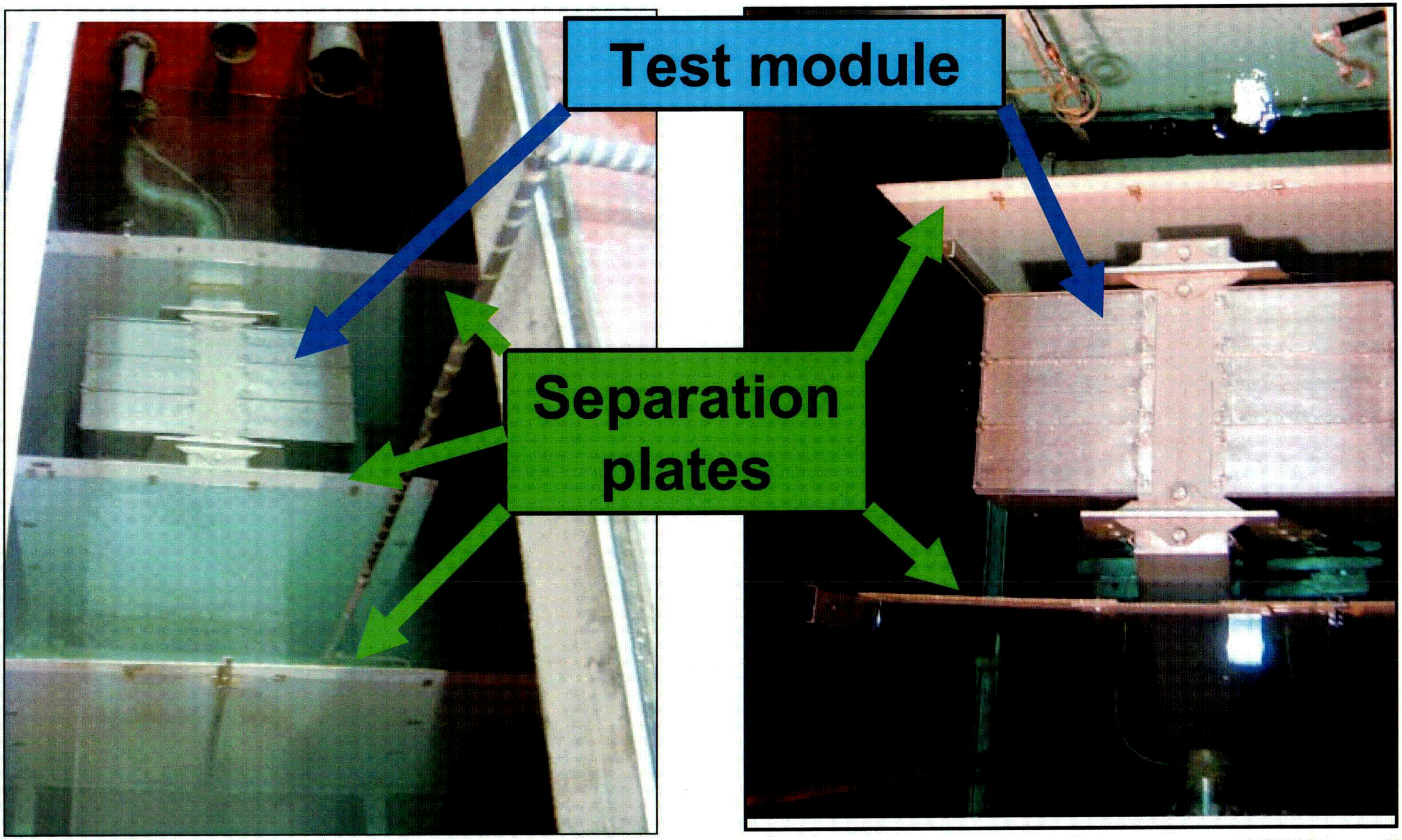
Example of strainer module



Strainer Layout on Containement floor



Large Size Test (LST) loop



Large Size Test loop

Demonstration of sedimentation and segregation

Thin bed formations with Fibres and Particulates

Large Size Test loop

Demonstration of sedimentation and segregation

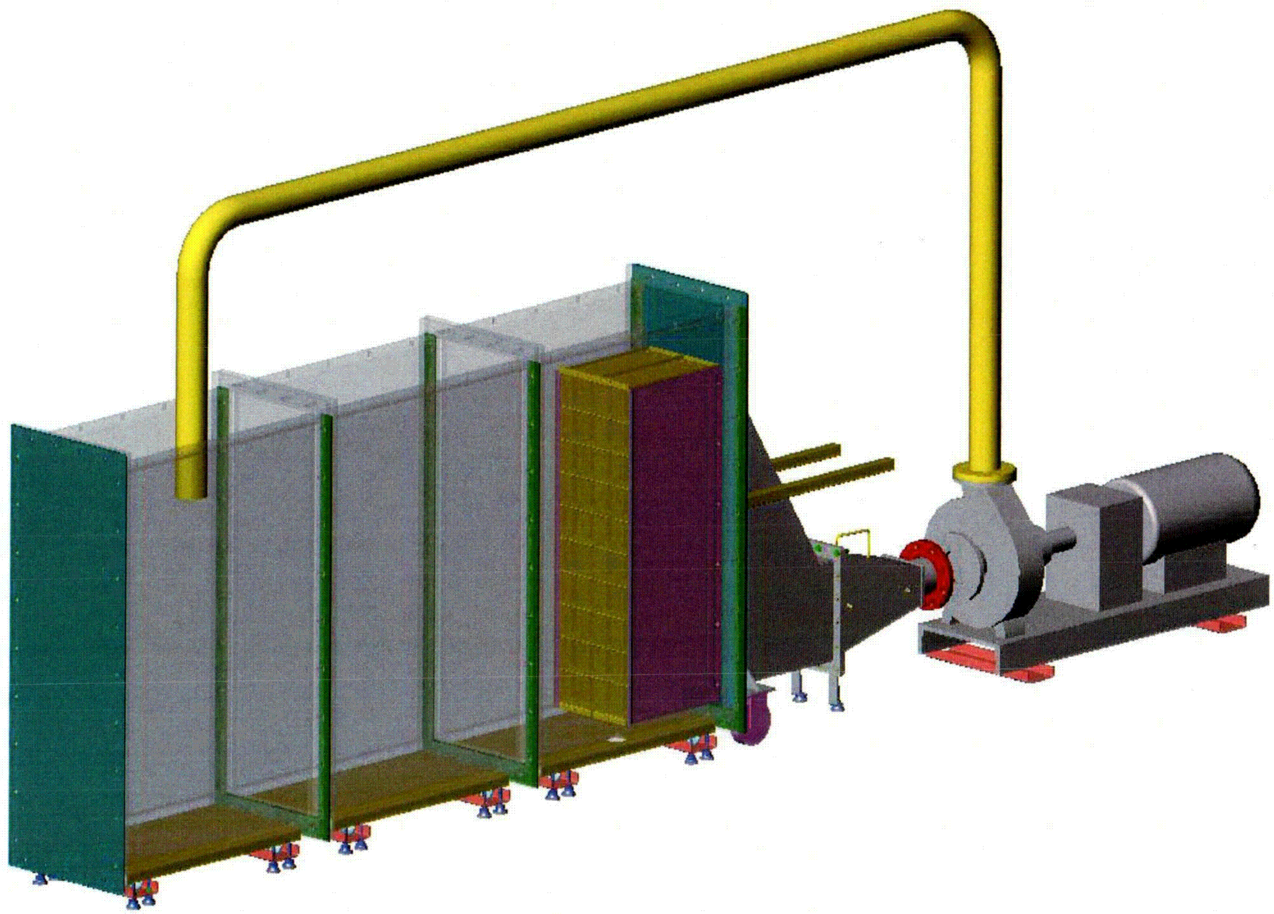
Thick bed formations with Fibres and Particulates

Features of Test Loops
Multi Functional Test Loop MFT

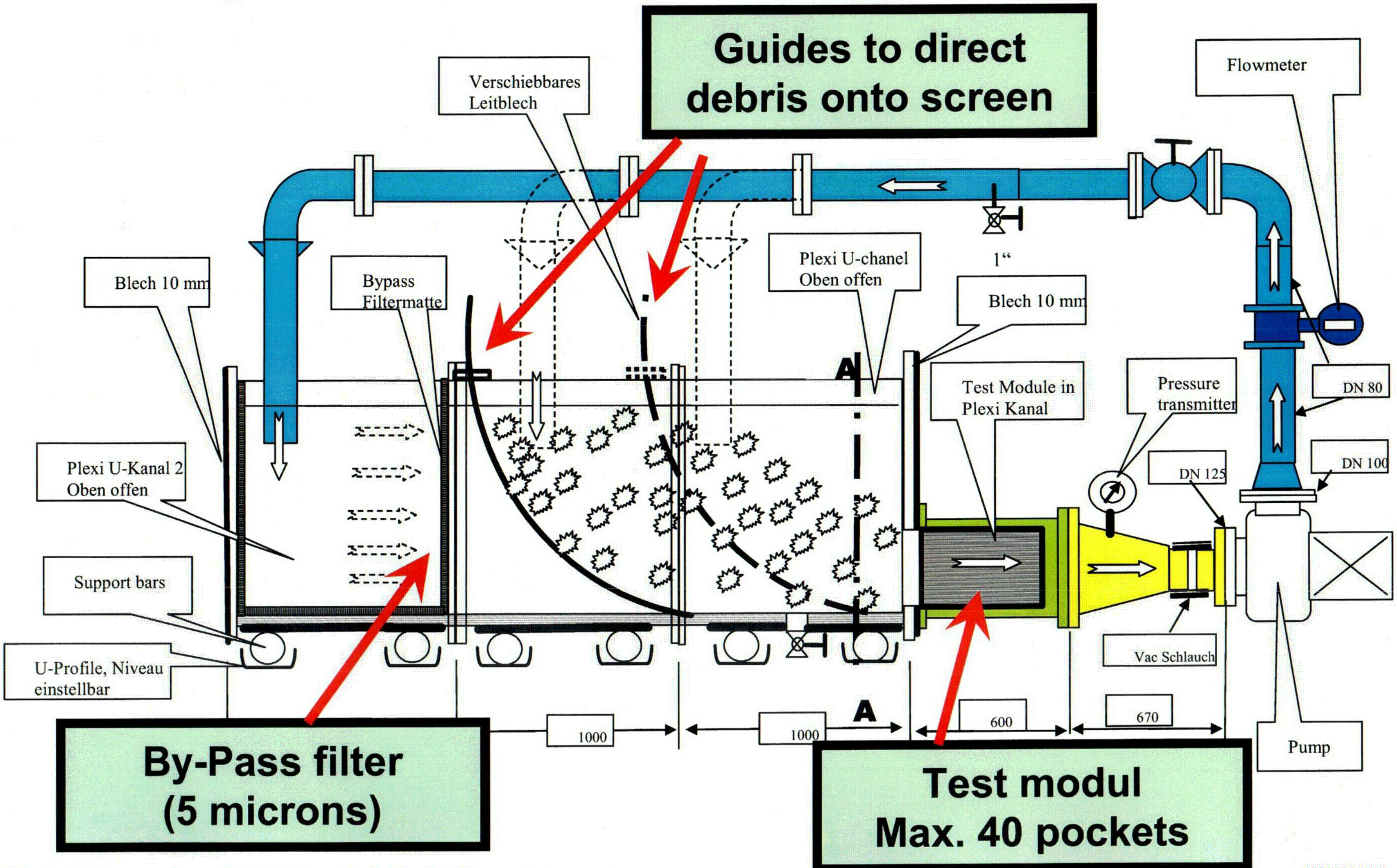
- Realistic horizontal flow orientation
- Realistic near field environment
- Moderate amounts of fibers and particulates
- Chemical agents and precipitates
- Measurement of down stream debris

Basic layout of MFT loop

~ 130 runs performed



Basic layout of MFT loop



Parameters of Test Loops	SST	LST	MFT
max. Number of pockets	6	120	40
max. Filtering surface (ft^2)	8	162	54
Range of scaling factors	250 – 1000	12,5 – 50	35 – 150
Typical flow rate range (gpm)	< 40	< 440	< 200
max. Temperature (°F)	100	86	110
Chemical effects possible	Y	Y	Y
Near field effects possible	N	Y	Y
Bypass Test possible	Y	N	Y

CCI strainer design parameters (PWR worldwide)

		High	Low	Average
filtering surface area per reactor	ft^2	19'000	2'300	5'000
Screen approach velocity	ft / s	0,0092	0,0021	0,0042
Pocket approach velocity	ft / s	0,125	0,029	0,058
NPSH margin	ft WC	6	0,1	3
NPSH relevant temperature	°F	212	190	200
Strainer hole size	in	1/12	1/16	

CCI strainer list of Licensees in the US and test status

Site	no. units	SST	LST	Chemical	Transport	Bypass
Oconee	3	✓	✓	O	✓	O
Salem	2	✓	✓	O		✓
Byron	2	✓	✓	✓		✓
Braidwood	2	✓	✓	✓		✓
Palo Verde	3	✓	✓	O		
DC Cook	2	✓	✓	O		
Arkansas Nuclear One	2	✓	✓	O		
Calvert Cliffs	2	O	O	O		O
Total US	**18**					

CCI Worldwide Strainer Supply

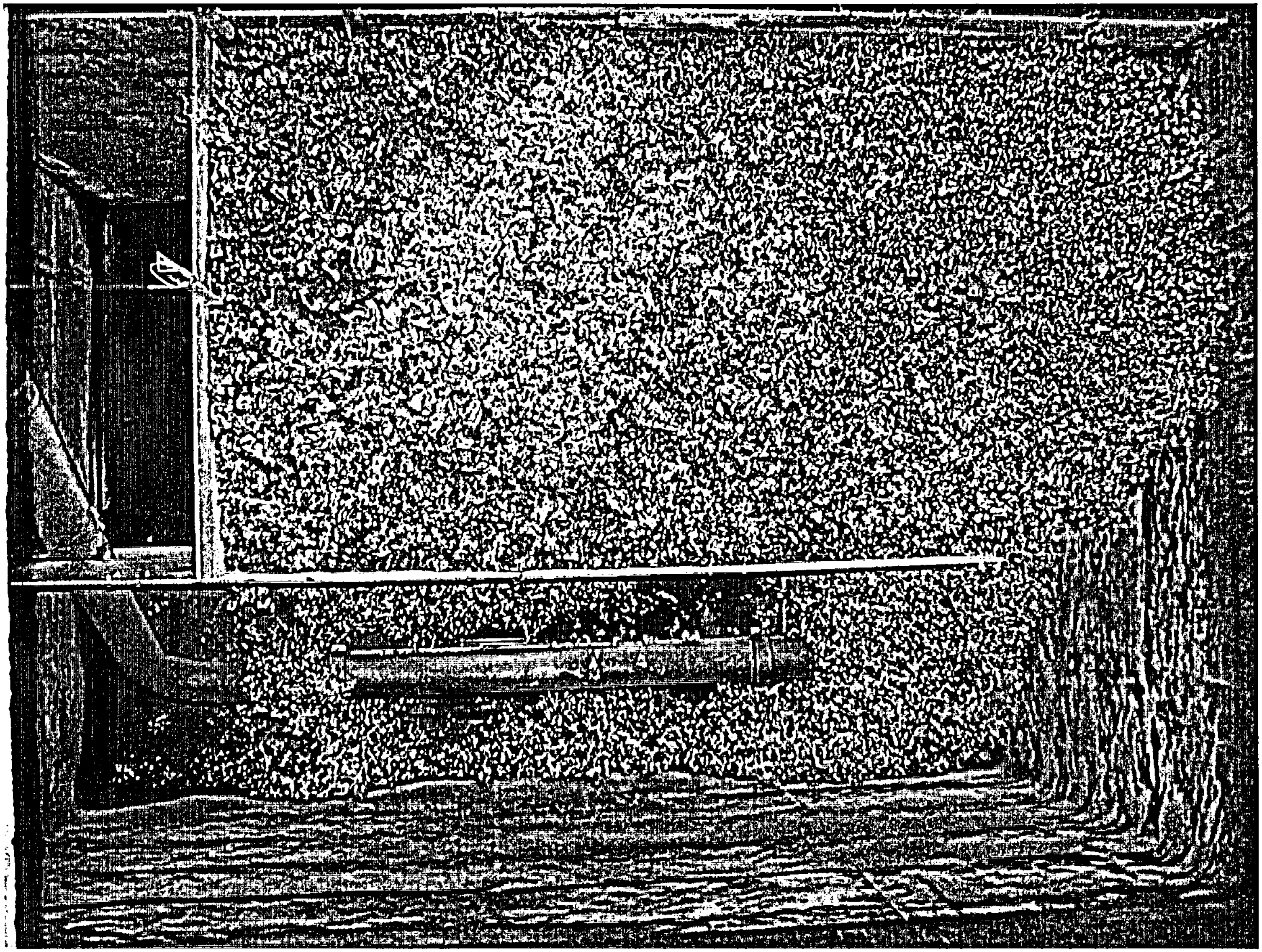
- 1992 – 2004 9 BWR units (Switzerland, Germany, Spain, Taiwan)
- 2004 – 2009 22 PWR units in France
- 2005 – 2007 18 PWR units in USA
- 2006 1 PWR unit in Switzerland
- 2004 – 2008 17 BWR units in Japan

Total = 67 units

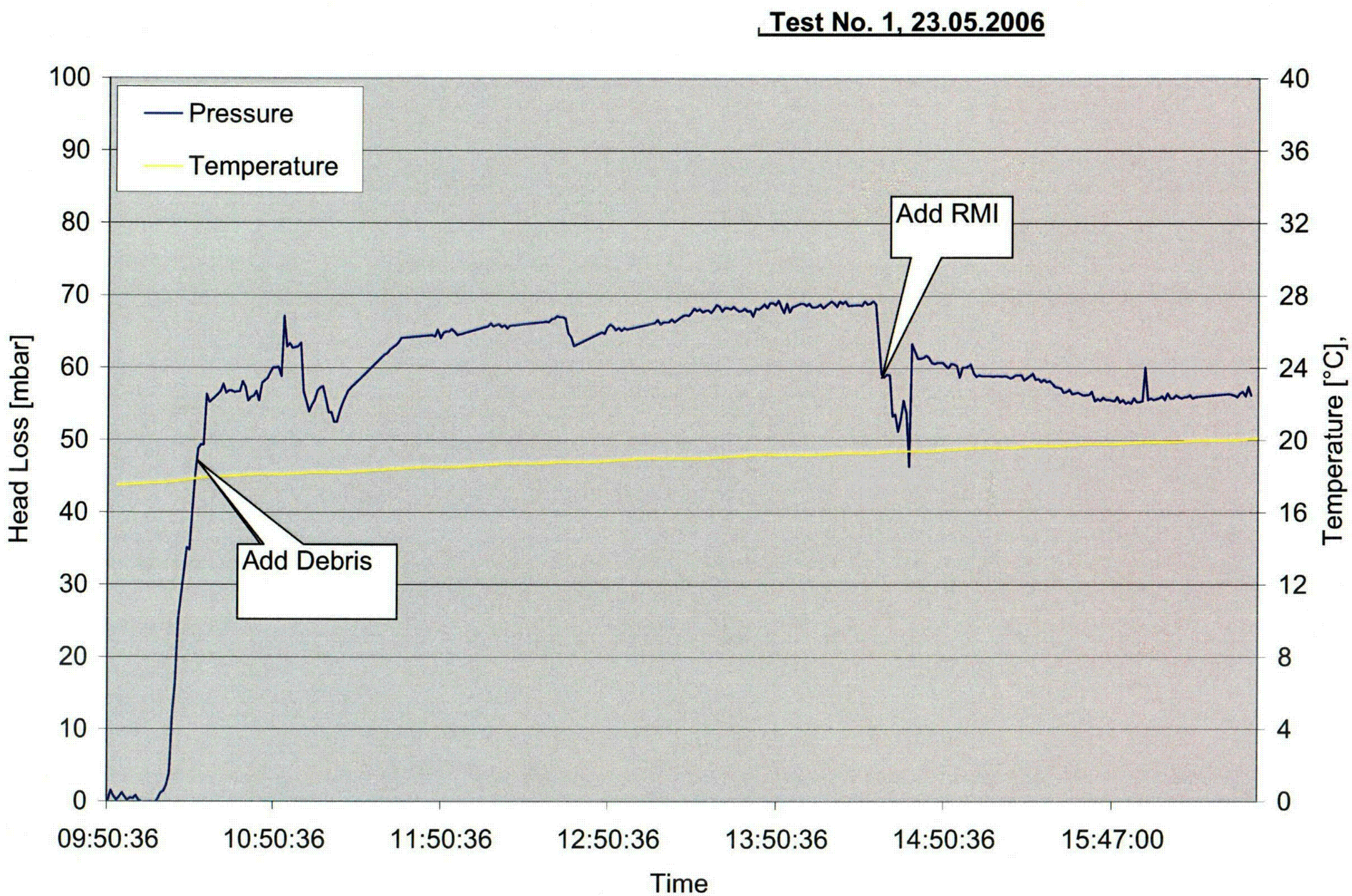
Generic test observations

- Uniform debris beds are not formed in realistic conditions
- It's difficult during horizontal testing to get all the debris to the screen, meaning in reality settling will occur
- No « thin-bed-effect » (fiber bed equivalent thickness ⅛ inch) was observed
- Circumscribed debris accumulation only occurs with RMI, not with fibers for CCI strainers in USA

Strainer submerged under RMI



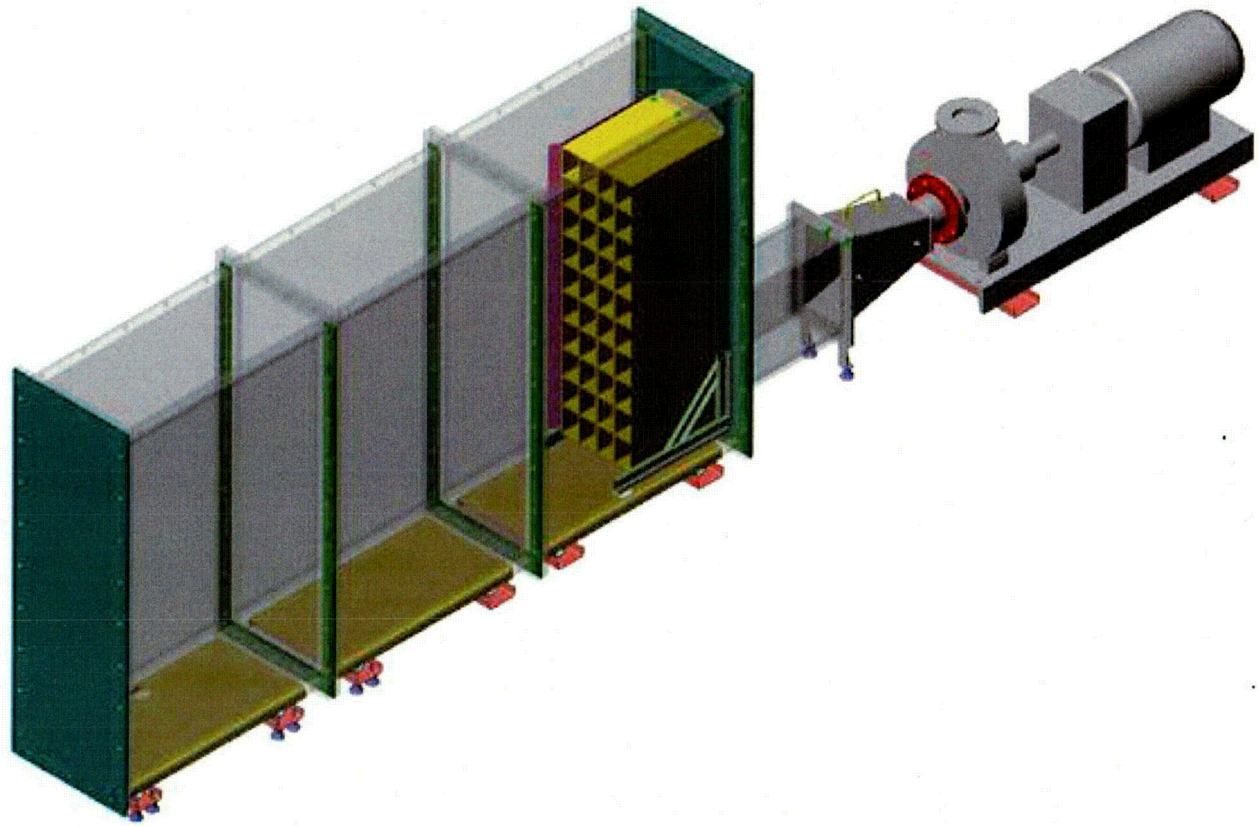
“Bore Hole“ effect



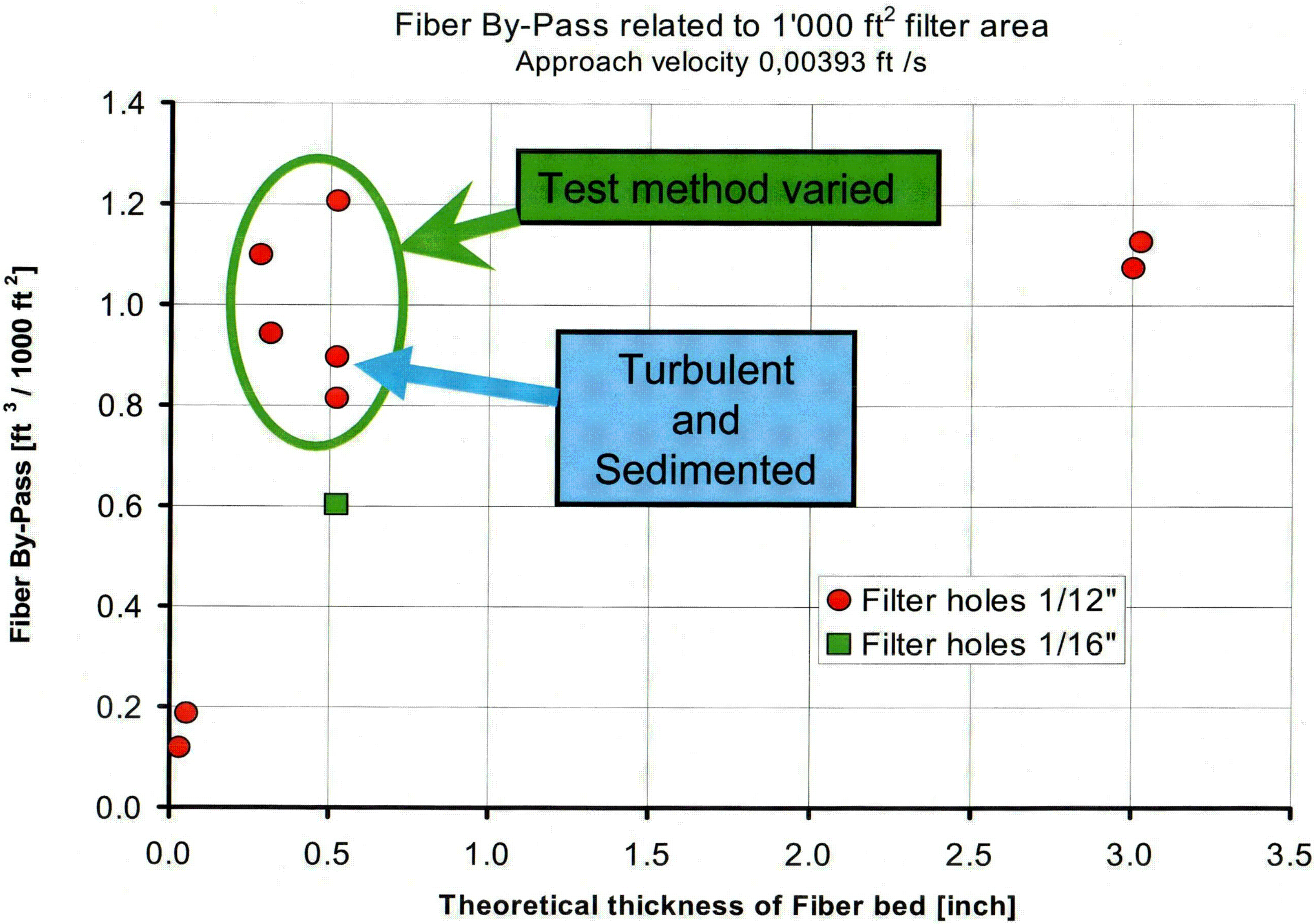
Scaling Methodology of test results

- Temperature :
  - CCI has used room temperature testing.
  - Conversion to elevated temperature by viscosity.
- Geometry :
  - CCI does not credit debris settling in the vicinity of the strainer modules. In all cases debris was introduced just in front of the pockets.
  - test configuration as close as possible to actual configuration

Screen By-Pass Test

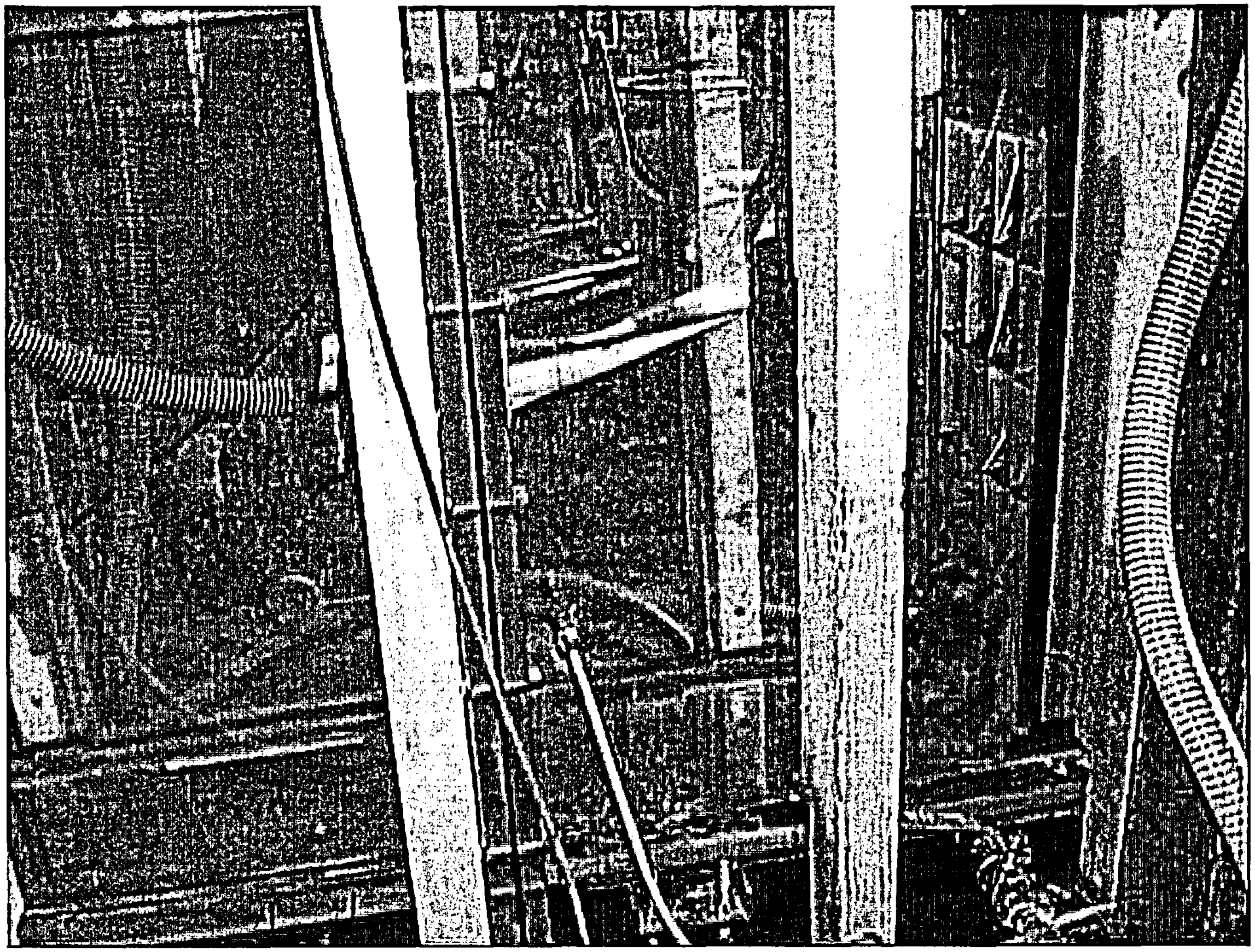


Fiber By-Pass Test Results



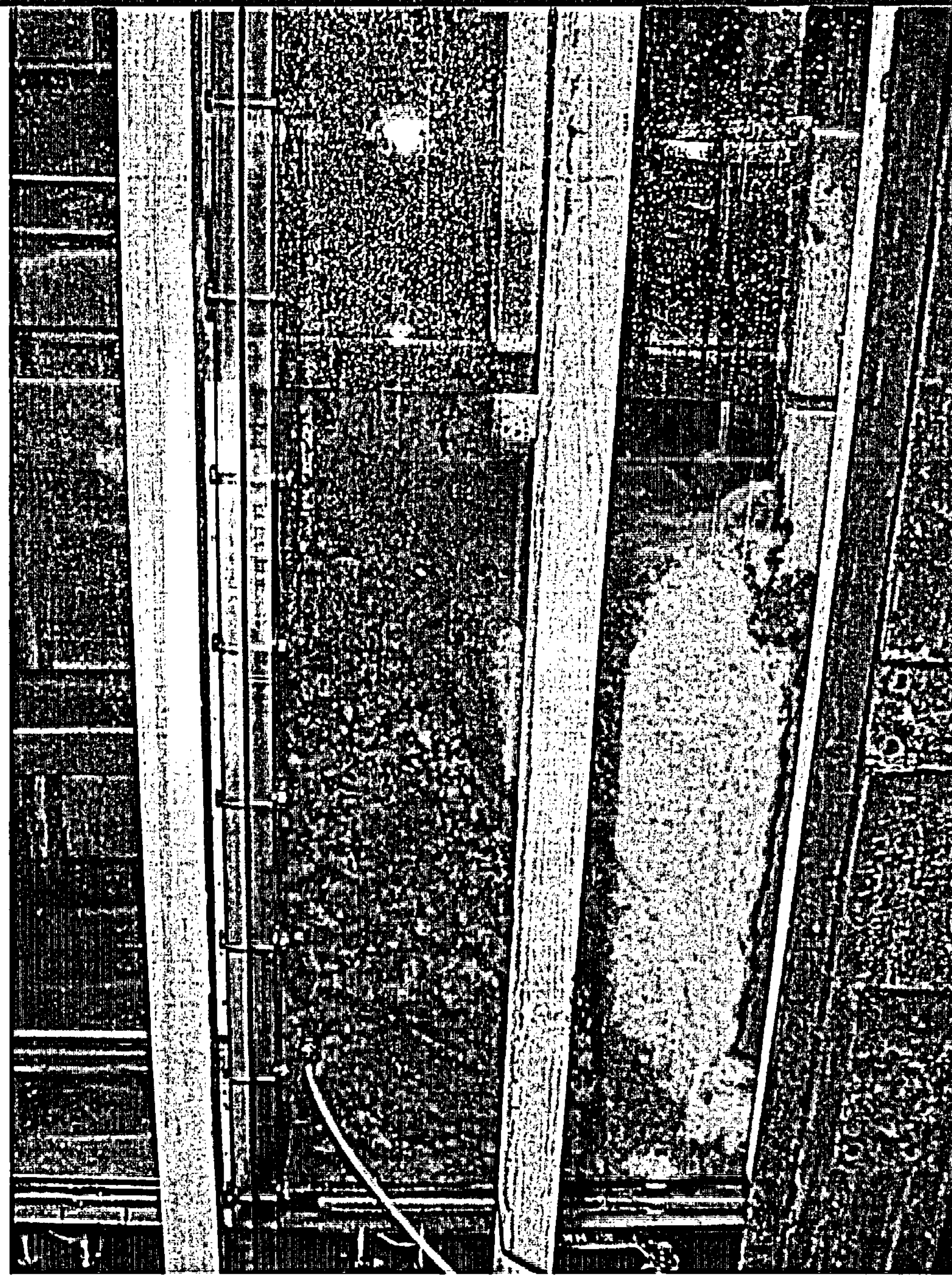
Screen Bypass Test

Hand stirred



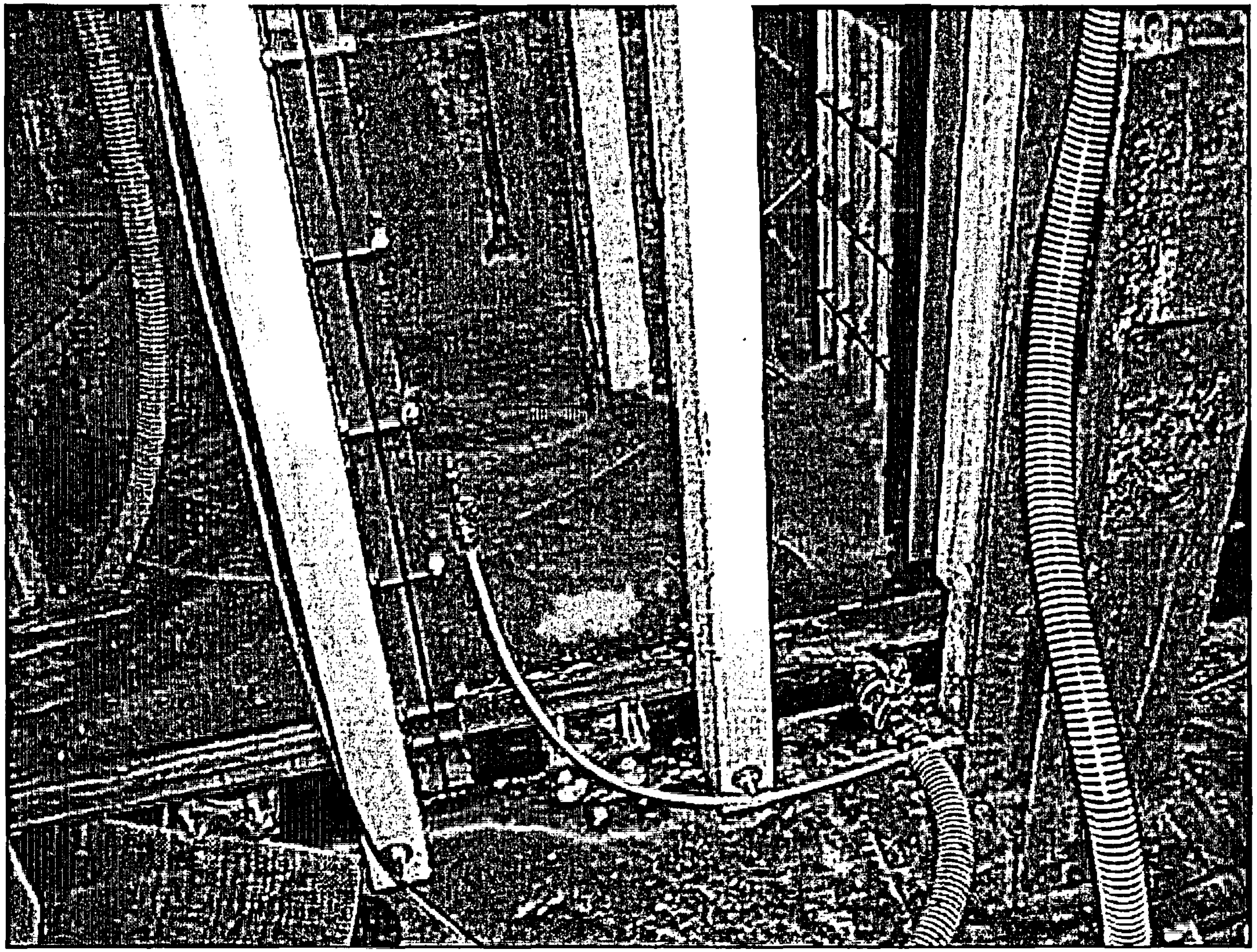
Screen Bypass Test

High turbulence flow



Screen Bypass Test

With sedimentation



Fiber By-Pass Size analysis

	fiber size	amount of fiber
class 1	0.1 to 0.5 mm	63.1 %
class 2	0.5 to 1.0 mm	27.3 %
class 3	1.0 to 2.0 mm	8.2 %
class 4	> 2.0 mm	1.4 %

Table 2: Bypass Test Data

Test done with screen hole size of 1/12" (2,1mm)

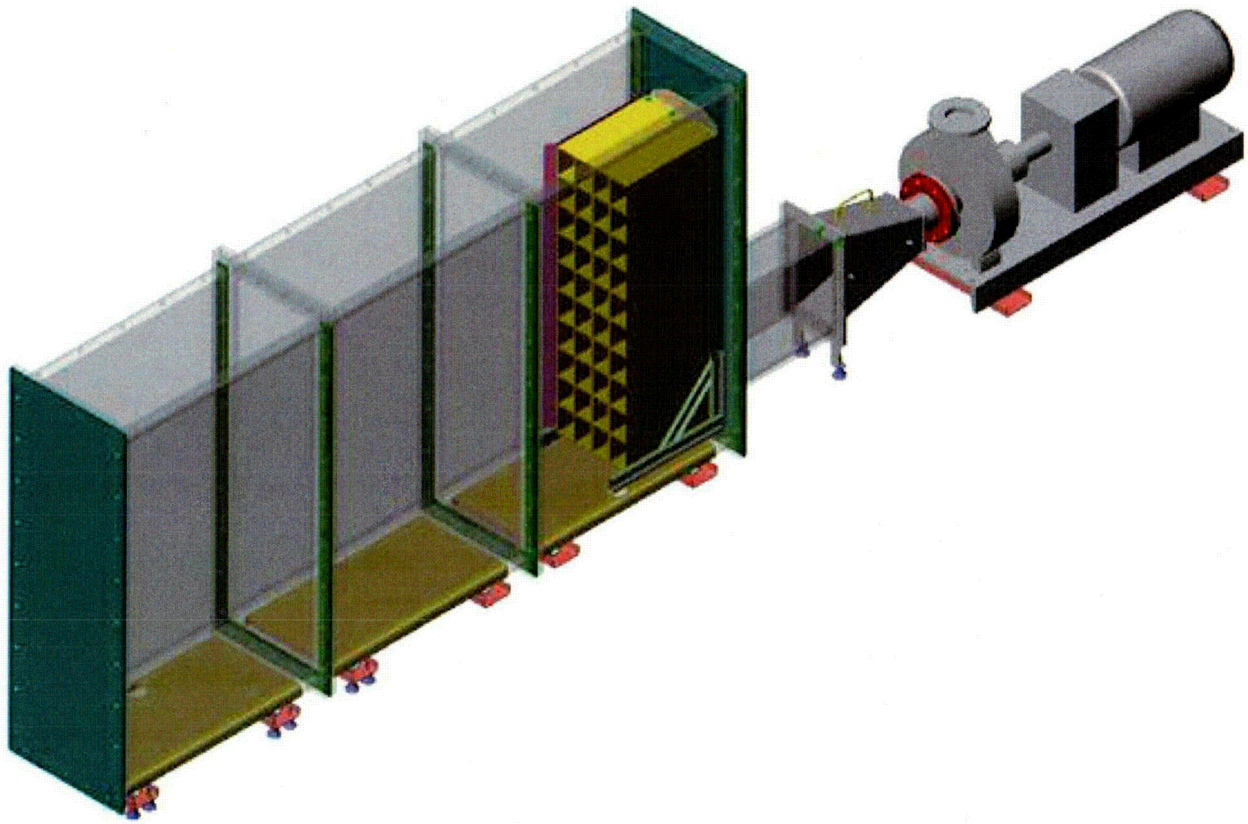
Conclusion:

The measured length of the fiber By-Pass is for about 2/3 smaller than 0,02" (0,5mm) and for 90% smaller than 0,04" (1mm)

Results and Conclusions of By-Pass Testing

- Above approx. 0,25" equivalent fiber bed thickness the By-Pass is more or less constant
- Size of perforation holes influences the By-Pass approx. linear with the hole diameter
- Test procedure influences the test result not significantly
- Reduction of screen area does not reduce By-Pass due to increased approach velocity
- Size of fiber, passing the screen is small

Head Loss due to Chemical Effects



Head Loss due to Chemical Effects

- SST and LST head loss testing was done with chemical precipitants on Aluminum basis
- The chemical particulate generator is the loop itself
- Consideration of two scaling factors :
  - Pool water volume scaling
  - Screen size and flow rate scaling
- Extensive chemical analytical tests before head loss test :
  - Investigation of influence of tap water chemistry
    - Chemical assay of tap water
    - Lab test of precipitants formation with tap and deionized water
  - Investigation on surrogate material stone flour
    - Chemical assay of surrogate
    - Dissolution test in boric acid
  - Integral chemical tests with all chemical contributors

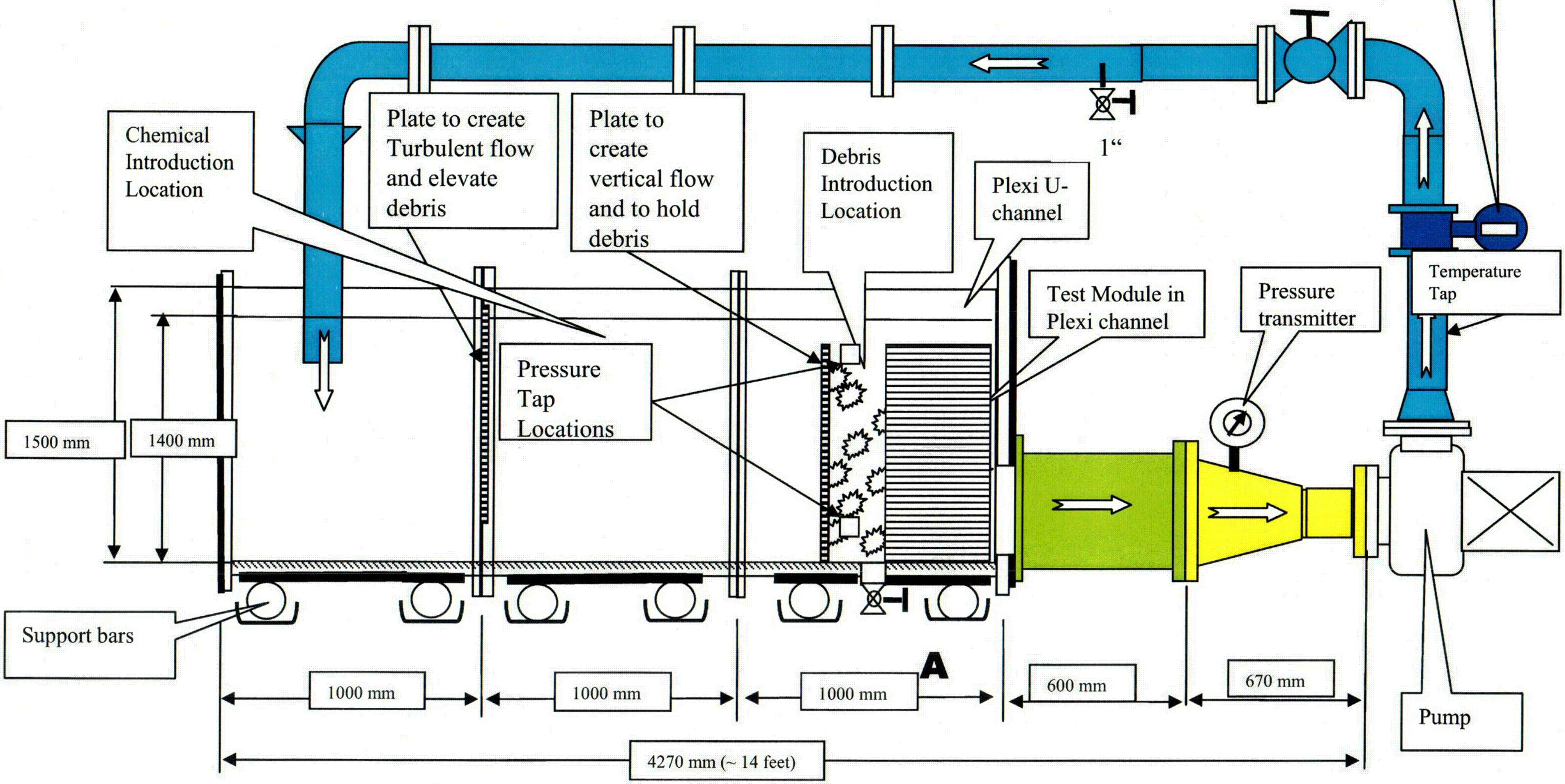
Head Loss due to Chemical Effects

- Additional analyses from laboratory:
  - Mixing tests
  - Determination of total suspended solids
  - Determination of total amounts of Na, Ca, Si and Al
  - Determination of pH and viscosity
  - Precipitate settling rates analyses
  - Precipitate size analyses
  - Precipitate filterability
  - Results have been shown within ranges of WCAP data

    → **Conclusion: surrogate chemicals are OK**

Head Loss due to Chemical Effects

Test Loop configuration

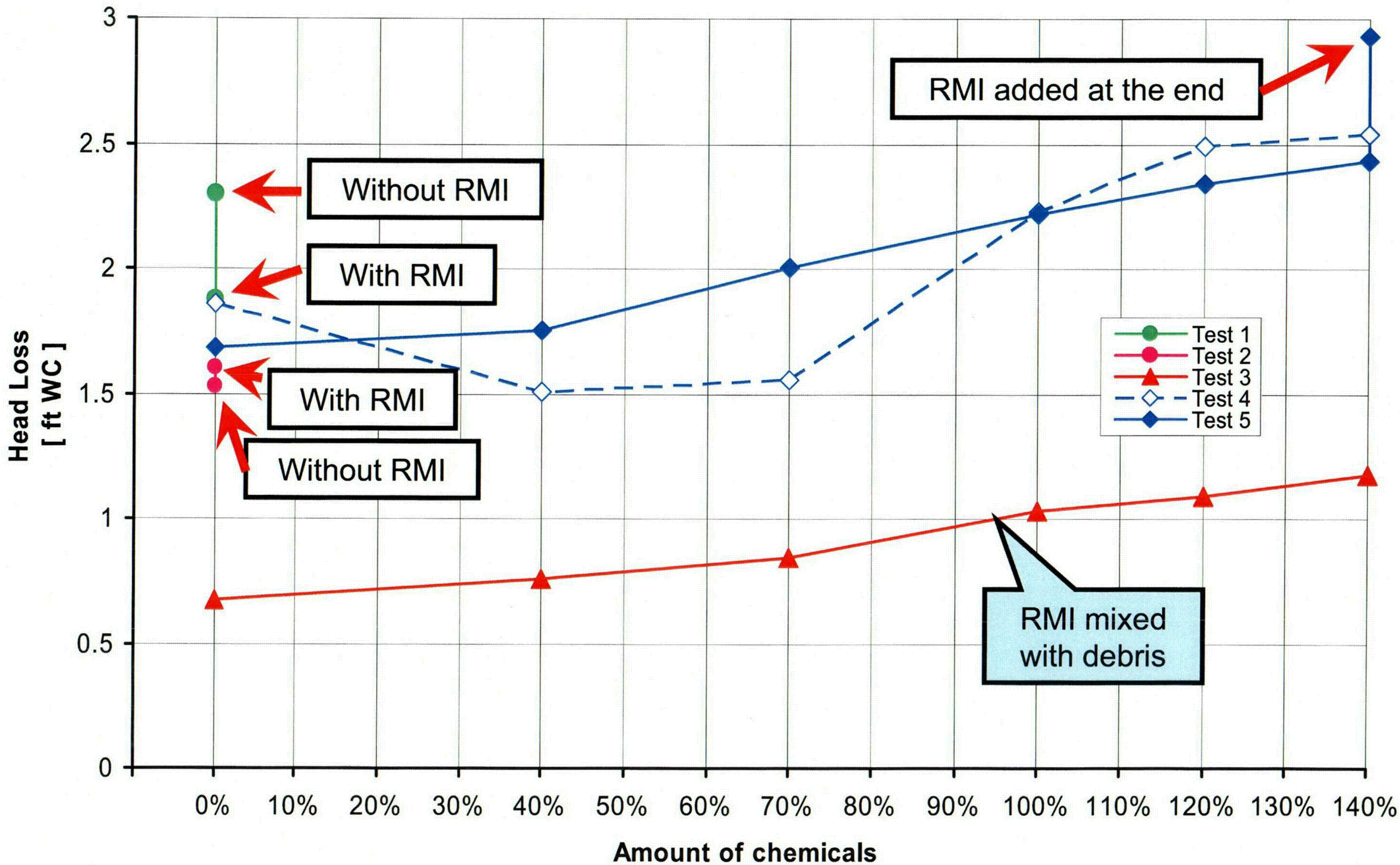


Head Loss due to Chemical Effects

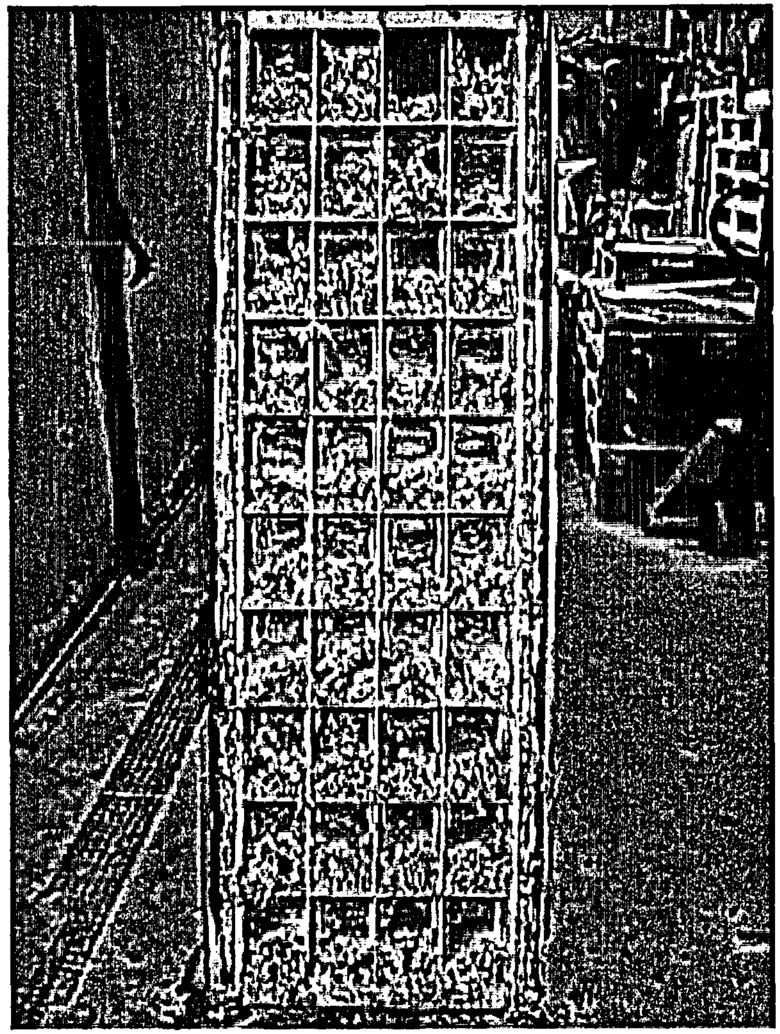
- Filter surface approach velocity 0,0117 ft / s
- Equivalent fiber bed thickness 0,054 inch
- Test performed at ambient temperature
- Test matrix:

Test	RMI	Stone Flour	Zinc Dust	Transco	Glass	Boric Acid	Sodium Aluminat	Calzium Clorid	Sodium Silicate	Sodium Hydroxide	Nitric Acid
(Nr.)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
1	13.243	51.9	104.73	0.253	0.407						
2	13.243	76.6	37.37	0.253	0.407						
3	13.243	51.9	104.73	0.253	0.407	31.033	65.414	4.794	1.85	2.399	26.4
4		51.9	104.73	0.253	0.407	31.629	64.13	4.701	1.812	0	17.363
5	13.246	51.9	104.73	0.253	0.407	31.323	64.288	4.712	1.82	0	19.615

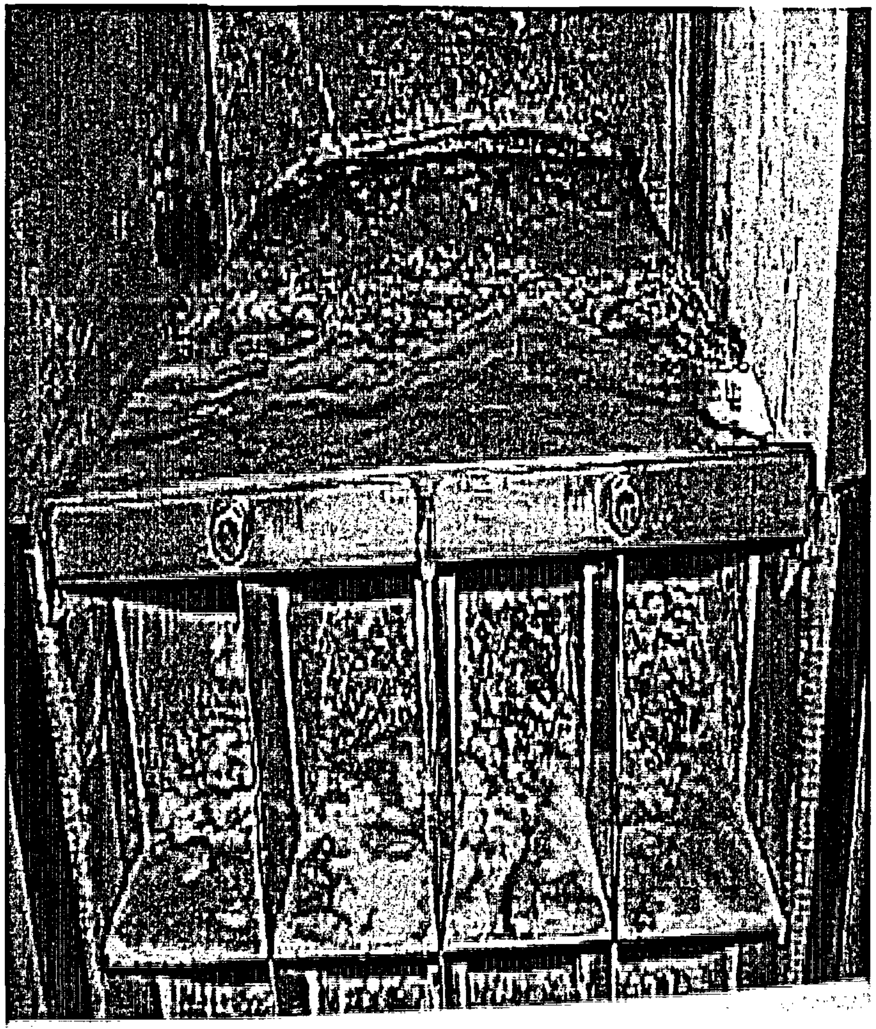
Head Loss testing with chemicals

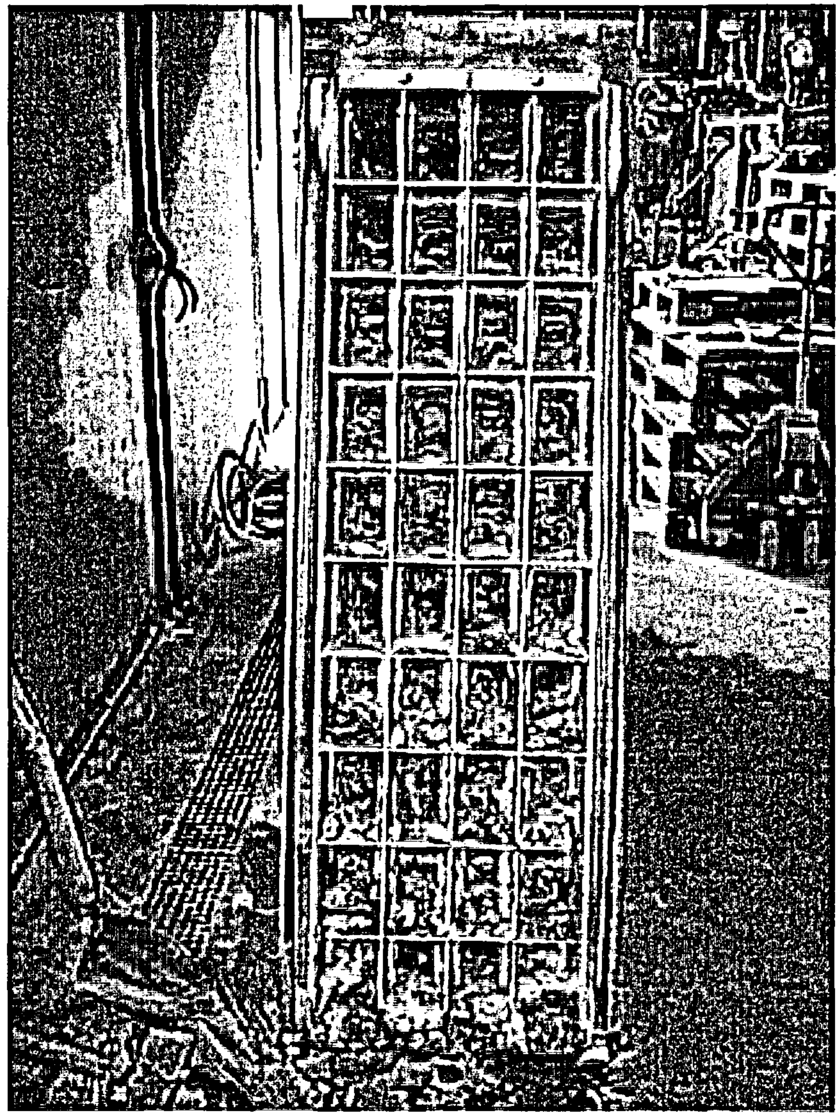


RMI introduced with debris (Test 3)



Test 4 without RMI





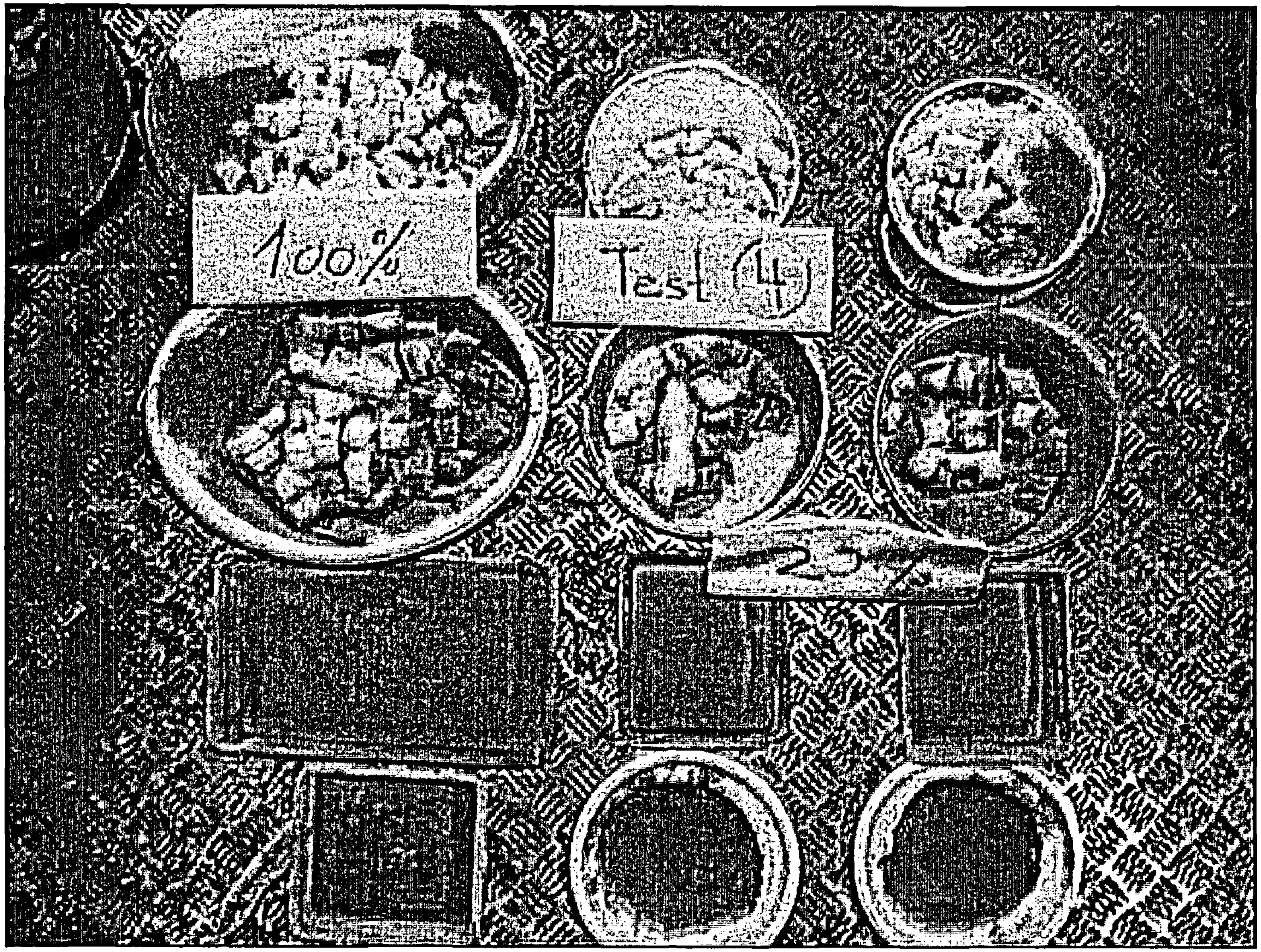
Head Loss due to Chemical Effects Conclusions

- Tests performed by CCI so far didn't show significant increase in Headloss
- Repeatability for tests with same conditions is relatively good
- If fibers and particulates are mixed with RMI Headloss is significantly less than without RMI

Debris Preparation Methodology

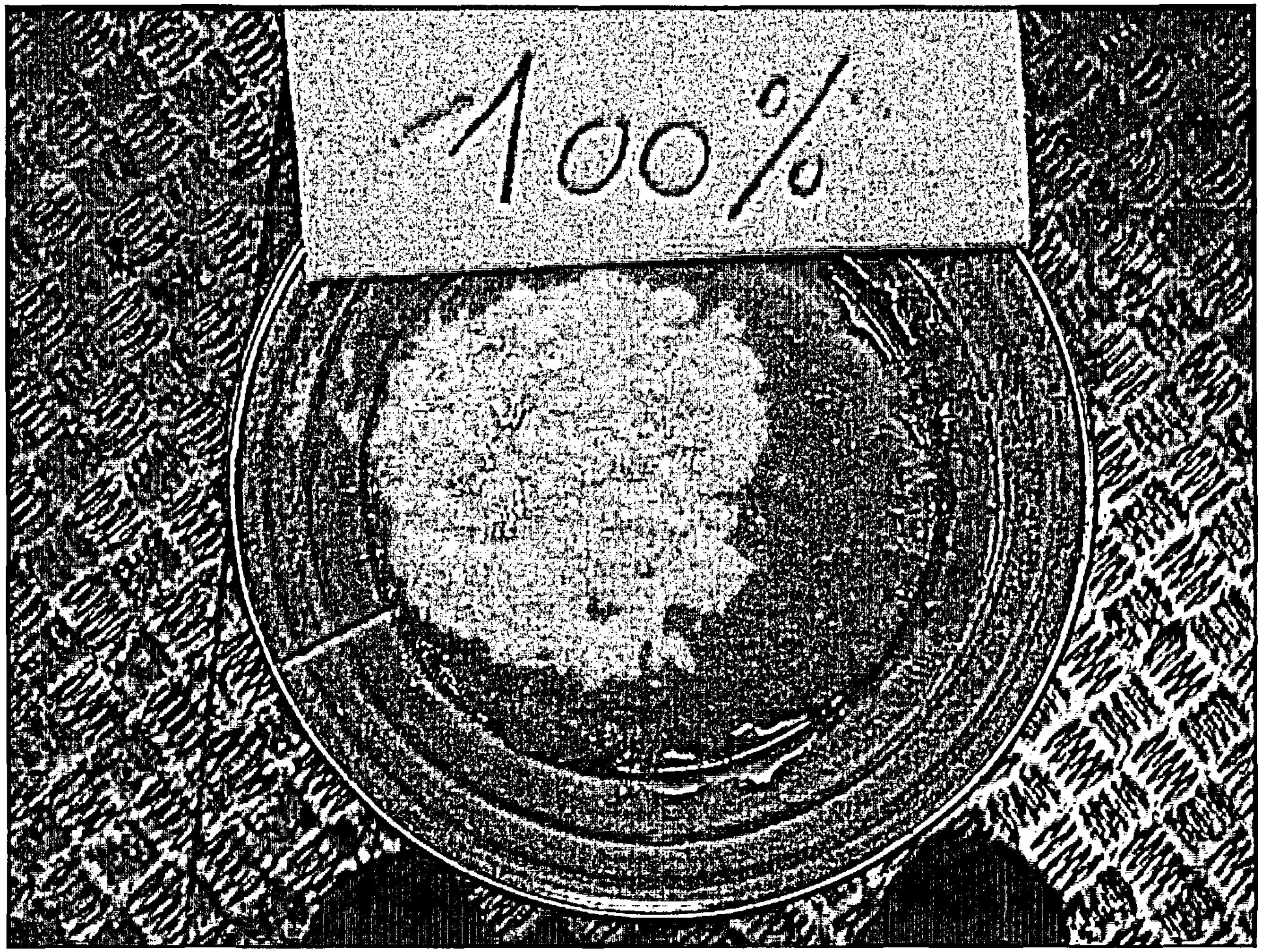
- The quantity of Debris for the tests is measured by weight in dry condition.
  - Fiber glass
  - Transco thermal wrap insulation
  - Stone flour
  - Zink filler IOZ coating
  - RMI

Debris Preparation Methodology



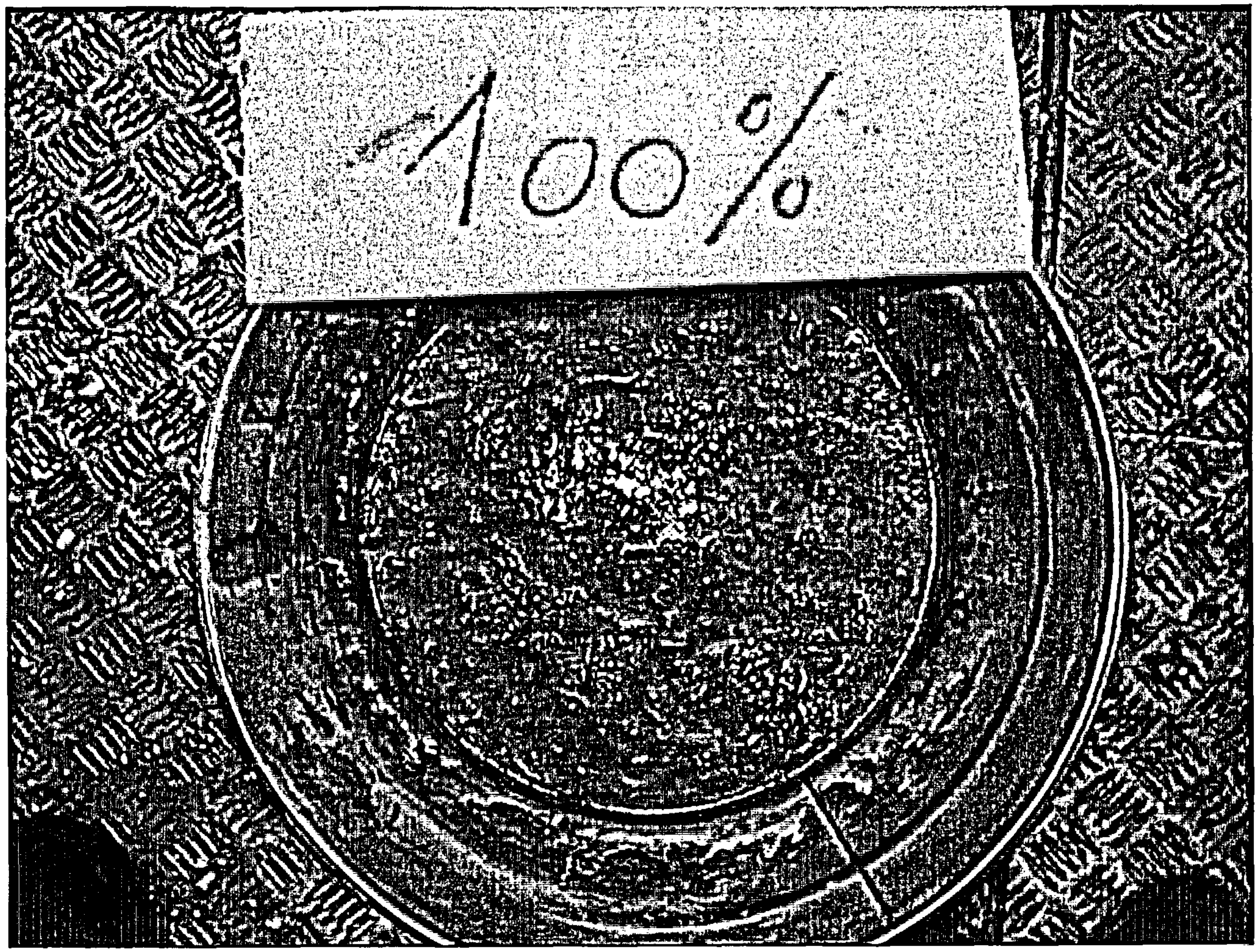
Debris Preparation Methodology

High density fibreglass soaked in water with high pressure water jet.



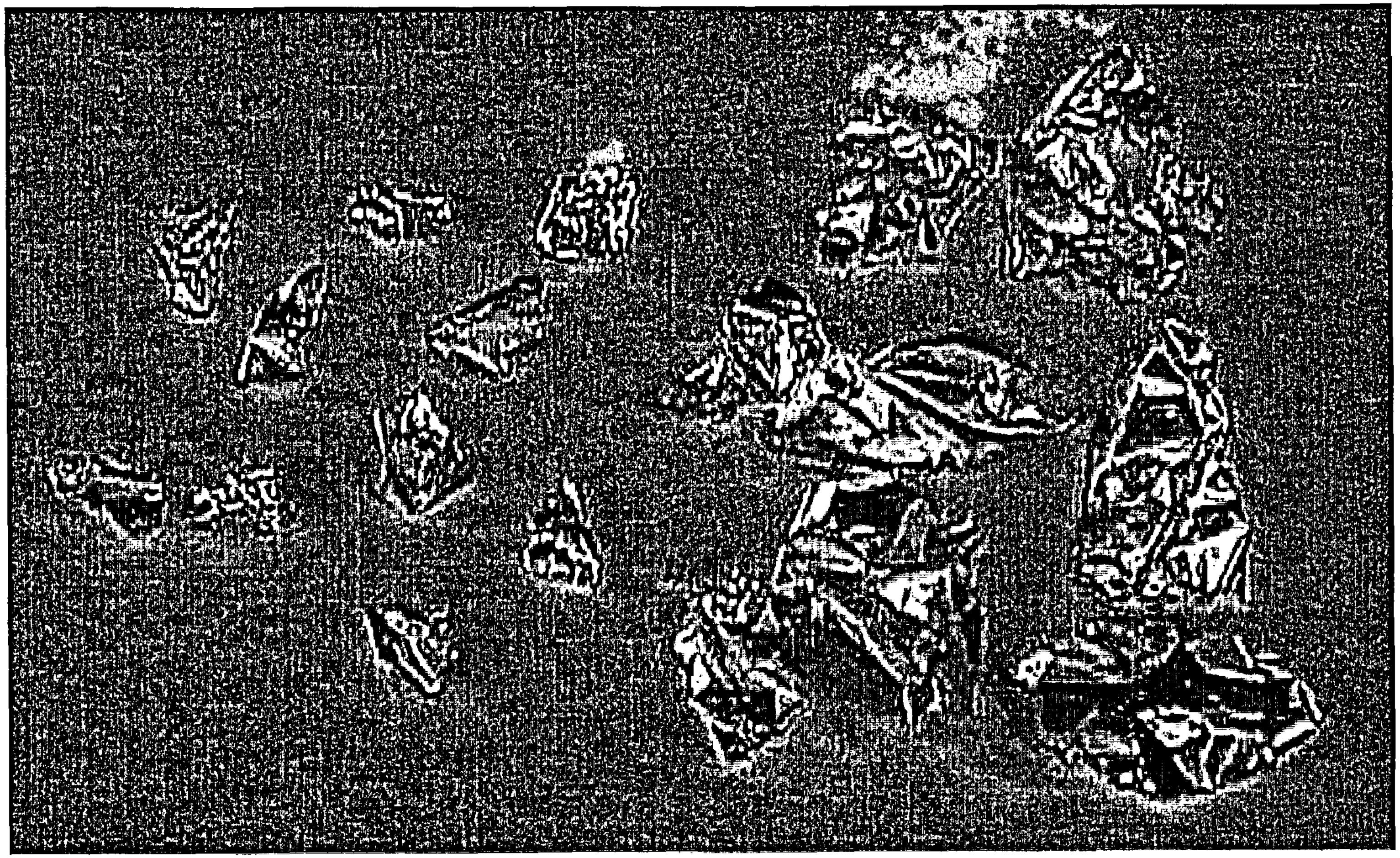
Debris Preparation Methodology

Transco thermal wrap insulations soaked in water with high pressure water jet.



Debris Preparation Methodology

Typical RMI prepared for testing



Debris Introduction Methodology

- CCI basically introduces debris simultaneously.
- This tends to lead closest to a uniform bed without strong layering.
- Debris settling is not credited for in most cases by introducing debris directly before strainer pockets

Termination Criteria

Test Loop	Changing (%)	Time (Min)	Gradient (%/h)	Depending of Head Loss Band from	Band to ft H_2O	max
SST	10	60	10			
LST	3	60	3			
SST	10	60	10			
LST	3	10	18			
MFT	6	20	18	0	1/2	
	6	40	9	1/2	1	
	2	60	2	1		
LST	3	10	18			12
SST	10	60	10			10
MFT	1	30	2			
LST	3	10	18			12
LST	3	10	18			12

THANKS FOR YOUR ATTENTION !