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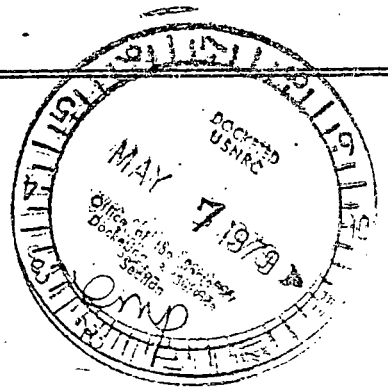

IN THE MATTER OF:

PUBLIC SERVICE ELECTRIC & GAS COMPANY

(Salem Nuclear Generating Station,
Unit No. 1)

Docket No. 50-272
(Spent Fuel Expansion)

Place - Salem, New Jersey

Date - 3 May 1979 **Pages** 509 - 700

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the matter of:	:	
PUBLIC SERVICE ELECTRIC & GAS COMPANY	:	Docket No. 50-272
(Salem Nuclear Generating Station, Unit No. 1)	:	(Spent Fuel Expansion)

Salem County Courthouse,
94 Market Street,
Salem, New Jersey.

Thursday, 3 May 1979.

Hearing in the above-entitled matter was convened, pursuant to notice, at 11:15 a.m.

BEFORE:

GARY L. MILHOLLIN, Esq., Chairman,
Atomic Safety and Licensing Board

LESTER KORNBLITH, Jr., Member

DR. JAMES C. LAMB, III, Member.

APPEARANCES:

On behalf of Licensee, Public Service Electric and Gas Company:

MARK J. WETTERHAHN, Esq., Conner, Moore & Corber, 1747 Pennsylvania Avenue, N.W., Washington, D.C.

RICHARD FRYLING, JR., Esq., Assistant General Solicitor, Public Service Electric & Gas Company, 80 Park Place, Newark, New Jersey.

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On behalf of the Regulatory Staff:

BARRY SMITH, Esq. and JANICE MOORE, Esq.,
Office of Executive Legal Director, United States
Nuclear Regulatory Commission, Washington, D.C.

On behalf of the State of New Jersey:

RICHARD M. HLUCHAN, Esq., Deputy Attorney General,
State House Annex, Trenton, New Jersey.

On behalf of the State of Delaware:

JUNE D. MacARTOR, Esq., Deputy Attorney General,
Tatnall Building, Dover, Delaware.

On behalf of Intervenor Lower Alloways Creek Township:

CARL VALORE, JR., Esq., Valore, McAllister,
DeBrier, Aron and Westmoreland, 535 Tilton Road,
Northfield, New Jersey.

On behalf of Intervenors Eleanor and Alfred Coleman:

KEITH A. ONSDORFF, Esq., Deputy Attorney General,
520 East State Street, Trenton, New Jersey.

wb

CONTENTS

Witnesses:	Direct	Cross	Redirect	Recross	Exam by Bd
Edwin A. Tilden		612	629		601
Robert F. Douglas				632	643
Thomas G Eckhart				644	
Warren S. Nechodom					
(Continued)					
John Weeks	648	654		690	691
Gary Beck					
Edward Lantz					

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3.235

P R O C E E D I N G S

CHAIRMAN MILHOLLIN: The hearing will now come to order.

The public session of this hearing is now reconvened.

Whereupon,

EDWIN A. LIDEN

ROBERT F. DOUGLAS

THOMAS G. ECKHART

and

WARREN S. NECHODOM

resumed the stand and, having been previously duly sworn, were examined and testified further as follows:

CHAIRMAN MILHOLLIN: Mr. Onsdorff, the Board understands you have a few more questions on cross-examination.

MR. ONSDORFF: That's correct, Mr. Chairman.

kxxxxx

CROSS-EXAMINATION (Continued)

BY MR. ONSDORFF:

Q Mr. Liden, I believe you previously testified that you're going to have certain responsibilities in regard to the surveillance program to be instituted by Public Service in the spent fuel pool; is that correct?

A (Witness Liden) That's correct.

Q To your knowledge, has a standard, or level of corrosion and the pitting and these sort of adverse effects

wb2

been set, at which time you will deem it significant and take appropriate action?

A There has been no standard set.

Q Do you anticipate that in the generation of data you will require some sort of a standard to know whether or not the data being generated is, in any fashion, significant or important to the safe operation of the spent fuel pool?

A The surveillance program is intended to bear out the previous corrosion experiments that have been conducted.

Q Are you referring to the Exxon experiments?

A Yes.

Q And their prediction is that there is not going to be a problem. That was done on a laboratory simulation. You're going to be with the actual live application of that experiment. And my question to you is: Have you anticipated observing data to determine whether or not the experiment is in fact being borne out?

A Yes; through periodic inspection of the surveillance specimens.

Q And when you look at that data how are you going to know whether it is bearing out the experiment or not?

A By visual inspection and determination of weight gain.

Q And what weight gain will bear out the experiment, and what weight gain will not?

wb3

A I think Mr. Eckhart can address that one.

A (Witness Eckhart) I'd like to correct the implication of your question. We have found no adverse effects from any of the measurements that we have taken or observed by others that will affect the use of the Boral material for which we are intending to use it at Salem.

MR. ONSDORFF: I would like to interrupt at this point. I don't believe that was responsive to the question, and I believe it is in the form of editorializing. My question was not whether the Exxon experiments found adverse effect; I, in fact, stated they didn't. I'm concerned about the operation of the spent fuel and the actual data which is generated there, and what data is going to be deemed significant. Certainly there may be events which occur there that-- Why are you going to watch them, if you're not going to be concerned that the results are going to be meaningful? That's the essence of my question.

WITNESS ECKHART: I'm trying to answer that. Let me finish before you interrupt.

What I'm trying to say is the following:--

MR. ONSDORFF: I would appreciate it if--

CHAIRMAN MILHOLLIN: Allow the witness to answer.

WITNESS ECKHART: We do not anticipate from any of the tests that we have done, or have reviewed, that there will be any effect on the Boral plates or the Salem storage

wb4 pool coupons provided for surveillance that will ever lead to any problem with the Boral for the purpose for which it was intended.

That doesn't imply, from a judicious, conservative operating point of view that you would not want to provide samples in the Salem storage pool to verify that what all other tests and experiments and predictions have shown to be the case is indeed what is happening in the Salem storage racks. We are not providing samples in the Salem storage racks because we're expecting problems; it's just one more degree of conservatism and proper engineering judgment that calls for them to be put in the pool.

BY MR. ONSDORFF:

Q That's precisely my question. You put coupons in there to verify, and they're going to generate data. And my question is, At what point does that data verify, and at what point does it contradict? There has to be a level of action upon those coupons which is deemed to be within design specifications and other data which would indicate that you're going beyond what your prediction was.

MR. WETTERHAN: Objection. I think Mr. Onsdorff has just testified.

BY MR. ONSDORFF:

Q Isn't that true, sir?

A Are you making objection, Mark?

agb1
wswb4

MR. WETTERHAHN: I'll withdraw my objection.

WITNESS ECKHART: If the Licensee found any properties in the specimens that he withdrew from the pool at the intervals which he has specified that indicates that the B_4C particles could become dislodged, that is when you start taking steps to determine what the problems are.

BY MR. ONSDORFF:

Q Is this going to be the Licensee's responsibility or is Exxon going to have personnel there to determine the dislodging of the B_4C particles?

A (Witness Eckhart) I'll turn the microphone back over to Mr. Liden. If they wish to contract with us or do it themselves, that's certainly their responsibility.

A (Witness Liden) That's correct. It is obviously the Licensee's responsibility for the operation of the facility, including the surveillance. How we carry it out may be with Exxon.

Q You haven't determined that at this time?

A That's correct.

Q Mr. Eckhart, I believe you testified previously that the maximum temperature that you would expect in the spent fuel pool would be 240 degrees Fahrenheit, is that correct?

A (Witness Eckhart) The maximum temperature of the water in the spent fuel storage pool I would not expect to exceed 240 degrees Fahrenheit, that's what I said.

agb2

Q Is that consistent with the question I asked you?

A No, it is much more specific. You indicated the environment of the pool, I said the pool water temperature would not exceed 240 degrees Fahrenheit.

Q We have the same meaning then, I believe.

What would the water be -- what would its chemical activity be at 240 degrees?

A I do not understand the question.

Q Would its physical characteristic be as a liquid entirely?

A The conditions under which the pool water could ever reach 240 degrees Fahrenheit would be if you lost both of your Class 1 cooling systems of the pool. In other words, you have no heat removal from the pool whatsoever.

Under those conditions, the pool water will gradually heat up so that at the surface of the pool you would begin to boil. If the surface temperature of the pool reached 212 degrees Fahrenheit, the water temperature at the bottom of the storage pool due to the difference in head, the 40-foot head of water, would be very nearly 240 degrees Fahrenheit.

Q So we're talking about, in essence, a breakdown of some of the operating systems to result in that environmental effect in the water to occur?

A That's correct.

Q Are you aware of any operating pressurized water

agb3 reactors that have experienced those type of difficulties?

MR. SMITH: I object. The line of questioning seems to be going beyond the contention in this proceeding. We're talking about the spent cooling mechanisms and not the Boral anymore.

CHAIRMAN MILHOLLIN: What is the connection between the line of questioning and the contention?

MR. ONSDORFF: The link-up would be, Mr. Chairman, that there could be an experience which would occur that would certainly combine with deterioration. You could always hypothesize ideal conditions operating at all times. I feel very strongly, however, that that has not been the case with our experience with nuclear power in this country.

CHAIRMAN MILHOLLIN: Well I'll sustain the objection. If you want to ask a question which is specific to this contention which has to do with the temperature of the water, that would be acceptable.

BY MR. ONSDORFF:

Q Mr. Eckhart, have you endeavored to perform tests which would indicate the degradation and corrosion potential for the Boral material in a spent fuel pool with elevated temperatures in the vicinity of 240 degrees Fahrenheit?

A (Witness Eckhart) We have two specific programs to address the question that you asked. Number one, the maximum elevated temperature which will be allowed in the Salem spent

agb4

fuel storage pool for any long period of time is 150 degrees. Accordingly, we structured the tests that were delineated in the corrosion report around the 150 degree figure.

Second, we ascertained the effects on corrosion due to both low and high temperature conditions and determined in meetings and conversations with Battelle that, indeed, as you go above 150 degrees Fahrenheit, many of your corrosion rates are reduced, not accentuated.

Q Mr. Liden, do you know what part of the proposed racks come into direct contact with the pool liner?

A (Witness Liden) The support feet on the fuel storage racks come in contact with the pool liner, as well as bumpers on the sides.

Q Could you tell us how the racks are levelized or leveled?

A The rack -- the support feet are leveling feet such that they can be adjusted to account for any contour of the bottom of the spent fuel pool.

Q And what is the process of manipulation to achieve that levelized state?

A Those are details of the installation procedures. I guess I really don't understand what process you're looking for.

Q Well would you envision the potential for any corrosion or degradation effects resulting from unlevelized racks?

agb3

A No.

Q Have you endeavored to do any scientific analysis to support that conclusion?

A The only portions of the racks that are in contact with the pool liner are the stainless steel portions, which are of the same material. I don't see how that leads to corrosion.

Q Could it lead to a greater stress condition, that accomodation with corrosion might result in the degradation or breaking of the rack structure?

What's the purpose of the levelization, I guess that's what it comes down to?

A The racks are laid level such that the fuel can be inserted and removed in a vertical plane.

Q So it's necessary for proper operation, then?

A That's correct.

end2A

2b eb1

Q What is the weight of the fuel that is inserted into the cells?

A A fuel assembly weighs on the order of 14 to 15 hundred pounds.

Q Have you determined the additional weight, fuel weight which will be inserted into the enlarged spent fuel pool when it is filled to its maximum capacity?

A Well, it would be the difference between 1170 and 264 assemblies.

Q My question is have you made that calculation?

A Times 1400 pounds. I don't know what it is off-hand.

Q Mr. Eckhart, would you be in a position to assist Mr. Liden in that calculation?

A (Witness Eckhart) Mr. Liden's answer stands as is. I can perform the algebra for you. It's 1170 times 1450. Do you really wish to have it multiplied out?

Q Indeed I do, yes. Thank you.

CHAIRMAN MILHOLLIN: Mr. Onsdorff, what's the relevance of the weight of the material put into the pool?

MR. ONSDORFF: Well, Mr. Chairman, in our Contention 2 we have the concern with the increased corrosion and degradation combining with -- that deterioration combining with a seismological event.

CHAIRMAN MILHOLLIN: A seismological event?

MR. ONSDORFF: That's correct, which could--

eb2 CHAIRMAN MILHOLLIN: In Contention 2?

MR. ONSDORFF: I believe it is in Contention 2.

Let me take just a brief second. I have the order here.

Yes, Part D of Contention 2, it is indicated as being dismissed. However, the order reads, and I quote:

"However, insofar as evidence which might be offered under Part D may relate to Parts A and B of Contention 2, that evidence may be considered."

CHAIRMAN MILHOLLIN: Well, the question is how does it relate, Mr. Onsdorff?

MR. ONSDORFF: I'm sorry, I got diverted by Mr. Smith's interjection of his belief as to--

CHAIRMAN MILHOLLIN: Well, why don't you tell the Board how this letter of inquiry relates to your contention?

MR. ONSDORFF: We have a combination of the deterioration and the potential degradation of the racks acting in concert with the increased density to be impacted by a seismological event, to result in the dislodging of the

c4 fuel cells and having this material fall together.

CHAIRMAN MILHOLLIN: Well, why don't you ask the witness that question.

MR. WETTERHAHN: Mr. Chairman, may I interpose an additional objection?

I just have had time to check the order following

eb3 the special prehearing conference of the Board dated May 24, 1978, where Contention 2-C was specifically excluded. One of the items specifically excluded was the question of the redesign or the design of the fuel pool as to seismic effects.

CHAIRMAN MILHOLLIN: Yes, the Board is aware of that, Mr. Wetterhahn.

BY MR. ONSDORFF:

Q Mr. Eckhart, have you performed your calculation?

A (Witness Eckhart) Yes, I have. Now specifically which number did you want?

Q The increased weight which will be contained in a maximally filled pool.

A The increased fuel weight between having 1170 bundles in Salem 1 and 264 bundles in Salem 1 would be 1,268,400 pounds. That is neglecting part of the buoyancy weight of the fuel cell itself in water.

Q Thank you.

Mr. Liden, has there been any analysis of the potential combination of the degradation of the racks in combination with this additional weight factor to determine whether or not the containment would be breached in a seismological event of record as a result of the combination of all these factors?

MR. WETTERHAHN: Objection. That question makes no sense. The fuel pool is not within the containment.

eb4

MR. ONSDORFF: The fuel pool building containment is the containment I was referring to.

MR. WETTERHAHN: I would again renew my objection as to the scope of this question as beyond the scope of either 2-A or 2-B.

CHAIRMAN MILHOLLIN: Overruled.

WITNESS ECKHART: I don't believe I understand your question.

CHAIRMAN MILHOLLIN: Restate your question, please.

BY MR. ONSDORFF:

Q Has there been any analysis performed, to your knowledge, as to the combination of the anticipated degradation as performed by Exxon or otherwise, studies that have been brought to your attention, in combination with the additional weight of the additional fuel in a compact spent fuel pool as to any seismological events of record, their accommodation to result in a breach or other adverse effects on the spent fuel pool containment building?

A (Witness Liden) I don't see how they're all related.

CHAIRMAN MILHOLLIN: The question is have you performed any analysis of their possible combination?

WITNESS LIDEN: No.

BY MR.ONSDORFF:

Q Mr. Liden, in welding the stainless steel shrouds

eb5

covering the Boral to create leak-tightness, are the welds heat treated?

A Mr. Eckhart is better qualified to respond to this.

Q Thank you.

A (Witness Eckhart) The conditions under which the longitudinal seam welds on the spent fuel storage welds are produced are very tightly controlled so that the maximum amount of input minimizes any resulting stresses built into the completed storage cell.

And prior to going into production, full-scale production of the stainless storage cells, detailed tests were run on longitudinal seam welds to insure that the maximum stresses met all the code and design requirements.

Q Mr. Eckhart, if I understand you, are you saying that the surfaces adjacent to the welds are not sensitized stainless steel then?

A No, I'm not saying that. I'm saying that the degrees of heat input in a completed storage cell is so low as to insure there would be no adverse effects from heat sensitization.

Q Are you familiar with the adverse effects which occurr as a result of steel becoming sensitized as a result of the welding?

A Generally, yes.

Q What are those effects, briefly?

eb6

A I'd prefer you to ask a specific question rather than ask the general effects of heat sensitized zones of welds.

Q Have there been cracking problems in those sensitized stainless steel materials used in nuclear--

MR. WETTERHAHN: Objection. I think we're going beyond the scope of the contention. He's already testified that it will not be sensitized, and I see no reason to go into the effects of some hypothetical situation not involved in the spent fuel pool for Salem.

MR. ONSDORFF: Mr. Chairman, I believe it's very clear that he indicated he felt it would not be significant. That's conclusionary. If we've had experience with cracking that's clearly a degradation that would allow gaps to be created that would allow the water in to begin the corrosion problem that we're very concerned about.

CHAIRMAN MILHOLLIN: You asked him whether there would be sensitizing from this process, as I understand it, and he has said No. Is your question now if there were, then would certain effects ensue?

MR. ONSDORFF: Maybe we should go back to that point because I didn't understand him to say No on the sensitized stainless steel.

CHAIRMAN MILHOLLIN: Very well.

BY MR. ONSDORFF:

eb7

Q In the Salem 1 racks, would the steel become sensitized?

A (Witness Eckhart) As I answered before, no.

The license submittal-- Both Mr. Liden's document and all the correspondence that's part of the public record on this license submittal indicates the specific parameters and the specific codes to which the cells and the racks were manufactured, and those codes and standards insure that along with the proper materials and the QA/QC controls which were specified in the appropriate documents, that there would be no adverse sensitization, heat sensitization in these longitudinal seam welds that we're now talking about.

Q Do you make a distinction between sensitized and adverse sensitization?

A No, I'm just trying to answer your question directly.

Q You make no distinction between adverse and-- Would your answer be the same leaving out the word "adverse"?

A I don't think that's appropriate.

Q That wasn't my question.

A I can't answer your question. It doesn't make sense.

CHAIRMAN MILHOLLIN: The question is would there be any adverse sensitization?

Is that your question?

MR. ONSDORFF: That's my question.

WITNESS ECKHART: The answer is no.

eb8

BY MR. ONSDORFF:

Q Do you make a distinction between no adverse sensitization and no sensitization?

A (Witness Eckhart) From a grammatical standpoint, I make a distinction, but from a technical standpoint I see none.

Q Mr. Liden, the Salem 1 site was initially a wetland or a mudflat. Is that correct?

MR. WETTERHAHN: Objection; beyond the scope of the contention.

CHAIRMAN MILHOLLIN: Sustained.

MR. ONSDORFF: Mr. Chairman, we've had experiences with a number of nuclear power plants in this country where buildings have begun to settle. We talked before about the need for the racks to be levelized. My point in attempting to elicit that information is if there is any interaction between any potential settling of the site--

CHAIRMAN MILHOLLIN: Again, Mr. Onsdorff, all you have to do is ask the specific admissible question on that point, and then you can explore it.

MR. ONSDORFF: Thank you.

BY MR. ONSDORFF:

Q Has there been any analysis as to any interaction between potential settling of the spent fuel building and corrosion or degradation in the spent fuel racks, Mr. Liden?

eb9

Maybe one preliminary question would be appropriate: Has any settling been detected in the building itself?

A (Witness Liden) No.

Q Has there been any analysis as to the consequences should such settling occur?

MR. WETTERHAHN: Objection. That's another hypothetical.

CHAIRMAN MILHOLLIN: Again if you're concerned with the connection between settling and your contention, ask the question which explores the connection.

MR. ONSDORFF: I'm endeavoring to do so.

BY MR. ONSDORFF:

Q Has there been any analysis as to what level of -- what degree of settling would have any impact upon the non-corrosive, non-degradation properties of the fuel racks in the spent fuel pool?

A (Witness Liden) I have to say no to that. It doesn't make any sense to me.

Q No, there hasn't been any analysis?

A There has been no analysis of a relationship of the two.

Q Thank you.

MR. ONSDORFF: Excuse me, Mr. Chairman. I am about to begin a new line of examination.

ab10

CHAIRMAN MELNICOFF: How much cross-examination do you have? We're not moving very fast.

MR. ONSDORFF: Ten minutes maximum more.

CHAIRMAN MELNICOFF: Very well.

(Pause.)

MR. SMITH: Are we in a break now, Mr. Chairman?

CHAIRMAN MELNICOFF: Excuse me, gentlemen. We're not having a break.

Mr. ONsdorff, I'm going to have to ask you to proceed.

MR. ONSDORFF: I was just trying to see if we had an exhibit number for a letter of October 31, 1978, from Mr. Libriszi to Mr. Schwencer.

MR. VALORE: Mr. Chairman, I think that's I-H.

BY MR. ONSDORFF:

Q Mr. Liden, do you have the letter with the attachment, the October 31 letter, 1978? I believe it is Exhibit I-H.

A (Witness Liden) Yes, we have it available.

Q May I direct your attention to page number 2, lettered paragraph C.

Do you have that before you now?

MR. KORNBLITH: What was the page again?

MR. ONSDORFF: Page 2, Mr. Kornblith.

BY MR. ONSDORFF:

Q I believe we referred to a fuel pin to deform inward.

eb11 Is that accurate to characterize that as a reverse bulge?

A (Witness Liden) The paragraph refers to a fuel assembly, not a fuel storage cell.

Q This is a new phenomenon in essence? Is that what we're concerned about? That's my question.

A This is part of a test that was performed. I don't know whether I can characterize it as a new phenomenon.

Q Well, it wasn't covered in the Monticello or the un-bonded bulges that we've discussed previously? That's my question.

MR. WETTERHAHN: Objection. I think we're mixing up apples and oranges. We were talking about bulges as an effect on the boron before, and now we're talking about some effect on a fuel assembly as opposed to a rack itself, and I think that goes beyond the contention.

CHAIRMAN MILHOLLIN: Can you explain the connection between your question and your contention, Mr. Onsdorff?

MR. ONSDORFF: I believe we have the same leak-type test except this was taking it one step further. We have the type of degradation to the Boral material, and now we have the leak with the fuel cell which is the progression from the type of experience that we discussed previously which could lead directly into this type of undue event.

CHAIRMAN MILHOLLIN: And so?

MR. ONSDORFF: Well, that's precisely my question.

eb12 What was the relevance of the tests that were performed, if any?

CHAIRMAN MILHOLLIN: The relevance to what?

MR. ONSDORFF: To the continued integrity of the Boral and the containment of the radiation within the --

CHAIRMAN MILHOLLIN: Very well. Please restate your question in a way that everyone can understand, and we'll rule if there is an objection to it.

MR. ONSDORF: Thank you.

BY MR. ONSDORFF:

Q If there is a degradation problem with the Boral material, as studied by the Exxon tests, in combination with the type of undue event as analyzed here, would that result in a potential impact on the criticality calculations that were done which indicated compliance with the .95 k effective standard?

A (Witness Liden) There is no impact.

Q And what is your-- What's the basis for that opinion, sir?

A (Witness Eckhart) I'll speak specifically to your criticality question.

As you reduce the amount of water in the storage cell due to the inward swelling which is specifically identified in Paragraph C, your k effective array will decrease. The water inside that storage cell is of a nature which will

eb13 aid or tend to increase k effective.

The Licensee did not take credit or in any way address the resultant decrease in k effective due to the inward swelling. It was only in a conservative direction.

Q The test reports, Mr. Eckhart, which are attached to the October 31, 1978, letter, they were also performed by Exxon Nuclear Company. Is that correct?

A That's correct. And the gentleman most familiar with that is Mr. Warren Nechodom.

Q Mr. Nechodom, welcome aboard.

I assume, since we have begun to discuss the content of your contribution, there has been a differentiation made between this report and the proprietary material which was considered in camera.

Could you enlighten us as to how the two reports differ?

A (Witness Nechodom) This test report reports the results of an experiment to determine the consequences of the bulging of a fuel cell in terms of whether or not there will be an effect on the ability to remove fuel from the cell once that bulging had occurred.

It's an entirely different report and we did not label it proprietary.

Q That's still my question.

Why was the other one deemed proprietary and this one

ab14 not?

MR. WETTERHAHN: Objection.

CHAIRMAN MILHOLLIN: That's an improper question.

MR. ONSDORFF: I withdraw it.

BY MR. ONSDORFF:

Q Mr. Nechodom, I would just like to say in concluding my cross-examination, you gentlemen have offered extensive testimony in verifying the production and testing for the Salem 1 fuel racks. Would you say it would be an accurate characterization to say that this is in essence a turnkey project, if you're familiar with that terminology?

MR. WETTERHAHN: Objection. I don't see what relevance it has.

MR. ONSDORFF: I would submit that the relevance is that Exxon has done this in its entirety and it is going to be turning it over to Salem, the plant, to Public Service. I wanted to differentiate the responsibilities as to those parties responsible for having the expertise on the corrosion and degradation events which have been analyzed and verifying compliance with the NRC rules for this license application.

CHAIRMAN MILHOLLIN: Sustained.

Does this conclude your cross-examination?

MR. ONSDORFF: Yes, it does, Mr. Chairman.

CHAIRMAN MILHOLLIN: Mr. Valore, do you have cross-examination at this time?

eb15

MR. VALORE: I understood I was to go last. Do you want me to go now, Mr. Chairman? I'll go now. It makes no difference.

CHAIRMAN MILHOLLIN: Was there an agreement that Mr. Valore would go last? If there is, then if you prefer, it doesn't matter to the Board, if that was the agreement of the parties.

MR. WETTERHAHN: I don't know what agreement the Intervenors and the States made, as far as the order, among themselves.

CHAIRMAN MILHOLLIN: Could you inform the Board of any agreement?

MR. VALORE: I thought Mr. Wetterhahn had indicated we were going ahead with the alternative contention last. I just automatically assumed that that meant that I would cross-examine last. I have no problem if you want me to proceed.

CHAIRMAN MILHOLLIN: Very well. Proceed.

BY MR. VALORE:

Q Panel, I would like to conclude the line of cross-examination I was conducting in the proprietary or closed session, and we have moved from proprietary areas to the open public meeting area.

Did you do any analysis of spent fuel heatup following a loss-of-water accident in the pool, and the effect it would have in respect to deteriorating the neutron absorbing material?

eb16

A (Witness Liden) No, sir.

MR. METTERHAHN: Mr. Chairman, I have an objection. The so-called loss-of-water accident is what I would characterize as a Class 9 accident. There has been no showing that such an accident could occur, and I think, as discussed in my objection to certain testimony, I believe the Commission's rules prohibit the discussion of so-called Class 9 accidents.

I would renew my objection as far as any such discussion at this session or any other session of this hearing with regard to the so-called loss-of-water accidents.

MR. VALORE: Mr. Chairman, I don't think that's accurate at all. To the best of my knowledge, I don't think there has been any experience with loss-of-water accidents in spent fuel pools. I don't think they have ever been considered as Class 9 accidents or Class 7 accidents or Class 2 accidents.

In fact, I don't know that the state of the art of spent fuel loss-of-water accidents exists.

The question I have for this Licensee is a very simple question. If they didn't do the analysis, that's the end of that line of examination. If they did do the analysis, I'd like to find out more about it as it bears on the potential for criticality with 1,170 fuel assemblies.

CHAIRMAN MILHOLLIN: As the Board understands your question, it would not be necessary for us to rule on the

eb17 question whether Class 3 accidents are necessary or appropriate for us to consider in order for us to let you ask the question. The question as I understand it is whether analysis has been performed, basically of the effect of increased heat upon the absorption material.

Is that correct?

MR. VALORE: That's correct.

CHAIRMAN MILHOLLIN: I think that's a proper question and we'll let you ask it.

WITNESS LIDEN: The answer to your question is No.

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BY MR. VALORE:

Q Are you familiar with the Sandia Laboratory report entitled, "Spent Fuel Heating Following Loss of Water During Storage?" It bears the Sandia designation 77-1371. It's dated September, 1978, by an A.S. Benjamin.

MR. WETTERHAHN: Mr. Chairman, may I ask Mr. Valore to tender that document to the witnesses so they may examine it?

CHAIRMAN MILHOLLIN: Yes.

MR. SMITH: Is this a draft? There's a final on it.

MR. VALORE: My question relates to the draft.

(Document handed to witness panel.)

WITNESS ECKHART: Yes, we're familiar with it.

MR. SMITH: Mr. Chairman, I would like clarification of the line of questioning. Is it possible that any question can be asked in this proceeding that if in any way you can tie anything to deterioration then that's a line of questioning that can be pursued? Where is the bounds of this contention?

CHAIRMAN MILHOLLIN: Well the Board has been ruling as objections have been tendered to specific questions. If it appears that the testimony is not relevant, the Board will exclude it.

BY MR. VALORE:

Q Panel, do you believe that the SFUEL computer code which was used in the Sandia draft report is sufficiently

agb2 developed and verified to provide reliable heatup temperature predictions with reasonable accuracy?

MR. WETTERHAHN: Objection, this clearly goes beyond the scope of this contention, which is deterioration.

MR. VALORE: Mr. Chairman, I don't think that it does. They said that they haven't done any calculations, but they say that they're familiar with this report which does deal with the heatup problems if there were a loss of water accident. Now I'm asking them if they believe the computer code that was used was reliable. Their opinion may be it's not reliable, and that may explain why they haven't done it.

CHAIRMAN MILHOLLIN: I will allow your question with the understanding that you will soon tie this line of questioning to the contention.

MR. SMITH: Mr. Chairman, I would also like to pose an objection, although these are not our witnesses. But actually in anticipation for a panel of witnesses, why Mr. Valore didn't file any outline of cross-examination in this area.

And I believe the Sandia report has come up in this hearing and it has been available, apparently, since September, 1978.

MR. VALORE: I didn't file any outline of cross-examination because this whole line of questioning occurred to me as I've spent a day, today and yesterday particularly,

sitting here -- and this morning, listening to Mr. Onsdorff's cross-examination.

CHAIRMAN MILHOLLIN: Well my view is that this line of cross-examination can be disposed of fairly rapidly if you would ask a question which is connected to the contention. So the Board would urge you to do that.

MR. VALORE: I think I have a pending question.

CHAIRMAN MILHOLLIN: Yes, you have a pending question and the Board has ruled that it must be answered.

Could you restate your question for the convenience of the witness?

WITNESS ECKHART: It's not necessary.

The Licensee's thermal hydraulic analysis and the impact upon both material performance and criticality were specifically done within the scope that your pool will be filled with water, and that's consistent with all the current Reg. Guide's on licensing of spent fuel storage rack applications.

The Sandia report goes well beyond the scope of the license application submittal, and accordingly, it was not addressed within their submittal.

BY MR. VALORE:

Q That's very interesting information, but the question I had asked was do you believe the computer code that was utilized in that report is sufficiently developed and verified

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to provide reliable heatup temperature predictions with reasonable certainty.

MR. WETTERHAHN: Mr. Chairman, I would object for lack of foundation. There's no question as to whether they have knowledge of details of the computer code, only of familiarity with documents.

CHAIRMAN MILHOLLIN: The question is whether the witness is able to state something with respect to the computer code, and I think that's a proper question.

WITNESS ECKHART: We have not reviewed the computer code in that kind of detail.

MR. VALORE: Thank you.

BY MR. VALORE:

Q I would now like to ask you a line of questioning in respect to the state of the art on the product that is to be used at Salem 1, that is, the dense storage racks that are to be utilized.

Can you tell me at present where are the dense storage racks, where are they physically at present?

A (Witness Liden) At present, the spent fuel storage racks are in Seattle, Washington.

Q Has title to these storage racks passed to Public Service Electric and Gas?

MR. WETTERHAHN: Objection.

CHAIRMAN MILHOLLIN: Sustained. I don't see the

agb5 relevance.

MR. VALORE: I think the relevance might be, Mr. Chairman, if I may, that it may go to credibility of the witnesses. Especially in respect to Mr. Eckhart's testimony, I think I should be able to explore whether the sale is contingent upon this application being approved. If so, one or more of the witnesses may have a financial interest in this application being approved.

CHAIRMAN MILHOLLIN: Well if that's your goal, why don't you get to it and just ask your question on that point?

BY MR. VALORE:

Q Is the purchase of the dense storage racks contingent upon this Licensing Board's approving the application for a new design, that is, the new dense racks to be put in at Salem 1?

A (Witness Liden) It is not.

Q And has the Licensee purchased the racks?

MR. WETTERHAHN: Objection. Clearly with the previous answer, he has exhausted his line of questioning as to the credibility of the witnesses.

CHAIRMAN MILHOLLIN: Sustained.

BY MR. VALORE:

Q Panel, at how many other pressurized water reactors has the type of racks that are to be installed at Salem 1 if this application is approved been utilized?

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MR. KORNBLITH: What do you mean by "this type of rack?" Can you define it a little better?

BY MR. VALORE:

Q Panel, the Board has asked me to flesh out or to define that question a little better.

When I say the same racks that are to be used for Salem 1, where I'm going is, have the racks that are to be delivered to Salem 1 to be used to densely store spent fuel, have identical racks been installed anywhere else at any other nuclear power spent fuel pool or very similar to them, that type of thing.

A (Witness Eckhart) There are very similar racks employed in several applications. It is impossible to have identical racks, obviously, from one plant in one pool to another.

Q Have these similar racks been installed in any plant?

A Yes, they have.

Q What plants?

A Now you're speaking steel racks for storing spent fuel storage, as I believe?

Q I'm speaking to similar dense storage fusl racks to the ones that are proposed in this application for the Salem 1 Plant.

A I will still have to ask you to be more specific. There are many types of high-density storage racks that no fewer

agb 7 than 16 different firms are providing to the industry today.

Now what kind of similarities do you want us to compare with what has been used elsewhere and Salem?

Q Thank you for that answer. Let me ask you this question:

In respect to the.... May I ask you, you did tell me once before but I don't have it in my notes, the company that makes the racks, what is the name of the company?

CHAIRMAN MILHOLLIN: What's the relevance of this question?

MR. VALORE: I think the relevance is I should be able to find out where racks similar to the ones at Salem 1 are, how long they've been installed at other installations, whether any deterioration has occurred there.

CHAIRMAN MILHOLLIN: You've asked the witness whether racks similar to those at Salem have been installed elsewhere.

MR. VALORE: Right.

CHAIRMAN MILHOLLIN: And the answer was it depends on what you mean by similar.

MR. VALORE: Right.

CHAIRMAN MILHOLLIN: So if you could define that word, maybe you could get the answer to your question.

MR. VALORE: Well he said there were 16 different industries, so I thought it would narrow it down to the Brooks and Perkins, the manufacturer of the ones for Salem.

agb8

CHAIRMAN MILLOLLIN: Very well.

BY MR. VALORE:

Q Perhaps I could ask this question: Could you tell me any other nuclear plants where Brooks and Perkins' spent storage racks similar to the ones that are to be installed at Salem 1 have been installed?

MR. WETTERHAHN: Objection. I think that misstates the previous answer. I think it was stated that Brooks and Perkins in a supplier of the Boral, rather than a supplier of the completed racks.

CHAIRMAN MILLOLLIN: That is correct.

WITNESS ECKHART: Brooks and Perkins is a manufacturer of poison materials and have been making Boral identical to that being utilized for Salem for storage rack applications for over seven years and over 15 storage pools. As I indicated this morning in earlier testimony, the only significant difference in the Boral is the boron loading.

MR. VALORE: Mr. Chairman, I don't think that's an answer to my question, and, if I may.... I had the opportunity to look at a brochure that's put out by Brooks and Perkins and it sounds to me like they were advertising themselves to be a manufacturer and distributor of racks. And if I could have that brochure, which I think the Nuclear Regulatory Commission has, I would appreciate having it.

CHAIRMAN MILLOLLIN: Well perhaps the witness could

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simply answer whether, to the witness' knowledge, any other reactor has a rack which is similar enough to the ones proposed for Salem to make it scientifically valid to compare them.

WITNESS ECKHART: To answer the question, he's referred to a very specific kind of material or structural performance, and I would like him to identify what he's after. There are many different properties incorporated within a storage rack. Is he talking about steel, talking about Boral, what qualities does he want me to compare between the two?

CHAIRMAN MILHOLLIN: Would you state the qualities of the racks that you would like him to address? Presumably, they'd be made of the same material as the ones at Salem. I'm not going to suggest questions to you, however.

BY MR. VALORE:

Q Would I be correct in saying that ---

MR. VALORE: Well Mr. Chairman, I think I can go at it another way which will make it faster.

CHAIRMAN MILHOLLIN: Very well.

BY MR. VARLORE

Q Panel, will you tell me the name of the manufacturer you are purchasing the high density fuel storage racks from?

A (Witness Eckhart) The Leckenby Company.

Q I missed that, will you give it to me again?

A The Leckenby Company in Seattle, Washington.

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Q Now, does that company or some company eventually assemble and put together all the material including the Boral neutron absorbing material which is supplied by Brooks and Perkins into one finished product that's delivered to the Salem site?

A Yes.

Q Which company is that?

A Lackenby assembles the completed storage rack.

Q Now can you tell me if the completed Lackenby assembled racks similar thereto which are to be stored -- which are to be utilized for storage in Salem 1, have been placed in any other nuclear facility in this country?

A Yes, there have.

Q Where?

A Racks similar to the ones we're talking about for Salem have been installed at Monticello, they've been installed at Browns Ferry, they've been installed at Connecticut Yankee, they've been installed in Vermont Yankee, they've been installed in Three Mile Island. I don't have the list in front of me, but there have been 50 reracking performed in the last three years, of which no fewer than 15 have involved very similar concepts with boral poison materials.

Q Thank you.

MR. VALONE: One moment, Mr. Chairman.

(Pause.)

agb11

BY MR. VALORE:

Q Now Panel, you had indicated earlier that there would be a monitoring program at Salem 1 after these racks were installed in order to attempt to determine if there was any deterioration of the Boral material. Can you tell me if you had any reports from Monticello or Browns Ferry or Connecticut Yankee or any of the other 15 or so installations you mentioned where there has been a deterioration problem?

A (Witness Liden) No.

MR. VALORE: I have no further questions.

CHAIRMAN MILHOLLIN: Thank you, Mr. Valore.

Does either the State of New Jersey or the State of Delaware have any questions at this time?

MS. MAC ARTOR: I have 7 questions.

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CHAIRMAN HILHOLLIN: You may proceed.

MS. MAC ARTOR: Thank you.

BY MS. MAC ARTOR:

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Q I would like to have some clarifications, and I will start with the document of the application, the amended application, which is Exhibit 1-C I believe.

On page 11 of that document, Section 3.1, the last sentence, no credit was taken for the boron in the pool water. And I believe yesterday the testimony was that the boron in the pool served no purpose. I believe it was Mr. Liden's statement.

Is that correct?

A (Witness Liden) Yes, ma'am.

Q And if you would look also at page 12, the first paragraph, the last sentence:

"Credit would be taken under accident conditions of a dropped fuel assembly or placement of the fuel assembly outside the fuel storage array."

I was not clear as to the relationship between those two sentences.

A (Witness Eckhart) During normal operation, the Licensee does not take credit for the dissolved boron in the pool water environment, even though it is there.

Q Let me stop you just a minute.

Does the boron absorb neutrons?

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A Yes, it does. The boron in the water provides the same function as the boron in the Boral plates serves. They are both neutron absorbers, whether in the water or in the Boral.

But for purposes of the analysis and for the license submittal, we did not take credit for the boron in the water during normal operation.

For accident or unusual conditions, the current guidelines allow the Licensee to take credit for a minimum amount of boron in the water. His license is based on 1700 ppm of boron.

Q I think I'm still not quite clear as to why you can take credit under accident conditions and not under normal conditions.

A It's the current NRC guidelines for review and acceptance of spent fuel storage applications.

Q Would it be your answer that that question then should be directed to the NRC?

A Yes, ma'am, it would.

Q On page 25 you are speaking of the coolant entering the hole in the bottom of the cell I believe. Yes, a six-inch hole in the bottom of the fuel storage cell serves as a coolant inlet.

Could you explain how that relates to the actual fuel itself, how the coolant water, the pathway of the coolant

eb3 water in the assembly?

A In your document on page 43--

Q The same document?

A Yes, the same document.

-- you will see a picture of a storage rack module. On the base plate--

Q Excuse me. Page 43?

A Yes.

Q I don't have a page 48.

A Do you have a Figure 1.2-1?

Q No, sir, I skip a page here.

A Well, I'll go ahead without it.

MR. WETTERHAHN: I will tender a copy of that, and we'll get her a replacement copy.

(Handing document to Ms. MacArtor.)

MS. MAC ARTOR: Now I have it.

WITNESS ECKHART: In each oneof the storage cells that you see in that rack module, and that's a 10 x 10 rack module, the fuel is inserted in each discrete cell and sits on the bottom base plate, and the feet or the pedestal upon which the fuel is supported are on the four corners of the fuel assembly.

Right in the middle of the base plate directly beneath each storage cell is a six-inch hold which is drilled through for the purpose of allowing natural circulation of

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fresh pool water to flow through the fuel storage cell and the fuel assembly.

BY MS. MAC ARTOR:

Q And then what happens to the water?

A (Witness Eckhart) The water would flow upward through the fuel assembly by natural circulation if you had a hot fuel assembly in there. If you had no heat sink or heat source without a fuel assembly, the water would probably not flow through the cell whatsoever.

Q Then am I clear that under normal operations you would not expect this water to be going through, it would be in case of a heat buildup?

A It would take a driving force, in this case a heat sink, which would be the fuel assembly, to promote any substantial flow through the fuel cell. You probably would have a nominal flowthrough there during all conditions.

Q Is there any provision for forced flow?

Let me ask first: Would there be a need for forced flow?

A I'll try to clarify that. The forced flow in the storage pool takes the following form:

The pumps put fresh water, cool water in at the bottom of the storage pool, and sometimes at the opposite sides, sometimes on the same side where the inlet is, there is a scrubber or an outtake from the pool, taking the water

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back over to the heat exchangers and the pumps.

From that standpoint, you have forced water in and removal from the storage pool, but you don't have any forced water per se going through each and every storage cell.

Q Why is that?

A It's not required.

Q It's not required because it's not needed, or--

A It's not needed for the removal of heat from the fuel cell.

Q On page 29 you speak of the temperature that we talked about a bit earlier in testimony.

What's the boiling point of the borated water which is in this pool?

A At the surface of the pool it would be 212 degrees Fahrenheit.

Q 212.

And I think your testimony then is that this would result in a temperature at the bottom of the pool of 239?

A I indicated it would be of the order of 240 degrees.

Q Could you explain that phenomenon a bit?

A Basically with the depth of the water -- this are 40 foot high pools -- the increased pressure or the head due to the height of 40 foot of water will insure that the bottom of the pool, if you didn't have perfect circulation, could reach as high as 240 degrees Fahrenheit.

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What is really happening is if you don't assume proper mixing, the hot water that comes out of the fuel assembly will not go up to the top of the pool; it may come out, turn around and go down again. That's the hottest temperature you would ever have at the bottom and that results in around 240 degrees Fahrenheit.

Q And one other term I didn't understand in that same paragraph is the saturation temperature. Is thatwhat you were just explaining?

A Yes. That means that you would be right on the threshold of boiling at 240 degrees at the bottom of the pool.

Q And this is a physical phenomenon? It simply cannot get above that?

A That is correct.

Q On page 37-B--

CHAIRMAN MILHOLLIN: Ms. MacArtor, I would like to remind you that the Board is limited in its power to the things which are relevant to this contention. Even though you may establish something which is interesting, if it is not relevant to this contention, the Board will take no action on it.

MS. MAC ARTOR: I'm aware of that. I have attempted to limit it to the contention. As one develops the cross-examination question, one does it by going through the document and at any point at which I get beyond the contention,

eb7 I am sure someone will remind me of it.

BY MS. MAC ARTOR:

Q The dropped fuel assembly section may be such an area, and I did make a note here on that particular point.

I realize that in installing the racks in a contaminated pool, there will have to be an additional procedure filed with NRC. However, it seems to me that it might be addressed under Contention 2 in the increased density. Installing the racks in a contaminated pool would not be needed except for the fact that we are going to have increased density. And I only have one question with two subparts on this. It relates to page 37-B.

Is there a change in the-- Would there be a change in the analysis of the dropped fuel assembly accident with intalling this rack in a contaminated pool?

A (Witness Liden) There would be no change.

Q No change at all? I believe you testified yesterday that you'd be bringing in a temporary crane.

A Yes, ma'am.

Q And the present crane track is fixed so that it cannot go over the pool with the heavy load. But you're going to have a heavier load with this rack.

A That's correct.

Q And it will be over the pool, and there is fuel in the pool.

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A But it will not be over that portion of the pool containing fuel.

Q Oh. All right.

Then that takes care of that line completely.

MR. KORNBLITH: Could I just follow that up for a moment?

I don't find anything in the document which says this. This is a criterion that you're announcing essentially for the first time, as far as this Board is concerned. Is that right, that there will be something that prevents carrying a fuel rack over stored fuel?

WITNESS LIDEN: The installation procedures will specify that the new racks will not be handled over the spent fuel stored in the pool.

MR. KORNBLITH: Have those procedures been prepared yet?

WITNESS LIDEN: They are in draft form at present.

MR. KORNBLITH: And this is the sort of provision that will be included?

WITNESS LIDEN: Yes.

MR. KORNBLITH: Thank you.

And these of course will be subject to review by the NRC people?

WITNESS LIDEN: Yes, NRC will review and approve it.

MR. KORNBLITH: Thank you.

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I'm sorry for the interruption.

MS. MAC ARTOR: That's all right.

BY MS. MAC ARTOR:

Q Moving to the document, Exhibit Number 5--

CHAIRMAN MILHOLLIN: Could I ask you how much longer you intend to be? I ask for purposes of the lunch break.

MS. MAC ARTOR: I'll be a while.

CHAIRMAN MILHOLLIN: Well, then perhaps it might be well to break for lunch at this time.

MS. MAC ARTOR: This would be a good time.

CHAIRMAN MILHOLLIN: Very well.

We will break for lunch at this time and we will reconvene at 1:45.

(Whereupon, at 12:30 p.m., the hearing in the above-entitled matter was recessed to reconvene at 1:45 p.m. the same day.)

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AFTERNOON SESSION

(1:45 p.m.)

5.175

CHAIRMAN MILHOLLIN: May I have your attention, please? Ladies and gentleman, the hearing will now reconvene. Whereupon,

EDWIN A. LIDEN,

ROBERT P. DOUGLAS,

THOMAS G. ECKHART,

and

WARREN S. NECHODOM

resumed the stand as witnesses on behalf of the Licensee, and, having been previously duly sworn, testified further as follows:

CHAIRMAN MILHOLLIN: Ms. MacArtor, you may proceed.

MS. MAC ARTOR: Thank you.

CROSS-EXAMINATION (Continued)

BY MS. MAC ARTOR:

Q Before we turn to Exhibit Number 5, a couple of more questions on the application. I don't have the page referenced, but we had spoken of the impact of the dropped fuel assembly matter. But another area, would that have any effect on the thermal cooling of the fuel assembly that was damaged in the drop?

MR. METTENHEIM: Objection. At this point, I would interpose an objection that we have gone far afield from the

agb2 contentions and we're beyond the contested issues in this proceeding.

CHAIRMAN MILHOLLIN: I sustain the objection.

You may say your reasons, how do you intend to connect this with the contention?

MS. MAC ARTOR: It would be Contention Number 3. The increased density makes these things more crucial because if the thermal cooling is damaged of one, it's possible, so far as I know that, with closer spacing of these things, that the thing might go critical. So that it seems to me that the risk is increased when you put 1170 assemblies ---

CHAIRMAN MILHOLLIN: The risk of what, again?

MS. MAC ARTOR: The risk of criticality, which is Contention Number 2.

CHAIRMAN MILHOLLIN: That has something to do with dropping the fuel, you say?

MS. MAC ARTOR: That's what I'm trying to explore, as to whether it does or does not, I don't know.

CHAIRMAN MILHOLLIN: Very well, you can ask the witness whether criticality depends on dropping the fuel.

BY MS. MAC ARTOR:

Q If you had a thermal damage from a fuel drop, would that increase the chances of criticality?

A (Witness Liden) No, it would not.

Q Why would it not?

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A I heard you say thermal damage to the assembly that was dropped, is that correct?

Q Well what I meant was, the assembly that is damaged, would there be an impact on the thermal cooling of that, and would that then lead to criticality?

A No, it would not. Because if something happened such that an assembly could not be thermally cooled, the water in the vicinity of the assembly, the temperature would increase thereby reducing the K-effective further and it would become more subcritical.

Q All right.

MR. KORNBLITH: Could I interrupt for just a moment, Ms. MacArtor?

Maybe we can get an answer that will have a little broader application and can help respond to some of the other potential questions.

What is the relationship between reactivity and temperature, to what extent do they interact and in what direction?

WITNESS ECKHART: The interaction between storage pool K-effective and the pool water temperature is that, as you heat the water up, it becomes less dense.

And the main purpose of the water in the Salem storage rack project is as not a neutron poison but it is a moderator. What you have done here is essentially reduced the moderatability

agb4 of water and your K-effective goes down.

The Licensee's submittal addresses this and also addresses that the K-effective or the criticality calculations were based upon extremely conservative assumptions, that the water inside the storage cell was all at 68 degrees Fahrenheit, which is most dense, which would tend to make the fuel area most reactive.

However, the water in the interspace gap is at boiling conditions or 212 degrees Fahrenheit. You clearly can't have both, so that's what was assumed. That gives you the maximum reactivity in the water gap, you see the maximum reactivity inside the storage cell area, and that's the basis upon which the criticality is performed.

MR. KORNBLITH: If the temperature in the water in the fuel goes up, the reactivity goes down, is that correct?

WITNESS ECKHART: That's correct, yes, sir.

MR. KORNBLITH: And when the reactivity goes down, that's the same thing as saying you're getting farther away from accidental criticality?

WITNESS ECKHART: That's correct.

MR. KORNBLITH: Thank you.

MS. MAC ARTHUR: That disposes of two questions, Mr. Kornblith.

BY MS. MAC ARTHUR:

Q What would be the impact of objects that are

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inadvertently dropped into the waste storage pool, such as tools -- I understand the probability of that is low, nevertheless, it could happen.

For example, you testified yesterday that the vent drill device would be larger than the thing it was drilling into but the drill bit, by definition, can't be. Suppose some foreign object lodged in that, what would be the impact of that as related to criticality?

A (Witness Liden) There would be no relation to criticality in such an event.

Q Also to Mr. Liden: Now that we're talking about long-term storage of fuel assemblies, what provision is there for perpetual maintenance of this fuel pool as long as there is contaminated water in -- and I believe it does relate to the increased numbers of assemblies stored there and the age of them.

MR. WETTERHAHN: Objection. If this question relates to any time beyond the expiration of the operating license, it's beyond the scope of this hearing and the contentions, any contested contention.

CHAIRMAN MILHOLLIN: By long-term storage, are you referring to storage for the life of the plant?

MS. MAC ARTOR: The original application was for storage for one year. We're now talking about storage at least until 1993 and, so far as I know beyond, at this

agb6 point.

And the company -- I'm asking whether the company has arrangements for maintenance of the pool, because that water is contaminated.

CHAIRMAN MILLOLLIN: Yes.

In order to rule on this objection, I'm asking you to specify the length of time in which you're interested.

MS. MAC ARTOR: I'll break it into two parts: one the length of the operating license and one beyond.

CHAIRMAN MILLOLLIN: Very well, you may answer the first question.

Does the witness understand the question?

WITNESS LIDEN: I thought she was going to ask it again.

BY MS. MAC ARTOR:

Q What provisions do you have for maintenance of this fuel pool, both the structure, the racks, the assemblies, the whole thing, for the life of the operating license?

A (Witness Liden) I guess I'm a little confused as to what you mean by maintenance. The structure is there. The pool is there. There is really no maintenance per se required.

Q There are pumps and that type of thing.

A Yes. The pumps are inspected periodically, tested periodically, preventive maintenance is performed which is routine for any fluid systems, lubrication, whatnot. Or, I

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should say, maintenance procedure.

Q Now turning to Exhibit Number 5, the Exxon report, does --

CHAIRMAN MILHOLLIN: For purposes of the record, you're referring to the non-proprietary version of the report, is that correct?

MS. MAC ARTOR: Yes, sir. Exhibit Number 5 is the non-proprietary version, March, 1979.

BY MS. MAC ARTOR:

Q On Page 4-3, corrosion was in evidence along the edges where the holes were drilled into the test coupon. What would you attribute the corrosion to in the edges?

A (Witness Eckhart) The most precise way to answer your question, you would essentially initiate a pitting corrosion condition by drilling a small hole into the Boral face. That's the answer.

Q Is this the kind of corrosion that happens to metals under stress?

A No.

You'll recall earlier when we were discussing pitting corrosion, once you do initiate a pit in a smooth surface and you do start having pitting corrosion, that's not necessarily a self-limiting reaction. That's why the pits continue to grow.

Q Would the welds of the cladding be likely to develop

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similar corrosion problems over time? We touched on that this morning.

A No, ma'am.

Q Would you have the same kind of thing -- Mr. Kornblith was asking this morning about the cutting of the plates. Would you have the same kind of thing there that you had from the drill holes?

A Not really. You're comparing an edge face, where mostly what you're seeing is a matrix of B_4C and aluminum, what you would have right there is very local oxidation and corrosion of the aluminum versus what you're seeing on a flat surface where you drill a hole in it and initiate a pit.

Q I see.

Again we touched on it this morning but didn't explore it fully, the extrapolation by Exxon of a year or a year and a half of studies to the long-term or permanent storage situation. Your answer was that it was standard in the industry to do this.

Is this a standard unique to the nuclear industry?

A No, it is not.

Q What do you base the statement on that it is standard to extrapolate one year of data to 20 years or permanent?

A It is a widely accepted practice in trying to determine long-term effects of material properties to develop a test over a reasonably long period of time such that you can get

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enough information to make a general prognosis or extrapolation of material performance.

What I was saying this morning was that getting one year's worth of data specifically related to this corrosion report is a reasonable and widely accepted practice for generating long-term corrosion information.

Q Are there any standards for establishing the validity of the data in relation to how far you can extrapolate?

A No.

Q What confidence level did you establish for your extrapolation?

A Excuse me just a second.

(Pause.)

What we have done with the corrosion report here again is identify the various corrosion mechanisms and the material performance mechanism if you had any leak-tight cell.

What we were trying to establish with our specific program was how Boral in this environment compared to Boral in similar environments. We determined after one year's worth of work whether it compared very favorably with other studies. We found nothing here in terms of trends or actual raw data that would ever infer that the B_4C particles could become dislodged.

Q Am I clear, then, that had you found something that was a discrepancy from other studies, you would have not been

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able to extrapolate as far?

A That is correct. Or we would have had to have gone further ourselves.

Q Exxon suggests the inclusion of corrosion products in the edge seals to alleviate hydrogen production. And this -- I don't have the page reference. Is this corrective action a proven technology?

MR. WETTERHAHN: Objection. If we can't get the correct page citation, I want a foundation question as to whether that's a correct statement.

MS. MAC ARTOR: I'd be happy to.

BY MS. MAC ARTOR:

Q Is that a correct statement?

A (Witness Eckhart) I'm sorry, I didn't understand your question.

Q The inclusion of corrosion products in the edge seals to alleviate the hydrogen production, to prevent it.

A In the edge seals, are you referring to the Boral plates or the storage cell?

Q Just a minute, we'll find the reference.

Page 4-8.

"....require sealing of the edges with corrosion products to enable the internal gas pressure to increase sufficiently to expand the 10 mil aluminum cladding."

agb11

Let me ask you to clarify that paragraph, because possibly I don't understand it.

A All right. That was the issue that we spoke to this morning, when we were trying to differentiate between swelling storage cells and small random local bulges that you get into.

MR. WETTERHAHN: The witnesses are now trying to determine whether the information is proprietary.

CHAIRMAN MILHOLLIN: The question is taken from the non-proprietary version.

MS. MAC ARTOR: It was prepared before this morning, so all you have to worry about is your answer, not the question.

(Laughter.)

WITNESS ECKHART: That's what I'm worrying about.

The small random local bulges have nothing to do with the venting procedures that we discussed earlier.

BY MS. MAC ARTOR:

Q So that it wouldn't have anything to do with the hydrogen production, is that what you're saying?

A (Witness Eckhart) You would have hydrogen production, if you did form a bulge, if you did allow water to get into the inside of the plate to begin with, you would not worry about venting or trying to remove the hydrogen gas from those small bulges.

Q Did Exxon do the criticality calculations?

agb12

A Yes, they did.

Q Yesterday you deferred to NRC on certain questions regarding those calculations, specifically the change from the standard of 0.90 to 0.95. I'd like to inquire into the Exxon expertise of performing the criticality calculations.

Have your calculations been proven in practice?

A Yes, they have.

Q Where?

A Do you want other storage rack applications or do you want benchmark applications?

end2E

2f ebl

Q I think I would like to have both. That comes from volunteering answers, Mr. Eckhart.

(Laughter.)

5.460

MR. WETTERHAHN: I warned him before about volunteering.

(Laughter.)

MR. SMITH: I would like to interpose an objection. I don't understand where this line of questioning is going with relationship to this contention.

CHAIRMAN MILHOLLIN: Can you enlighten us on that?

MS. MAC ARTOR: The criticality calculations of course are crucial.

MR. SMITH: To this contention?

MS. MAC ARTOR: The contention has to do with criticality. The increased density leads to increased criticality.

MR. WETTERHAHN: May I be heard? May I respond?

CHAIRMAN MILHOLLIN: Yes.

MR. SMITH: If you read this contention, the first sentence I would have to agree with Ms. MacArtor's characterization. But you go on and it seems to say the additional consideration of criticality is required due to the following, and then we have parts A, B, and D.

The first sentence is very broad, and it is narrowed by the second sentence.

eb2

MS. MAC ARTOR: I have a different semantic view, that the first sentence stands alone, and the word "additional" in the second sentence-- In fact, I gave a great deal of thought to it, that the second sentence speaks of "additional" consideration. It could be read Mr. Smith's way, it could be read my way.

CHAIRMAN MILHOLLIN: I think it should be interpreted so that the words "additional consideration" refer to-- I think the word "consideration" in the second sentence defines the word "consideration" in the first sentence, which means I don't read it the same way you do, Ms. MacArtor.

MS. MAC ARTOR: I felt the effect of that.

CHAIRMAN MILHOLLIN: So I would have to ask you to go back in your line of questioning to deterioration.

MR. KORNBLITH: Your last question had to do with how the results of the witness' criticality calculations had been evaluated.

MS. MAC ARTOR: Yes, where they had been validated.

CHAIRMAN MILHOLLIN: Yes, and I asked you to tie that to deterioration.

MS. MAC ARTOR: Criticality calculations are basic to any discussion of criticality, whether it is deterioration or any other.

CHAIRMAN MILHOLLIN: Well, in this contention we're

eb3 concerned about the effects on criticality of deterioration, so if you can tie your inquiry with respect to criticality to the possible effect of deterioration, then the question would be permissible.

MS. MAC ARTOR: If the criticality calculation is off in any way, then the deterioration effect of either the Boral plates or the rack structure will be changed; that is, less deterioration of those plates or the rack structure will cut off the criticality point.

CHAIRMAN MILHOLLIN: Perhaps. If you'd like to explore that you may.

BY MS. MAC ARTOR:

Q Mr. Eckhart, do you recall what the last question was?

A (Witness Eckhart) If you have the Applicant's license submittal before you, Table 3.1-5 --

MR. WETTERHAHN: For the record, that is again Exhibit 1-C.

WITNESS ECKHART: Exhibit 1-C, page 44.

MS. MAC ARTOR: One moment if you will, please. Let me find that.

MR. SMITH: Will you repeat the page again, please?

WITNESS ECKHART: Page 44, --

MS. MAC ARTOR: Yes.

WITNESS ECKHART: -- in conjunction with page 45,

eb4

summarizes the benchmark critical experiments performed by others at Exxon Nuclear to verify the accuracy of our models.

Also in the text of the submittal is a description of the models which have been widely accepted as the industry standard for criticality calculations.

BY MS. MAC ARTOR:

Q In these calculations, the standard models which you use, what is the statistical uncertainty in calculating the KF?

A (Witness Eckhart) Your question is a little broad. Do you refer specifically to the benchmark criticals?

Q Yes.

A On page 44, the stipulated uncertainties, the statement is plus or minus .005.

On page 46, the one sigma level uncertainty level for cases 1 and 2 are .006, for case 3 is .006, and for cases 4 and 5, .005.

Q Mr. Douglas, I believe your affidavit stated that--

MR. WETTERHAHN: Objection. Mr. Douglas' affidavit is not in evidence.

MS. MAC ARTOR: Shucks.

Mr. Douglas is a member of the panel.

MR. WETTERHAHN: He certainly is.

MS. MAC ARTOR: All right.

BY MS. MAC ARTOR:

eb5

Q Mr. Douglas, part of your qualifications for being on the panel I believe are that you conducted the environmental impact parts of the original application.

A (Witness Douglas) Portions of the application relating to the offsite environmental impact, yes, were prepared under my supervision.

Q Would the increase in the fuel storage have any increase in the impact on the Bay, the fisheries resources and so forth?

MR. WETTERHAHN: I would object to that question. It is clearly beyond the scope of the contention.

CHAIRMAN MILHOLLIN: Sustained.

MS. MAC ARTOR: Thank you, Mr. Douglas.

BY MS. MAC ARTOR:

Q Does the addition of boron in the water have any connection with the deterioration of either the Boral plates or the rack structure?

A (Witness Eckhart) The license submittal states that there is no difference in the material performance of the stainless steel 304 structural materials due to the pool water environment. The Exxon Nuclear design and the Salem storage rack concept as stated in the license submittal is based on the sealed concept which precludes the water from coming in contact with the Boral.

Nonetheless, as summarized both this morning and

eb6

this afternoon, there is no discernable difference in Boral behavior in DI water or boric acid water.

Q If the shielding should fail, does the fuel assembly then become critical?

MR. WETTERHAHN: Objection; no foundation. It's a hypothetical question without the elements being in evidence.

CHAIRMAN MILHOLLIN: Overruled.

WITNESS LIDEN: What shielding are you referring to?

BY MS. MAC ARTOR:

Q The shielding in the fuel assemblies.

A (Witness Liden) Shielding. Could you be more specific?

Q The stainless steel shielding, the cladding; I'm sorry. Is cladding the proper term?

A On the fuel storage cell?

Q Yes.

A And I forgot the rest of your question.

Q If the cladding fails, does the fuel assembly become critical?

A The stainless steel is there for structural purposes and is not a neutron absorbing material. The Boral-- The boron in the Boral takes care of that.

Q So that if the Boral went, that would cause the assembly to go critical?

A I think I'll let Mr. Eckhart tackle this one.

eb7

A (Witness Eckhart) If you lost part of all of the Boral material you would certainly have a serious impact upon criticality.

Q How much of that Boral would you have to lose for the criticality?

A A more precise way to address that is already in the Applicant's license submittal; specifically we have done detailed criticality analysis.

If an entire Boral plate was missing in a 5 x 5 storage array you would still be less than or equal to the 0.9 K effective criterion.

MR. KORNBLITH: Is that still without credit for the boron in the water?

WITNESS ECKHART: Yes, sir.

MS. MAC ARTOR: Could I have 30 seconds?

(Pause.)

CHAIRMAN MILHOLLIN: Mr. Eckhart, I have a question.

How many Boral plates would you have to lose in order for criticality to occur?

WITNESS ECKHART: With no boron in the pool water?

CHAIRMAN MILHOLLIN: Yes, with no boron in the pool water.

WITNESS ECKHART: I cannot answer that question precisely.

MR. KORNBLITH: How about with boron in the pool

eb8

water?

WITNESS ECKHART: You could lose them all.

MR. KORNBLITH: That's with fresh fuel?

WITNESS ECKHART: Yes, sir.

CHAIRMAN MILHOLLIN: So you're saying the boron in the water is a functional equivalent of the plates, the Boral plates?

WITNESS ECKHART: From the standpoint of meeting the K effective criteria, yes, sir. Yes, I am.

MR. KORNBLITH: How much K do you lose by virtue of having typical spent fuel in there as opposed to fresh fuel?

WITNESS ECKHART: A significant amount. You would drop-- Depending upon how much burnup you had on the fuel, you would drop in K effective from -- in the pool, from an environment around .95 downwards of around .7, .75, with typically discharged burned fuel.

MR. KORNBLITH: Taking the real life situation where you have boron in the water and you have spent fuel that has been in the reactor for a normal lifetime, you're way down in K effective, maybe of the order of .5?

WITNESS ECKHART: With boron in the water and Boral plates and typically burned fuel, that's probably a reasonable number.

CHAIRMAN MILHOLLIN: You may proceed.

BY MS. MAC ARTOR:

eb9

Q One last question in connection with Contention 6, the protracted association with the spent nuclear fuel.

Now in reading over the half-lives, I notice that some are 22 days and Kr is 85 I think. It said something like 10 years. Is that correct?

A (Witness Douglas) That's correct.

Q Then when the operating license life-- At the end of the operating license life, how much radioactivity will remain in these assemblies?

A I don't have that exact answer. It would be on the order of 10^6 or 10^7 curies of activity.

Q Is there a place today where that could be put, other than in this assembly at that level?

MR. WETTERHAHN: Objection.

CHAIRMAN MILHOLLIN: Sustained.

MS. MAC ARTOR: That's all the questions, Mr. Chairman.

CHAIRMAN MILHOLLIN: Mr. Hluchan?

MR. HLUCHAN: Most of the areas I intended to cover have been dealt with. I will be necessarily brief.

BY MR. HLUCHAN:

Q Exhibit Number 2, Mr. Liden's affidavit, paragraph 8. It is stated that the waste--

CHAIRMAN MILHOLLIN: Just a minute until we find the document.

MR. HLUCHAN: I'm sorry.

eb10

MR. SMITH: Mr. Hluchan, on what page, please?

MR. HLUCHAN: Page 5.

WITNESS LIDEN: I wonder if we could have a copy of that, please?

MR. WETTERHAHN: Surely.

(Document handed to the witness panel.)

BY MR. HLUCHAN:

Q Mr. Liden, in paragraph 8 of the affidavit which is Exhibit 2, at page 5, it is stated that:

"....the worst potential consequence would be failure to be able to insert the fuel...."

And I'd like to ask you what the basis for that statement is?

A (Witness Liden) The basis for that statement is that an empty fuel storage cell that developed a leak in the pool would have the inner stainless steel shroud wall bulge inward, thereby reducing the cross-sectional area of the storage cell.

Being an unused cell, the worst consequence would be that we could not install the fuel assembly in there.

Q And is that statement based upon any other study, other than the Exxon study which is in evidence? Is there any other basis for that statement, other than that particular study?

A No, I don't think so.

eb11

Q There has been no other testing done, to your knowledge?

MR. WETTERHAHN: I wonder if Mr. Hluchan could possibly enlighten us as to the consequence he is thinking of. It's an empty cell, as I understand.

CHAIRMAN MILHOLLIN: It's a proper question.

WITNESS LIDEN: There has been no other testing done. It is our contention that we would accept the fact that we would lose the cell for use.

MR. HLUCHAN: All right.

BY HLUCHAN:

Q What is the procedure which will be utilized to determine the existence of swelling prior to racking the spent fuel?

A (Witness Liden) I believe that's in our application someplace.

Q I wonder if you could summarize it briefly?

A Basically what we would do is insert what we call a dummy fuel assembly into the location, using normal operational procedures.

Q And this would be carried out for each cell prior to placement of each spent fuel assembly?

A Yes.

Q Now do I understand correctly from this exhibit that there is no way at all to make a cell usable once swelling

eb12 occurs?

A No, I don't think that's a correct statement.

Q Would you correct my statement? I'm just wondering if they can ever become--

A I would not say it is not possible, but we are accepting it as being lost from service.

Q All right.

On the same page, paragraph 10 of the affidavit, Mr. Liden, I take it that again all of the conclusions reached in this paragraph, which extends to the next page as well, are based solely on the Exxon testing?

A That is correct.

Q There have been no independent studies undertaken?

A No.

Q Mr. Eckhart, when you testified under examination by Ms. MacArtor that extrapolation of testing from one year to a greater period of time was a widely accepted practice, were you referring to the material that's contained in paragraph 10 of the affidavit, in which the conclusion is made that after 40 years, only a small percentage of the aluminum in the Boral core will be consumed, based on one year testing?

A Yes, I am.

Q That was the widely accepted practice that you referred to?

A No, that's not paragraph 10. Would you like to

eb13

rephrase your question? You were just talking about paragraph 10.

Q Yes. On page 6 it says:

"These experiments showed that simulated storage cells, with a leak simulating hole purposely made in the cell, will sustain aluminum corrosion which will consume only a small percentage of the aluminum in the Boral core after a 40-year exposure."

This is based on a one-year test, is it not?

A That is correct.

Q And is that the widely accepted practice to which you testified earlier, or was that something else?

A I'm saying if you extrapolate the results of our test program that you would expect to consume a very small portion of the aluminum in the Boral matrix after a one-year test program.

MR. KORNBLITH: Excuse me, Mr. Hluchan.

Wasn't your question whether Mr. Eckhart's statement was based on this statement in the affidavit, or was it the other way around?

MR. HLUCHAN: Well, Ms. MacArtor had gone into a similar area and I was wondering if this was the same type of area or not, namely, the extrapolation from a one year -- analyzing results over a one-year period and then extrapolating to what would occur over a longer period of time.

eb14

MR. KORNBLITH: Well, it's my impression that this statement of Mr. Liden's is based on Mr. Eckhart's work. Now could you explore whether or not that isn't the correct situation, rather than Mr. Eckhart's statement being based on Mr. Liden's work?

MR. HLUCHAN: I believe that has already been testified to.

BY MR. HLUCHAN:

Q Paragraph 10 is based solely on the Exxon report which was Mr. Eckhart's work; isn't that correct?

A (Witness Liden) That's correct.

MR. KORNBLITH: Thank you.

BY MR. HLUCHAN:

Q Mr. Liden, Paragraph 11 refers to a commitment by the Licensee to a surveillance program. Was that commitment made by the Licensee-- Did the Licensee offer that commitment, or was it extracted?

MR. WETTERHAHN: Objection. I don't see the purpose of the question.

CHAIRMAN MILHOLLIN: Sustained. The conditions under which the commitment was made are not really relevant.

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BY MR. HLUCHAN:

Q Mr. Liden, is this long-term surveillance program referred to in Paragraph 11, I assume that that is separate and apart from that which is described in Paragraph 8, namely, testing the individual fuel cells prior to inserting the spent fuel?

A (Witness Liden) Yes.

Q It's a different program?

A Yes.

6.215 Q During Mr. Valore's cross-examination, a member of the panel testified that there are approximately 15 or so other nuclear power plant spent fuel pools which contain racks that are similar to the ones that would be installed in Salem Number 1. Does the panel know if similar surveillance programs are in effect at those?

A (Witness Eckhart) I can't tell you if all the projects utilizing poison material today have surveillance programs. It is my belief they do.

Q Why is it that the surveillance program uses sample material when the actual rack is right there and is susceptible to inspection?

A (Witness Liden) The sample material is identical material to the racks, but smaller size such that they can be readily removed and examined.

Q Are you saying that there isn't any way that the actual

agb2

rack could be examined periodically as part of the surveillance program?

A It can be examined visually, but this allows for a greater examination.

Q I'm sorry? A car went by and I couldn't hear you.

A The racks can be examined to a limited extent visually, but the ability to remove a smaller sample allows you to be able to subject it to whatever tests you so desire.

Q What types of tests were those? What type of tests are you referring to other than visual?

A We would subject them to a weight gain test.

Q Which would not be possible with the actual rack?

A That's true.

Q Any other types of tests?

A That's all we foresee at the present time.

Q But the surveillance program, as I understand it then, does not entail any examination of the actual racks? other than to the extent that you check the fuel cell before you inject spent fuel?

A That's correct.

Q How many samples will be used in this surveillance program?

A 50.

Q 50?

A Yes.

agb3

Q How was it determined that examination of the samples would take place one year after rack replacement and every two years thereafter?

A That was just an arbitrary determination.

Q An arbitrary determination.

Did you just pick those numbers out of a hat or what? Is there any further elaboration that you can offer on that?

A We picked the numbers such that the samples would be in the pool for a reasonably long enough time for any, let's say, corrosive action that was going to occur, but yet not long enough that we felt that something could go by undetected.

Q WEll do you have any basis at all for choosing two years, for example? Do you have any information that would allow one to conclude that two years was more adequate than -- or was as adequate as one year or six months?

A We factored into account the corrosion tests that have been performed by Exxon.

Q And it would not be infeasible to examine these more often than every two years, would it?

A That's correct.

MR. KORNBLITH: Are you planning any destructive tests as part of this surveillance program?

WITNESS LIDEN: No, we don't.

MR. KORNBLITH: Do you plan to put the sample back in again after they're examined?

agb4

WITNESS ECKHART: May we confer just a moment, please?

MR. KORNBLITH: Sure.

(Pause.)

WITNESS LIDEN: Excuse me, I've been corrected. The weight gain measurement is a destructive test on the sample coupon.

MR. KORNBLITH: How is that carried out?

WITNESS ECKHART: Mr. Liden indicated we have 50 different samples. Half of them are identical small fuel sections to what is in the storage racks. Those are sealed coupons. We would not expect any failures with them unless it was swelling or something like this. Visual observation is all that's required.

The remaining 45 coupons are all designed to be destructively analyzed at a program that Mr. Liden has that he could not read to you, in general.

How you would do a destructive analysis is, you weigh the coupons prior to insertion in the pool. And these coupons would be dried by a prescribed procedure and then weighed. They would be identified, they would be placed in the pool and, at the prescribed intervals, you would take the coupons out, do a visual inspection. You would weigh them wet, you would dry them by a prescribed procedure and you would measure the weight change. And that would be an accurate indication of the amount of corrosion that took place during the specified

agb5 interval.

MR. KORNBLITH: That doesn't sound terribly destructive.

WITNESS ECKHART: Oh, once you have dried them and weighed them, you could not re-insert them and try to infer trends for continued performance in the storage pool.

MR. KORNBLITH: This is a characteristic of your particular drying process?

WITNESS ECKHART: No, it is just particular to Boral, we have learned this from experience with working at Brooks and Perkins.

MR. KORNBLITH: I see. All right. Thank you.

I'm sorry, Mr. Hluchan.

BY MR. HLUCHAN:

Q Who would receive reports of the results of the surveillance program?

MR. WETTERHAHN: I believe I would object. I believe that question has been asked already and answered earlier this morning.

CHAIRMAN MILHOLLIN: The witness may answer the question.

WITNESS LIDEN: We would send reports to the NRC.

BY MR. HLUCHAN:

Q I wonder if the Licensee would have any difficulty in making that type of report available to any other public agency, such as the State Environmental Protection Department?

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MR. WETTERHAHN: Objection. I don't see the relevance to the two contentions or this hearing.

CHAIRMAN MILHOLLIN: Is this line of questioning relevant to Contention 6? How is it relevant, Mr. Hluchan?

MR. HLUCHAN: Well, the contentions concern degradation of the rack structure. They said that they're going to carry out a surveillance program to watch over the situation, and it would seem appropriate that any information gleaned from the surveillance process be shared. And I'm simply asking whether or not, beyond reporting to the NRC, they would be able to make that information available to any appropriate local or state officials.

MR. KORNBLITH: It's an interesting question, but how will the answer to it affect our decisions?

MR. HLUCHAN: I don't think it's that important that it need be belabored. I'm happy to withdraw the question.

CHAIRMAN MILHOLLIN: I'm personally intrigued by the answer, but I'm afraid it can't really affect our decision in the case.

BY MR. HLUCHAN:

Q Has the spent fuel pool water been tested to determine its criticality control properties, since it has now been mixed with reactor coolant water?

A (Witness Liden) I don't understand your question. Would you define quality control property?

agb7

Q I think I'll just withdraw the question.

MR. KLUCHAN: That's all I have.

MR. KORNBLITH: Let me ask the question my way: have you measured the boron concentration since you have mixed it with the fuel pool water, with the reactor water?

WITNESS LIDEN: Certainly.

MR. KORNBLITH: Had it changed?

WITNESS LIDEN: The spent fuel pool was just initially borated the last month or two.

MR. KORNBLITH: Before it was physically connected to the fuel pool water -- excuse me, before it was physically connected to the reactor water?

WITNESS LIDEN: Yes, the boron concentration in the pool has to match the concentration in the reactor.

MR. KORNBLITH: And when you measured it again afterward, then it had not changed?

WITNESS LIDEN: Well we are in a refueling mode right now.

MR. KORNBLITH: Well let's start over again:

Before you opened up the pathway between the reactor and the pool, you measured the boron concentration in the fuel pool.

WITNESS LIDEN: Yes.

MR. KORNBLITH: You borated and measured the results of your boration.

agb8

WITNESS LIDEN: Yes. That's correct.

MR. KORNBLITH: Do you recall what the concentration was?

WITNESS LIDEN: I do not know.

MR. KOR BLITH: Then, subsequent to that, you allowed communication between the reactor water and the fuel pool water.

WITNESS LIDEN: Correct.

MR. KORNBLITH: And since that time, have you measured the concentration?

WITNESS LIDEN: I believe the boron concentration is measured on, I believe it is, on a daily basis during refueling by the tech spec limitations.

MR. KORNBLITH: And do you think that perhaps overnight you could find out what some of these numbers were that have been obtained from these measurements and tell us tomorrow?

WITNESS LIDEN: I certainly can.

CHAIRMAN MILHOLLIN: I have one more question on that point.

After the refueling mode has ended, do you continue to borate the pool?

WITNESS LIDEN: The boron concentration in the pool would remain constant, essentially.

CHAIRMAN MILHOLLIN: So it is independent of whether

agb9 you're in a refueling mode or not?

WITNESS LIDEN: Yes, there is no reason to de-borate.

CHAIRMAN MILHOLLIN: Thank you.

MR. BLUCHAN: Thank you, Mr. Chairman, I have nothing further.

BY MR. SMITH:

Q Does anybody on the panel know if there was swelling in the spent fuel storage cells at Browns Ferry?

A (Witness Eckhart) The only cells I know swelled for sure were the ones at Monticello.

Q Mr. Eckhart, I assume this question will be directed to you but if anybody on the panel knows the answer to this question or any other questions, please feel free to speak up.

Is it accurate to state that the spent fuel storage cell that you're providing to the Licensee is Boral surrounded by a stainless steel shroud?

A Yes, sir.

Q Now has that particular fuel storage cell been before in a PWR environment for use as a spent fuel storage cell?

A The stainless steel one and the Boral?

Q The storage cell in a PWR environment.

A In a PWR environment? Yes, but let me review -- I don't have my full list of reactors and racks with me.

(Pause.)

I can't answer you for sure.

agb10

MR. SMITH: That's all my questions.

MR. WETTERHAHN: I have about 10 or 15 minutes of redirect.

CHAIRMAN MILHOLLIN: Proceed.

MR. WETTERHAHN: May I confer with the witness?

CHAIRMAN MILHOLLIN: How long do you want to confer?

MR. WETTERHAHN: About a few seconds.

MR. ONSDORFF: Can we have an indication in the record as to the subject of that conference?

CHAIRMAN MILHOLLIN: There's no question pending, it won't be prejudicial.

REDIRECT EXAMINATION

BY MR. WETTERHAHN:

Q Mr. Liden, do you have the transcript of yesterday's session before you?

A (Witness Liden) NO, I don't.

(Document handed to witness panel.)

Yes, I do.

Q At Page 428, Line 22 of that transcript, you testified that about 10 percent of the volume of the fuel pool would be occupied by water. Is that response correct?

A That is not correct. I misinterpreted the question.

Q What did you mean to say?

A 90 percent.

Q Subsequent to the time you have done that estimate --

agb11

you gave the estimate of 10 percent, have you had a chance to refine your calculations?

A Yes. The refined calculations show 10.6 percent.

Q Thank you.

MR. KORNBLITH: Excuse me, that 10.6 percent is for the present racks, is that correct?

WITNESS LIDEN: No, sir, that's for the new racks.

MR. KORNBLITH: Well, looking at Line 20 is what led me to ask this question.

MR. WETTERHAHN: Perhaps I could clarify that.

MR. KORNBLITH: If you would, I would appreciate it.

BY MR. WETTERHAHN:

Q I will ask in a leading form, I hope no one objects. The 10.6 is the amount of water displaced by the new racks plus the fuel, if those racks are filled to their full capacity, is that not correct?

A (Witness Liden) That's correct.

MR. WETTERHAHN: Does that answer your question?

MR. KORNBLITH: Yes, thank you.

While we're on this subject, I notice at Line 13 it says, in response to the volume of the spent fuel pool, between 200- and 330,000 gallons. I think you said between 300- and 330- did you not?

WITNESS LIDEN: That's correct.

CHAIRMAN MILHOLLIN: So that's an error in

agb12

the transcript?

WITNESS LIDEN: Yes, sir.

BY MR. WETTERHAHN:

Q Mr. Eckhart, on Page 441 of the transcript, you stated that in the hypothetical case of a proper mixture and a proper combination of conditions, an explosive combination could result of hydrogen, if hydrogen and oxygen were combined together, is that not correct?

A (Witness Eckhart) That's correct.

MR. ONSDORFF: I'm sorry, we lost the last quarter of the question.

CHAIRMAN MILHOLLIN: Will you repeat the question?

(Whereupon, the Reporter read from the record as requested.)

BY MR. WETTERHAHN:

Q Could this combination of hydrogen and oxygen to form an explosive combination occur in the fuel handling building?

A (Witness Eckhart) No, I don't believe so.

Q What is the basis for your response?

A When the cell is vented with a very small hole, the hydrogen bubbles will begin to rise toward the surface of the pool and they will constitute, as they are going up, less than three cubic feet. Again these three cubic feet would be released in small bubbles and they would slowly rise to the

agb13

surface of the pool.

At the surface of the pool, the ventilation system exhausts 10,000 cubic feet a minute, providing the equivalent of 60 air changes per hour. The hydrogen gas that rose to the surface would be immediately diluted in the air flow to less than the flammable limit and certainly much lower than the explosive limit.

Q Thank you.

Mr. Liden, at Page 444 of the transcript at Line 21, you stated that the boric acid has no function, is that correct?

A (Witness Liden) I might better have said credit was not taken for the boric acid in the criticality analysis of the spent fuel pool.

Q Thank you.

Mr. Eckhart, at Page 450 of the transcript, you responded that you were not familiar with a document identified by the numbers, the letters and numbers, NUREG 0404. Is that not correct?

A (Witness Eckhart) That's correct.

Q Subsequent to the hearing, did I not show you a copy of NUREG 0404, the Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel?

A Yes, you did.

Q After examining that document, had you previously read it?

agb14

A I had read and reviewed that document, yes.

Q When did your review take place?

A Eight to ten months ago.

Q Thank you.

MS. MAC ARTHOR: Excuse me, I didn't hear the answer.

(Whereupon, the Reporter read from the record, as requested.)

BY MR. WETTERHAHN:

Q Mr. Liden, on Page 481 of the transcript at Line 11, you stated you were not familiar with the details of the crane which would be used to replace the fuel racks, is that not correct?

A (Witness Liden) That is correct.

Q Subsequent to that time, have you obtained any further details about this temporary crane?

A Yes, I have.

Q What were those details?

A We have designed a special crane to be used in the installation of the high density fuel storage racks. This is a bridge-type crane that will traverse the spent fuel pool. It has a lifting capacity of 20 tons. A spent fuel storage rack weighs approximately 17 tons.

The installation procedure for this rack -- for this crane is such -- for the racks, rather, is such that at no time will a rack be moved over the spent fuel stored in the pool.

agb15

Q Thank you.

Again, Mr. Liden, directing your attention to Page 486 of the transcript at Line 10 you stated that, when attempting to vent the Boral, you didn't -- I'm sorry, to vent the cell, you didn't want to drill through the Boral, is that correct?

A That's correct.

Q Have you subsequently reviewed your response made at that time?

A Yes, I have.

Q What is the result of your review?

A The response at that point should have been that we do drill through the Boral with a 1/16th inch hole in order to vent the cells.

MR. SMITH: Would the witness please speak up and could the Court Reporter read back the last answer?

(Whereupon, the Reporter read from the record, as requested.)

BY MR. WETTERHAHN:

Q Would that venting take place above the plane of the active fuel stored in such a cell?

A (Witness Liden) Yes, that is true, as was described in some of yesterday's testimony.

Q Thank you.

At Page 496 of the transcript, in response to a question of what the meaning of 95 percent leak-tightness with

agb16

a 95 percent confidence answer, there was a response that: "It could mean you have a 5 percent leakage." That's at Line 15, Page 496. Would you care to clarify that answer?

A Yes, I would. The response there should have said that we have a 95 percent confidence level that there is a 95 percent probability that the fuel storage cells will be leak-tight.

Q That does not mean that 5 percent of the cells will leak, does it?

A No, it doesn't.

MR. ONSDORFF: Objection. I think we're getting beyond the point where we're having the witness testify without overbearing leading.

CHAIRMAN MILHOLLIN: That was leading. Rather flagrantly leading, I might say.

BY MR. WETTERHAHN:

Q What do you mean by 5 percent -- I'll withdraw the question.

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3a ebl

BY MR. WETTERHAHN:

Q Mr. Liden, does 5 percent leakage have anything to do with the leakage rate?

A (Witness Liden) No, it does not.

Q Today, Mr. Eckhart, I understood you to say that racks from Monticello, Browns Ferry, Connecticut Yankee, Three Mile Island, and a number of other plants were manufactured by Leckenby.

Was my understanding correct?

A (Witness Eckhart) No, sir.

Q Can you tell me which racks were manufactured by Leckenby?

A Yes. I may have misunderstood the question.

Similar racks have been installed with similar material properties to those being proposed for Salem 1. The Leckenby Company itself is involved with five different storage rack projects, to my knowledge, including the Cooper project, the Kewaunee project, the Crystal River project, the Zion project, the Cook project, at a minimum. I don't have the full list of perhaps what else they may be looking at.

Q Mr. Eckhart, perhaps at this time you can summarize the specific use of poison and rack structural performance, structural performance at other fuel pools which are similar to the Salem Unit 1 pool.

A I would like to differentiate between Boral

eb2

performance and rack structural performance. Again, I don't have a list of the world reactors and U. S. reactors in front of me, but I do know that Boral has been utilized in the Duane Arnold facility, the Browns Ferry facility, the Monticello facility, the Cooper facility, and Maine Yankee facility, the Pilgrim facility, and the Vermont Yankee facility.

Exxon Nuclear itself has designed or fabricated the storage racks utilizing stainless steels and structural materials in very similar applications to that which is proposed for Salem for Omaha projects, Arkansas Unit 1 project, Indian Point Unit 3 project, as well as for the Salem project.

Q Does that complete your response?

A Yes, it does.

MR. WETTERHAHN: I have no further redirect.

EXAMINATION BY THE BOARD

BY MR. KORNBLITH:

Q I have a couple of questions I would like to ask, primarily of Mr. Eckhart.

I'm a little confused at this point as to what Exxon Nuclear's responsibility was in this project. I originally had the impression that you had fabricated the racks, but this apparently is incorrect. Could you straighten me out?

A (Witness Liden) We have contracted with Exxon Nuclear to design and fabricate the racks.

Q I thought that this other organization, Leckenby

eb3 manufactured the racks?

A We contracted with Exxon.

Q Okay.

A Let me let Exxon take it from there.

Q I thought I had directed the question to Mr. Eckhart originally.

A (Witness Eckhart) Exxon Nuclear does not fabricate rack structural or poison material components for storage racks. We do the detailed design, the engineering analysis, the licensing support, and the total project management and QA/QC required during the fabrication phases which we normally subcontract out to others.

Q Now a few moments ago, in response to a question by Mr. Wetterhahn, you said that Exxon has designed and fabricated racks for, and then followed a list of facilities. What did you mean by "fabricated" when you said that?

A I misspoke. We were responsible for the fabrication.

Q I see.

So essentially all the fabrication that you're responsible for you subcontract --

A Yes, sir.

Q -- to others?

A We are responsible both contractually and technically, but we do subcontract the fabrication out.

Q A different area entirely. It is my understanding

eb4

that Boral material has been used in reactors as control rod material for a number of years, in some reactors, I guess primarily test reactors, research reactors. Is this correct?

A Yes, sir, it is.

Q Can you make any comparison between the environmental conditions under which the material functions in those applications and the environmental characteristics we are concerned with here?

A Yes, sir.

There is one major difference between the shielding and control applications which Boral has been utilized for before and what we're talking about for the Salem project.

The radiation environment to which Boral has been exposed before is the demonstrated basis why there is well-known knowledge that there is no failure or deterioration of Boral in high radiation fields.

The radiation environment to which Boral will be exposed in the Salem pool is lower in all counts, both at an instantaneous dose rate and the long-term effect than all the Boral that has been used for shielding and control rod applications.

The application which our corrosion report addressed and earlier testimony addressed that is unique for the Salem application is that you are storing or you are placing Boral in a sealed stainless steel can which is in a boric acid

eb5

environment. That is essentially different than the control rod and the shielding material applications that Boral has been utilized for in the past.

Q You say it's different. Could you characterize it as being more or less severe?

A From a radiation environment standpoint, it's a great deal less severe in the Salem storage pool than the control and shielding applications that it has been used for in the past.

Q How about from temperature and corrosion points of view?

A Also, from a temperature standpoint, it's been used in much more severe applications. There has been a great deal of information, a lot of it referenced in the Licensee's submittal, primarily undertaken by Battelle and Brookhaven, which quality or quantify the performance of Boral in various environments.

What our corrosion program has substantiated is their predictions that there should not be a great deal of change in a boric acid environment as opposed to a DI water environment.

Q Incidentally, what does DI stand for?

A Deionized.

Q Thank you.

MR. KORNBLITH: That's all I have, Mr. Chairman.

eb6

BY DR. LAMB:

Q I have a few questions I would like to ask to assure that a couple of things are in the record which I think may be missing.

The first one, for Mr. Liden, referring to the statement on page 5 of your affidavit which we were discussing a moment ago about the consequences of swelling,-- This is under paragraph number 8 -- you indicate that:

"....the worst potential consequence would be failure to be able to insert the fuel thereby losing the affected cell from service."

If I understood you correctly a few minutes ago, you indicated that that cell would be lost from service. Is that correct?

A (Witness Liden) That's correct.

Q Now I'm trying to reconcile that with your statements which were made yesterday on pages 496 and 497 and 499 of the transcript, in which you responded to Chairman Milhollin's questions, indicating that in the event these units were vented that they would be reused.

A I indicated that it could continue to be used, yes.

There is a difference here. In my affidavit I was referring to a storage cell that was empty and developed a leak, and swelled the inner wall. We accept that that cell would be lost from service.

eb7

If that cell had developed a leak with a fuel assembly already in it, the bulging might still occur. The venting would relax the bulge and you could leave the fuel assembly in there. There would be no reason to remove it.

An empty cell that swells would swell more because there would be no fuel assembly in there to stop the cladding from swelling.

Q So the difference between the two has to do with the amount of swelling? Is that correct?

A Yes.

BY MR. KORNBLITH:

Q Are you saying if there were no fuel in there it would swell beyond the elastic limit?

A Yes.

Q Whereas otherwise it would not?

A That's true.

BY DR. LAMB:

Q What would be the basis for it going beyond the elastic limit, though, because isn't the maximum head development that you could get inside the unit 17 feet of water, according to your statement yesterday?

A Let me let Mr. Eckhart answer that.

A (Witness Eckhart) The inner shroud on the storage cell is approximately 20 mills thick, and the four to six pounds differential pressure you're talking about, it is

eb8

possible to go beyond the elastic limit to the point where the storage cell, if vented, could not return to its original position.

Q If you go beyond the elastic limit, where are you then relative to the stress which the shell would be capable of taking without rupture?

A I don't have the precise figure. I can get that for you by tomorrow morning. I believe you are 10 to 15 percent below the point where you would have any serious problems. You're talking yield limits, I presume?

Q Yes.

What I'm wondering is whether there-- if you are going to exceed the elastic limit, whether there is the possibility of the stainless steel failing entirely?

A No, there is not. I can give you the precise numbers tomorrow. All I can tell you is it's possible it will not return to its original shape.

CHAIRMAN MILHOLLIN: I'd like to follow it up just a second.

BY CHAIRMAN MILHOLLIN:

Q Are you saying that the elastic limit will not be exceeded when the swelling occurs at the time spent fuel is in the cell?

A (Witness Eckhart) Yes, we are.

Q And so you must be saying that you expect the cell

eb9

to return to its normal dimension after venting --

A That's correct.

Q -- when it has fuel in it?

A Yes, that's correct.

BY DR. LAMB:

Q Now if I understood you a while ago, you indicated that there was swelling I believe in the Monticello unit; is that correct?

A Yes, sir.

Q Were those cells vented?

A Those cells were not vented when they were first put in the pool; that's correct.

Q I beg pardon?

A When they were initially installed, they were not vented.

Q No, but were they vented to relieve the swelling?

A Yes, sir, they were.

Q Did they have fuel in them at the time?

A No, they did not.

Q Have they been used subsequently, do you know?

A I believe they have.

CHAIRMAN MILHOLLIN: They have not, you say?

WITNESS ECKHART: I believe they have.

BY DR. LAMB:

Q They have been used to store fuel since then, since

eb10

being vented?

A (Witness Eckhart) That's my understanding.

Q But in this instance, if I understood Mr. Liden, you would not intend to use cells in this facility which had been vented if the swelling had occurred without a fuel element in it.

A (Witness Liden) That is correct.

Q With respect to the release of hydrogen, let's see, I guess we explored that question with respect to the explosive mixture. I was going to pursue that.

After venting, would the corrosion rate be higher than it was before venting?

A (Witness Eckhart) Will you repeat the question, to make sure I understand it correctly?

Q In the event that you obtain swelling and then vented by drilling a hole and allowing the hydrogen to escape, would the subsequent corrosion rate of the Boral within the shroud be higher?

A No, sir.

Q Would the venting allow the space between the shroud and the Boral to fill with pool water?

A Yes, it would.

Q Wouldn't this expose more of the Boral to the opportunity for corrosion in contact with the liquid environment?

A You will get the initial swelling because -- and this

eb11

is kind of important to the description. Unless you have a small hole in a storage cell near the bottom, you will not have this differential pressure formation causing the swelling to begin with.

In the case of a small hole at the bottom of a storage cell which allows water to enter the storage cell and cause corrosion, when you vent the gas off in the small area where the gas will stop any water from seeping, there still is some room for the aluminum clad material to establish initial oxidation.

Up to that point you will get a little bit more oxidation, but that's the only further oxidation or corrosion you will get due to the venting at the top of the storage cell.

Q Well, my question was directed toward maybe a misinterpretation that the initial formation, the initial corrosion and formation of hydrogen would be due to a relatively small amount of water getting in at the bottom and compressing the gas and generating hydrogen within the shroud, but that the shroud would not then be full of water. Is that correct?

A That is correct.

Q Then when you drill the hole and the gas is allowed to escape, would the shroud fill with water?

A Yes, the shroud would fill with water.

Q And would that expose then the Boral to water which had not been exposed before?

eb12

A The part, as I tried to say before, hthat the gas displaced would now be occupied with water.

Q Right. So that was the basis for my question.

Now since more Boral is exposed, would the corrosion rate increase?

A The corrosion rate would return to what it had been initially when the leak first developed.

Are you speaking about rate per unit time, or corrosion rate per unit area?

Q Well, I'm working my way around ultimately to the cubic feet of hydrogen generated per unit time.

A I see. The maximum amount of hydrogen you can generate in the entire Boral plate if all four sides were exposed to the pool water environment would be three cubic feet.

Q Three cubic feet? In what period of time?

A I will answer that approximately. I believe Dr. Weeks is more qualified to give you a more precise response.

I believe in the first week of exposure to the pool water environment, you would release most of the hydrogen gas.

Q Okay.

Now in your calculations relative to being well below the explosive limit or the flammable limit, would those

eb13 calculations also include these rates that we were just talking about?

A It would be inclusive because we are presuming in the three cubic feet that I mentioned earlier that the total Boral-aluminum clad was exposed and therefore oxidized.

Q Then it is your professional judgment that you couldn't generate enough hydrogen in this fashion to create a flammable atmosphere?

A That is correct.

MR. KORNBLITH: Excuse me. Could I get in here for a minute?

BY MR. KORNBLITH:

Q This three cubic feet is essentially with how much Boral? One whole storage cell, or one face of it, or what?

A (Witness Hechodom) May we confer for a minute?

(The panel conferring.)

A (Witness Eckhart) The answer is one entire storage cell. This is comprised of four Boral plates.

Q And it would cover both faces of each of the four plates?

A That is correct, sir.

Q Thank you.

BY DR. LAMB:

Q Now with respect to the swelling which we've been discussing as a result of gas formation, I'd like to change

eb14 over to the other type of possible swelling which might occur, either because of growth in quantity of materials due to growth in corrosion products or occurrence of the bulging which you refer to in your report.

Could either of those distort the panels enough to jam a fuel element after insertion?

A (Witness Eckhart) I believe Mr. Liden's testimony indicated that if you have a fuel cell in there and you did have a small hole at the bottom of a storage cell that allowed this differential pressure to cause the inner can to swell--

Q It's my fault, I wandered too much in my question. My question doesn't relate to that swelling. My question relates to distortion of the stainless steel shroud because either of corrosion within it or because of the type of bulges which we were talking about and which you discuss in your non-proprietary document.

And my question is could you get swelling enough to jam the fuel element, apart from the swelling which you might get from gas formation?

A No, sir, you could not.

Q Have you checked that out? I'm wondering about the basis for your statement.

A You're talking about the small bulges again?

Q The small bulges or perhaps even the growth in the material within the shroud as a result of the formation of

eb15

corrosion products which might expand.

A If you could convert all of the aluminum to the oxide form, you're talking again about a 91 mill thick panel of which the inner Boral is only 71 mills, and the amount that you would expand that panel would be less than a factor of two or three from the initial thickness of the material to begin with.

I believe Dr. Weeks can give you more precise information but that would be a very conservative estimate of how much you would increase the thickness of the Boral panel.

On the issue of the small bulges which I described earlier this morning, the maximum amount that the bulge would rise above the surface, in reviewing with Dr. Johnson from Bechtel and his staff, who reviewed our program, was not expected again to rise more than .1 or .2 of an inch above the surface. The inside square dimension of the storage can again is 9 inches. The fuel itself is slightly less than 8-1/2 inches. You have a substantial margin for the two events which you are describing before you would have an interaction between the storage cell and the fuel assembly.

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Q I guess part of the question, part of what was bothering me about that when you discussed it this morning had to do with the fact that the bulges only occurred after twelve months and did not occur -- you did not receive any indication of any rate or what ultimately might happen.

A We were originally concerned that it might be rate-dependent. What we did determine was the reason we did not observe it in the entire 2- and 6-month periods was that pitting had not gone through the aluminum skin of the Boral matrix. Once it had, it allowed water to enter the matrix. That, in turn, would cause the internal corrosion. But the pit had not gone through the aluminum clad in the 2- and 6-month intervals.

BY MR. KORNBLITH:

Q How do you know that the corrosion had run its entire course in the remaining six months?

A We did a detailed metalography microscopic exam, as you can see from the pictures in the corrosion report, and determined that all of the aluminum in the area adjacent to the bulge had been oxidized, that no further oxidation would take place.

BY DR. LAMB:

Q So then it's your professional opinion that this would not go beyond -- well, I guess this morning you mentioned possibly as much as two-tenths or a quarter of an inch?

wb2

A That's correct, sir.

Q Mr. Liden, I'm still having some trouble with what you mean on page 4, I guess it is, of your affidavit. I wonder if you could clean up the question of what is 95 percent leak-tightness with a 95 percent confidence level.

A (Witness Liden) Well, sir,--

Q If I understood you correctly a while ago, that does not mean that as many as 5 percent of these could leak?

A It means far fewer than 5 percent. The manufacturing process controls are such that it does give us that 95/95 probability .

Q What I'm not understanding is what the 95/95 probability you're referring to means. How does this interpret in terms of the number of units which might leak? I don't understand the nature of the statistics which you present.

A (Witness Eckhart) Let me address that.

The license submittal and the questions and answers that evolved back and forth referenced both the ASME guidelines on statistical sampling as well as a paper - by John Jacob at Exxon Nuclear Company that delineate and describe the application of statistics to the leak-tightness we're now addressing.

The requirement from the industry that prescribes the 95/95 limits is a measure of confidence that one must

wb3

establish and meet to, in our case, assure that the cells are leak-tight.

The fabrication process controls and the QA and QC sampling plans employed both at Brooks and Perkins and at Leckenby in themselves assure that at a 95 percent confidence level that you will have a maximum number of 5 percent of the storage cells that could leak. From a pure statistical basis, if you need the exact number, that would infer significantly less than 5 percent of the storage cells would leak.

As a second order of testing, we invoked with Brooks and Perkins a helium leak check test to determine what, if any, of the cells did have leakers. That, in conjunction with the fabrication process controls and the QA/QC sampling plans put the overall confidence level at significantly higher than 95 percent.

If you would like a more precise number of what percentage of the fuel cells might be reasonably expected to leak once you insert the racks in the pool, I could get that for you by tomorrow.

Q Thank you.

BY MR. KORNBLITH:

Q Let me ask one other question. I'm not sure I understand the construction of these cells.

If you get a leak in a cell, are all four Boral pieces exposed to the water from that one leak, or just one

wb4 of them?

A (Witness Eckhart) Most likely all four plates.

Q So that the space surrounding all four of them communicate with each other?

A Yes, sir.

Q All right. Thanks.

CHAIRMAN MILHOLLIN: I also have some questions. But before I ask them we'll take a recess until three-forty-five.

(Recess)

CHAIRMAN MILHOLLIN: Ladies and gentlemen, may I have your attention, please?

The hearing will now resume.

BY CHAIRMAN MILHOLLIN:

Q I have a few questions for the witness panel at this time.

Mr. Eckhart, do I understand you to say, do I understand the testimony of the panel to be that corrosion does not decrease the neutron absorbing capacity of the Boral?

A (Witness Eckhart) That's correct.

Q Is it also true, then, that the principal safety consideration connected with corrosion is the generation of the gas?

A No. I do not see any safety considerations with the generation of the gas.

wb5

Q Let me put it this way: Would you say that the principal disadvantage of corrosion is the generation of gas?

A Yes.

Q If that is true, then why don't you use vented cells?

A As I indicated, I do not believe that either the gas or the corrosion constitute a safety problem with the Salem storage cells. Despite the fact that our corrosion program, and tests done by others, indicate no known degradation of the Boral material in pool water environments typical of Salem, the Licensee and Exxon agreed that a judicious approach to the Salem storage racks is to maintain and ensure that all the storage cells are leak-tight and sealed from the pool water environment.

Q Well, is it true, then, that this effort to have leak-tight cells produces swelling?

A If you have a leak.

Q In the event of a leak?

A And the leak has to be at the bottom.

Q Yes.

Well, why is it, then, that you don't consider it more desirable to vent the cells before you install them, so as to avoid having the possibility of swelling, since corrosion has no effect on the capacity of the Boral to absorb neutrons?

wb6

A To reiterate the Licensee's and Exxon Nuclear's position, the purpose of the corrosion report undertaken by Exxon Nuclear was in the event that you had a random storage cell which leaked and possibly caused corrosion. It was not based or predicated on the event that boric acid pool water environment could come into each and every storage cell.

The number of samples we may have tested, the length of the program that was conducted may have been affected by the decision that we weren't going to have every single storage cell exposed to the pool water. The conclusion of our report was, on a random basis if you have an occasional cell that is exposed to the pool water environment, then we see no effect whatsoever that could affect the safety of the Salem storage rack.

Don't try to read into that that we are saying that we recommend that every cell should be vented.

Q Well I guess I'm still not clear on why it's not more advantageous to use vented cells to avoid the possibility of swelling. --whatever that possibility is. And I assume we could infer from the evidence that it's significant.

A We would not want to infer-- I've gone into the proper way to construct your corrosion program and how you extrapolate one year to forty years, depending upon what you're trying to extrapolate and the accuracy of your information. Our information is a confirming type of piece of

wb7

information for a random set of leaking storage cells that occur on a very infrequent basis. I would not want to install, nor are we recommending, nor is the Licensee recommending, that they install storage racks in the Salem pool that are all vented based solely on the one-year corrosion report that Exxon Nuclear has conducted.

It is possible that the surveillance program that the Licensee will implement will demonstrate, and for a prolonged period of time, that there are no differences in effects between one year, five years, ten years. But that's not the basis upon which all storage cells and all storage racks should be vented.

Q So then you're saying that there are, or might be disadvantages to having all the cells vented?

A I'm saying that's a possibility.

Q Do you think the possible disadvantages of having all the cells vented are such that the disadvantages are greater than the disadvantages of possible swelling?

A I think I understand your question. And the answer is Yes.

Q In other words, you think there is more inconvenience which might arise from corrosion than from swelling?

A No, that's not what I'm saying.

The possible long term effects on the storage pool, which have not been completely put to bed in a one-year

wb8 program, might be worse than a small inconvenience of a random cell which indeed had a small hole at the bottom which, in turn, caused the corrosion which caused venting. It would be a very, very rare event and something the Licensee does not believe will inconvenience his operation of the storage pool.

Q So if I might pursue, you think it is preferable to take the risk of swelling, you think it is better to take the risk of swelling than it is to take the risk of corrosion in a pool which would have cells vented before installation?

A Yes.

BY MR. KORNBLITH:

Q Let me just follow that up a little bit.

We have, on one side, the advantage of not having swelling, and, on the other side, the advantage of not having corrosion. If we add to that the disadvantage of the additional cost of trying to make the cells leak-tight in the first place, and the QA programs and the quality control programs that go along with that, are the advantages still in favorof spending that extra money on quality and trying to make them leak-tight?

I guess we also have to take into account the fact that you have somewhat of a built-in conflict of interest here, because Exxon wouldn't make much money if you didn't have to turn out such a high quality product.

A I wish it worked that way.

wb9

(Laughter)

Could you repeat your question?

Q You've said that the benefit of not having corrosion is greater than the benefit of not having swelling. If we add the extra cost of preventing corrosion, then does this change that balance?

A Not for the Salem storage rack, no.

Q You think you're better off to spend the additional money, try and keep the material dry, and take a chance on a little swelling?

A We have already done it.

Q Okay.

BY CHAIRMAN MILHOLLIN:

Q Then if you think it is worth the money to take these rather significant steps to prevent corrosion, how can you at the same time say that corrosion has no effect on the ability of the Boral to absorb neutrons? What is there about the corrosion which worries you and causes you to take these extra precautions?

A Sir, you're the one who mentioned corrosion. There are perhaps other things that could happen. But let's restate the answer which I gave earlier.

The tests that we have done, and the report which we put out was based upon a random, or small number of leaking storage cells.

wb10

MS. MacARTOR: Possibly if Mr. Eckhart did not use the microphone but spoke up:-- I think the microphone may distort this particular witness.

CHAIRMAN MILHOLLIN: I can't tell from where you are. Is that the case?

MS. MacARTOR: I think it's a possibility.

CHAIRMAN MILHOLLIN: Could you please speak up?

WITNESS ECKHART: Do you want to repeat your question, please?

BY CHAIRMAN MILHOLLIN:

Q The question is: If corrosion does not decrease the capacity of the Boral to absorb neutrons, why do you think it's necessary to take such extensive measures to prevent corrosion from happening?

A (Witness Eckhart) All poison materials are subject to degradation of some form, depending upon the environment in which they're placed. In the case of Boral you have a matrix of aluminum and stainless steel held together. In the case of the Salem project you havethis Boral matrix encapsulated in stainless steel storage cells. Technically it is very possible that for thirty or forty years you will find no surprises, no unexpected events that could compromise the utilization of the Salem storage cells.

Exxon Nuclear and the Licensee are not recommending that all storage cells, based on our one-year test or the

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information we have obtained in other corrosion reports, that every storage cell should be ad hoc exposed to the pool water environment. It's a conservative, judicious way that the Licensee and Exxon have proceeded with the Salem storage rack project.

We are aware that others have considered not sealing the storage cells in a pool water environment.

A (Witness Necohdom) Can I add another aspect which I think Tom knows about, or is certainly familiar with but has not mentioned? That is, that this project was time-dependent; that while the design was going forward some of the problems in other areas, as were mentioned, at Monticello and Browns Ferry, were surfacing. And so the finaLizing of the design, to get on with the project, we and the Licensee both felt the prudent thing was to seal them up rather than to be concerned about the final outcome of those kind of things.

Q When you say "those kind of things," what do you mean?

A The Monticello, Browns Ferry, Yankee swelling phenomena, which were recent in the context of the time we were designing these cells.

Q You mean, to avoid the swelling you decided to seal them up; is that what you're saying?

A What I'm saying is, they were uncovering phenomena

wb12 which were then new, which were obviously associated with corrosion.

Q Well why did the discovery of these phenomena cause you to decide to seal up the Boral?

A The Boral in the Monticello case was clearly at the root of the swelling problem because of the leak-tight environment which subsequently did leak. It was our decision that until we knew the extent of the corrosion phenomenon in that cell, the prudent thing to do was to do an extensive QA program.

Q An extensive-- what?

A ....quality assurance program, and thereby ensure that if the leaks were to develop they would be verymminimal.

Q So you identified a problem which arose as a result of using sealed cells; is that what you're saying?

A Will ycu try that again?

Q You say there were these new phenomena which occurred at Monticello, I think you mentioned.

A Yes.

Q Did Monticello use sealed cells?

A No, they had not used seals. They had not designed their cells to be as leak-tight as might have been the case.

MR. VALORE: Mr. Chairman, a member of the public has asked me if the witness could speak into the microphone because they can't hear. I'm in a position where I can hear.

wb12

But a member of the public has asked me to request that.

CHAIRMAN MILHOLLIN: I think I had a question pending. And the answer to that is that, as I take, the cells on Monticello were not sealed sufficiently to prevent leaking.

BY CHAIRMAN MILHOLLIN:

Q Is that correct?

A (Witness Eckhart) You're addressing the specific application, whereas what we were referring to is that during the time--

Q Let me finish my question, so that I just make sure that I have the answer to it accurately.

What you're saying is that at Monticello the construction was such that the Boral was not sealed sufficiently to prevent leaking, but that swelling nevertheless occurred; is that what you're saying?

A (Witness Nechodom) Yes, that's what I'm saying.

Q So in order to avoid this problem you did what? And by "this problem" I mean a duplication of the events at Monticello at Salem.

A What we did was improve the quality assurance procedures to assure that we would not develop more than a very minimal number of leaks in the cells.

Q Why didn't you decide just to vent all your cells?

A (Witness Eckhart) Let me try again. We do not

wb14

see in Exxon Nuclear's experience and review of the available testing enough information to say that all storage cells in a boric acid pool water environment should be vented and opened up to the pool water environment. Monticello and Browns Ferry are very similar applications. Much of the information in our corrosion report substantiates there is not much difference from corrosion effects and other material effects between a DI water environment and a boric acid water environment. But that is fine to substantiate what may happen to a random storage cell which does develop a leak.

It is our recommendation, and it is our own good judgment that we would not, based upon the one-year study, as well as the other material which is available in the literature, recommend that all storage cells be exposed to the pool water boric acid environment.

Q Why is it that you can't recommend that based on your one-year tests? What is it about the possibility-- What possible things are youworried about? What makes you reluctant to recommend this course of action?

A What Warren Nechodom was trying to refer to in answering your question, three separate events have occurred in the past eighteen months which neither NRC nor the utility fully expected to happen, regarding poison materials. It turned out that none of these situations turned out to be severe. It turned out that the poison materials in all

wb15

instances will perform to the purposes for which it was intended. But if they had taken perhaps a more judicious or conservative approach to begin with, they may have avoided the problems they had.

From our knowledge of Boral, from our knowledge of spent fuel storage applications, it remains our recommended approach to the Salem storage rack that all storage cells remain sealed from the spent fuel pool water environment.

I don't know how to answer your question any more succinctly.

Q No; the question is, Why have you thought this to be prudent? Why is it that you are unable to recommend the course of action which would have all the cells vented? What is there about that course of action which you feel you could not recommend?

A It would be very unfortunate --

Q Are there disadvantages to that course of action?

A The disadvantage could be that, if in five to ten years from now, even if the probabilities were less than one-tenth of 1 percent, for instance, that you found an unexpected phenomenon after you exposed the Boral to the pool water environment, if you look at the cost-benefit analysis versus what wouldhappen to the racks if you had to pull them out, or do something else to them, versus the cost of making sure that they're leak-tight to begin with, thereis no question.

wb16

Q I see.

You're saying there are uncertainties which exist--

A There could be.

Q Well either there is an uncertainty or there is not. You say there is one, perhaps, at least, which causes to say that it is more conservative to seal them up than to take the risks associated with having them sealed?

A I'm saying based on our one-year test program I cannot conclusively say that every single possible effect due to Boral performance in a boric acid environment has been identified.

Q How does it affect your-- When you're referring to the capacity of the Boral, you're talking about its capacity to absorb neutrons?

A Or in influence the ease of using the storage cells. That's correct.

BY DR. LAMB:

Q Just to perhaps try to clarify:-- Let me ask you: I keep hearing you saying the situation in which there are two possibly competing undesirable circumstances, one in which there are, in attempting to project one year corrosion data for forty years, there have to be some questions. And another one in which, in the case of leakage in the sealed units, there would be perhaps some swelling.

wb17

Is it fair to say that what you have done is adopt a secondary line of defense against corrosion at the expense, perhaps, of losing a few cells which you cannot use because they're going to swell?

A Yes.

CHAIRMAN MILHOLLIN: That concludes the questions by the Board.

At this time we'll begin recross examination with the understanding that, of course, questions on recross are limited to those matters which were put forward on redirect. And we'll start with Mr. Onsdorff.

MR. ONSDORFF: Thank you, Mr. Chairman.

3C agbl

RECROSS-EXAMINATION

BY MR. ONSDORFF:

Q Mr. Eckhart, we've been over this a number of times, and I was just jotting down on a pad what I would consider to be a fair characterization of your rather technical explanation in possibly layman's terms, and I was wondering if you would agree with my interpretation of your testimony.

You say that, in essence, what you're concerned about is not treading where no one else has gone before?

MR. WETTERHAHN: Objection.

CHAIRMAN MILNOLLIN: Sustained, that's too general.

MR. ONSDORFF: I'll try to rephrase it, if I might -- I'll withdraw it.

BY MR. ONSDORFF:

Q I believe you testified on redirect that Exxon Nuclear had been responsible for the overall fabrication for the racks at Omaha, Arkansas 1, Indian Point 3 and Salem projects is that correct?

A (Witness Eckhart) We were responsible for their fabrication, that's correct.

Q Do you know the total number of reactor years for the operation of these new racks?

MR. WETTERHAHN: Objection. Beyond the scope of the contention.

CHAIRMAN MILNOLLIN: What's the relevance of that

agb2 question?

MR. ONSDORFF: I would submit that we want to find out whether or not there's any operating experience which would indicate corroboration of the tests results that they've done over the one year period.

CHAIRMAN MILHOLLIN: Ask whether they've tested --

MR. ONSDORFF: I'm asking if there's any commercial experience. We discussed the tests.

MR. WETTERHAHN: Mr. Chairman, my objection was, he's asking about the operation of the reactor. That has nothing to do with the spent fuel pool.

MR. ONSDORFF: That wasn't my question.

BY MR. ONSDORFF:

Q Has Omaha had any dense racks installed?

A (Witness Eckhart) Yes.

Q For what period of time have they been in operation, have they been in use?

A Our racks have been in use the better part of three years.

Q Have you obtained data as a result of that three year period?

A Excuse me just a second, please.

(The witness panel conferring.)

A Would you repeat your question, please?

Q Have you obtained -- you being Exxon Nuclear -- data

agb3

from the three year experience at the Omaha facility with the new spent fuel racks?

A We have been informed by the utility that the racks have performed as designed.

Q You have not independently verified that yourself?

A No.

Q Now, at Arkansas 1, have new racks been installed at that plant?

A Yes, they have.

Q For what period of time?

A For the better part of two years.

Q Has Exxon Nuclear obtained data from that two year period of time to determine whether or not they have performed in accordance with the design specifications?

A Yes, and the utility has again informed us that the racks have performed as specified.

Q Then Exxon Nuclear has not verified that?

A Exxon Nuclear cannot go onto a site without a specific invitation from the utility from that standpoint.

Q Which has not been tendered?

A That's correct.

Q Now at Indian Point 3, have new racks been installed at that facility?

A Yes, they have.

Q And for what period of time have they been in use?

agb4

A Approximately one year.

Q Has an invitation been tendered for Exxon Nuclear to obtain data from that one year period of use?

A The utility has informed us that the racks have performed as specified.

Q My question was, was Exxon Nuclear invited to --

A No.

Q Now on redirect, Mr. Eckhart, I believe you testified as to your familiarity with NUREG 0404, is that correct?

A That is correct.

Q Directing your attention to Page 3-8 --

MR. WETTERHAHN: Let me tender it to the witness, please.

MR. ONSDORFF: Thank you.

(Document handed to witness panel.)

CHAIRMAN MILHOLLIN: Mr. Onsdorff, could you supply the Board with a copy of that document, please?

MR. ONSDORFF: Yes, sir. Right at this instant?

(Document handed to the Board.)

CHAIRMAN MILHOLLIN: What page?

MR. ONSDORFF: Page 3-8.

BY MR. ONSDORFF:

Q The fourth paragraph from the top of Page 3-8 indicates:

"The spacing of racks for criticality control is not the only basic consideration in

egb5

planning for compact storage at existing plants. Other factors that must be taken into account are maintenance of adequate pool water cooling capacity, radiation protection and pool water cleanup capacity, meeting seismic design requirements with the new pool arrangement and to insure the protection of the public and workers during structural modification of storage pools already containing spent fuel and during normal operating and credible accident conditions after pool modifications are completed."

Did Exxon Nuclear have the responsibility for the Salem project for meeting these additional major factors in addition to criticality control?

MR. WETTERHAHN: Objection. This is obviously beyond the scope of the contention. It refers -- the question itself refers to factors beyond criticality.

CHAIRMAN MILLOLLIN: Sustained.

BY MR. ONSDORFF:

Q One final question on NUREG 0404. On Page 3-9, the Table 3.4, are you familiar with that table, Mr. Eckhart?

A (Witness Eckhart) I saw it many months ago. Do you have a specific question?

Q Yes. Isn't it correct that the data which is reflected in that table, that the Salem project is larger in its compact

agb6 storage factor than any other one except for one other utility so listed?

A You'll note how dated this table is. Salem is not even incorporated on the table. This table was put together from data which is approximately 24 months old.

The answer to your question is no.

Q WHich utilities reflected on the table have a compact storage factor in excess of the Salem project?

MR. WETTERHAHN: Objection. I fail to see the relevance.

CHAIRMAN MILHOLLIN: Sustained.

MR. KORNBLITH: What is a compact storage factor? I'm asking the witness, I guess he's the only person who's available to answer questions like this.

WITNESS ECKHART: It's the ratio of the planned increase to the original storage rack density.

MR. KORNBLITH: Thank you.

BY MR. ONSDORFF:

Q One final question, Mr. Eckhart, I forgot to ask previously. In those indications where Exxon Nuclear was not invited back onto the utility to obtain the independent verification, did Exxon Nuclear ask for that opportunity?

A (Witness Eckhart) No, sir, we did not.

MR. ONSDORFF: That's all I have.

CHAIRMAN MILHOLLIN: Mr. Valore, would you care to stay within the schedule we previously established for recross?

agb7

MR. VALORE: Yes.

CHAIRMAN MIKHOLLIN: And ask your questions now?

MR. VALORE: Yes, I will.

BY MR. VALORE:

Q Mr. Eckhart, I may have misunderstood your testimony or there may be an inconsistency in it which I would like you to clear up for us.

C8

On my cross-examination, you had indicated the location of some nuclear plants having similar dense steel Boral racks to what is the proposed design for Salem 1. On cross-exam by the NRC, you indicated you were not aware of any of these racks being in a pressurized water -- a PWR environment. Then on redirect by your legal counsel, you indicated that similar racks were in use at Crystal River, Cook and Zion.

Now those three plants are pressurized water reactor plants. Therefore, do you still stand by your answer that you do not know of any of these racks being used in the pressurized water reactor environment?

A (Witness Eckhart) I stand on the testimony that I gave to Mr. Wetterhahn in clarification of earlier questions. What you are referring to is specifically the storage racks that the Leckenby Company themselves have manufactured, it has nothing to do with stainless steel Boral racks. The racks they have fabricated are for Cooper, Kewaunee, Crystal River, Zion, now Salem and D.C. Cook. That's the experience that the

agb8 fabricator for the Salem storage racks has in fabricating steel fixtures.

Q Zion will be a pressurized water reactor, isn't that correct?

A That is correct.

Q Has that rack been installed at Zion?

A No, it hasn't.

Q The reference to the Omaha reactor, would that be the Fort Calhoun reactor?

A Yes, it would.

Q That's a pressurized water reactor, isn't it?

A Yes, it would.

Q Has that rack been installed?

A Yes, it has.

Q And is that a dense Boral steel rack?

A The list that you're referring to now that I gave for Omaha, SMUD, Arkansas, IP-3, are a list of storage rack projects utilizing stainless steel structural materials. They are high density storage racks not employing Boral.

Q In other words, the rack for Fort Calhoun doesn't have Boral in it?

A That's correct.

Let me clarify again. I gave a list of projects to Mr. Wetterhahn where stainless steel structural materials were utilized, and I gave a list to Mr. Wetterhahn where Boral

agb9 materials had been utilized.

MR. VALORE: I have no further questions.

MS. MAC ARTOR: I have a couple, Mr. Chairman.

BY MS. MAC ARTOR:

Q The plant that Mr. Onsdorff just questioned you about, you said you had reports that they had performed as expected. Did those plants have samples installed in the pool for surveillance as you are planning for Salem?

A (Witness Eckhart) No, ma'am, they did not.

Q Have there been, if you know, inspections of the rack and plates in those plants?

A No, we don't.

Q Do you have any other details, other than "performed as expected," about the characteristics of the installation now?

A Perhaps I should turn this over to Mr. Liden in terms of the utilities' responsibilities for maintaining the adequate use of the storage racks.

All these racks employ stainless steel structural materials which have been well documented as to their performance, therefore, no additional surveillance programs were required for these projects.

Q But you are planning those for Salem?

A Not stainless steel -- not for the purpose of measuring stainless steel performance, we are providing

agb10 poison coupons,

Q Yes.

A Yes, ma'am.

Q Well how about those in installations where the Boral plates have been used?

A To my knowledge, where Boral plates have been used, surveillance specimens have also been used.

Q And do you have any reports of the conditions of those after they have been in?

A No, I don't.

Q Mr. Liden, you testified about the temporary crane for putting the rack in, and you testified on redirect that it would not go over the stored fuel. But you did not say how that is to be prevented, by what mechanism.

A (Witness Liden) Through administrative controls.

Q There will not be the same type of physical stops that the present crane track physically cannot go over the fuel, there will not be that kind of arrangement with the temporary crane?

A There may be. I'm not familiar with the full details. At any rate, the procedures that we use will prohibit us from moving the rack over the area where the spent fuel is stored.

Q I'm sure you wouldn't plan to do it.

MS. MAC ARTHUR: That's all.

agb11

MR. HLUCHAN: No questions, Mr. Chairman.

MR. SMITH: The Staff has one question.

BY MR. SMITH:

Q Mr. Eckhart, at the beginning of the recross by Mr. Onsdorff, you mentioned at least three plants, Omaha, Arkansas, Indian Point 3 and were there a couple of other plants?

A (Witness Eckhart) Yes.

Q Could you name those?

A The list again is IP-3, Arkansas Unit 1, SMUD -- Rancho Seco and Omaha.

Q Now, did any of those plants use Boral as a part of its spent fuel storage cell?

A No, sir, they did not.

Q Isn't it true, then, that there are no racks now installed that have spent fuel storage cells with Boral and stainless steel in a PWR spent fuel environment?

A As I indicated to your earlier this morning, I don't know.

Q Did Exxon provide any for PWRs?

A No, they did not.

CHAIRMAN MILHOLLIN: So your answer then is you don't know of any?

WITNESS ECKHART: That's correct.

CHAIRMAN MILHOLLIN: Thank you.

agb12

MR. SMITH: That's all.

MR. WETTERHAHN: I have nothing further of this panel at this time. We have three minor items which we will provide to the Board tomorrow morning, if that's okay. I might provide the information by representation, otherwise we'll ask a member of the panel to give the information on the three items which the Board requested at the Board's pleasure.

CHAIRMAN MILHOLLIN: So your answer is you have nothing further at this time?

MR. WETTERHAHN: At this time.

MR. KORNBLITH: I have a couple of more here.

FURTHER EXAMINATION BY THE BOARD

BY MR. KORNBLITH:

Q There has been repeated emphasis on "in a PWR environment" when we talk about these racks. What is there different in a BWR environment that's relevant to our consideration?

A (Witness Eckhart) Principally, the BWR environment does not have boric acid.

Q There are none of them that have the pool storage?

A That's correct.

Q Okay.

One other question. You mentioned in response to some of the redirect that you have not gotten any data back from your customers other than the fact that the racks have

agb13 performed as expected. Is that a correct characterization?

A Yes, it is.

Q Are these racks under warranty of some sort?

A There is a standard commercial warranty associated with these racks.

Q So one would expect that if there were problems with them, you would have heard about them?

A Yes, sir.

Q Okay. Thank you.

CHAIRMAN MILHOLLIN: Does any party have a further question to direct to this witness?

FURTHER RECROSS-EXAMINATION

BY MS. MAC ARTOR:

Q How long is the standard warranty?

A (Witness Eckhart) I'm sorry, I can't answer that question. That varies from case to case and it is customer proprietary information.

CHAIRMAN MILHOLLIN: Mr. Wetterhahn, would you move that your witnesses be excused at this time?

MR. WETTERHAHN: I would so move, thank you.

CHAIRMAN MILHOLLIN: The witnesses are hereby excused with the thanks of the Board.

MR. WETTERHAHN: I assume we will now proceed with the Staff witnesses on the contention -- I'm sorry. I guess I'm presuming too much. I don't know if there's any direct case.

agb14

CHAIRMAN MILHOLLIN: We'll find out just as soon as your witnesses are excused.

(The witness panel excused.)

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CHAIRMAN MILHOLLIN: Does the Board understand correctly the agreement of the parties concerning the order of proof? It will now be appropriate for either the Colemans or any other Intervenor who has direct evidence to proffer it. Is that the correct agreement?

MR. WETTERHAHN: Only the Colemans. If my understanding is correct, only an Intervenor having a contention may introduce direct testimony.

CHAIRMAN MILHOLLIN: Yes. Excuse me. That is correct. So that limits the direct case to the Colemans, and the NRC Staff.

Do the Colemans have any direct testimony to proffer to the Board?

MR. ONSDORFF: No, we don't, Mr. Chairman.

CHAIRMAN MILHOLLIN: Very well.

MR. SMITH: Do I understand there is no direct testimony on the case by the Colemans? Is that correct?

MR. ONSDORFF: On these combined contentions, that's correct.

CHAIRMAN MILHOLLIN: Mr. Smith, are you prepared to go forward at this time with your direct case?

MR. SMITH: Yes. I would like to have a couple of minutes to get organized.

But before I proceed, I handed to the parties and to the Board a statement of professional qualifications of

eb2 Edward Lantz. Originally we had intended to file testimony on what we believed the contention to concern, that is, the deterioration of the bozon material.

I think the Board has limited the contention to that but there may be areas where criticality could be bound into that particular contention. In light of that, I would like to put on our panel, Dr. John Weeks, Mr. Lantz, and Mr. Gary Zeck. I think that that way we can be assured that if there are questions that can be related to criticality and maybe to some other things that may relate to these contentions that there's a panel up there to do that.

The criticality calculations, et cetera, performed by the Staff and the spent fuel cooling calculations are all in the SER. There's no new testimony. This is found in Section 2-1 and 2-2, so there's nothing new before the Board or the parties, except the fact that we are offering another witness to possibly answer questions in these areas.

Is that acceptable to the parties and to the Board?

MS. MAC ARTOR: Delaware has no objections to putting in evidence on criticality related to this contention.

MR. WETTERHAHN: Mr. Chairman, Licensee would not object to Mr. Lantz being on the panel, but we reserve our right to object should the examination wander beyond Contentions 2 and 6.

MR. ONSDORFF: We would have no objection.

eb3 Mr. Chairman.

CHAIRMAN MILHOLLIN: Very well.

You may proceed, Mr. Smith.

MR. SMITH: Mr. Chairman, I would like to call to the stand, and I will introduce them, Dr. John Weeks, Mr. Gary Zeck, and Mr. Edward Lantz.

These witnesses have not previously been sworn.

Whereupon,

JOHN WEEKS,

GARY ZECK,

and

EDWARD LANTZ

were called as witnesses on behalf of the NRC Regulatory Staff and, having been first duly sworn, were examined and testified as follows:

DIRECT EXAMINATION

BY MR. SMITH:

Q Mr. Lantz and Mr. Zeck, do you have before you a statement of your professional qualifications?

A (Chorus of "Yes.")

Q And Dr. Weeks, yours is attached to what is labeled "Affidavit of John R. Weeks"?

A (Witness Weeks) That's correct.

Q Are there any additions or corrections to these statements of professional qualifications?

eb4

A (Witness Zeck) I have one minor correction, Mr. Smith.

Q Will you please state that?

A Yes.

In the fourth paragraph in the second line from the bottom, I would ask to change the word "consisted" to "consistent."

That's the only correction I have.

A (Witness Weeks) I have none.

Q Mr. Lantz?

A (Witness Lantz) I have none.

Q And it is now true and accurate to the best of your belief?

A (Chorus of "Yes.")

Q Dr. Weeks, do you have before you what is labeled "Affidavit of John R. Weeks"?

A (Witness Weeks) Yes, I do.

Q Is this affidavit to be your testimony in this case?

A Yes, it is.

Q Are there any additions or corrections to that document?

A No, sir.

Q Dr. Weeks, attached to that affidavit was a document which was previously identified as Exhibits 7, "Corrosion of Materials in Spent Fuel Storage Pools, John R.

eb5 Weeks."

Are you familiar with that document, Dr. Weeks?

A Yes, I am.

Q Will you tell us how you prepared this document?

A I wrote the document, yes, sir.

Q Will you tell us what went into preparing the document?

A I have to ask again, are you referring to the 1977 document?

Q Yes.

A A telephone survey of a number of utilities that operate fuel storage pools, private conversations with other people working in this area, as well as information I had in my own files.

Q I refer you to what has been marked as Exhibit 8, "Corrosion Considerations in Use of Boral Spent Fuel Storage Pool Racks, John R. Weeks, January 1979."

This was prepared by you?

A Yes, it was.

Q Can you tell us how this was prepared?

A It was prepared from information I obtained at meetings with the NRC Staff and the Licensees in the case of the Monticello-Browns Ferry situation. Some of it was original work based upon experience that we had at Brookhaven on the use of this material in a reactor environment.

eb6

Some of the information in here again is based on documents that I had in my own files at Brookhaven which are all referenced in the document.

Q Mr. Lantz, do you have before you what has been marked as Staff Exhibit 6-A, the Safety Evaluation relating to this proposed fuel storage modification?

A (Witness Lantz) Yes.

Q And can you tell me which particular sections of that SER you were responsible for the preparation of?

A Section 2.1, 2.1.1, 2.2, and 2.2.1.

Q And can you tell us how you prepared these sections?

A I reviewed the submittal, did the review and wrote the Safety Evaluation.

Q Could you tell us what submittal you're referring to?

A The submittal by Salem, the Public Service Gas & Electric for the spent fuel pool modification.

Q Mr. Zeck, can you tell us your role in preparing Staff Exhibit 6-A?

MR. WETTERHAHN: For the record, Mr. Chairman, I believe the cover letter is 6-A.

MR. SMITH: I'm sorry, 6-B. You're right.

WITNESS ZECK: It's my job as Project Manager for the Salem Plant. My responsibilities involve the coordination of the review of the Public Service application for the

eb7

expansion of the spent fuel pool, taking the inputs from the various reviewers and writing the Safety Evaluation Report.

MR. SMITH: Mr. Chairman, I move that the affidavit of John R. Weeks be treated as testimony and bound into the record as though read, along with what has been marked for identification as Exhibits 7 and 8, and the professional qualifications of Mr. Zeck, Dr. Weeks, and Mr. Lantz, all being moved into evidence.

CHAIRMAN MILHOLLIN: They are admitted into evidence.

(The documents follow:)

EDWARD LANTZ

DIVISION OF OPERATING REACTORS

U.S. NUCLEAR REGULATORY COMMISSION

PROFESSIONAL QUALIFICATIONS

As an Engineering Systems Analyst in the Plant Systems Branch I am responsible for technical reviews and evaluations of component and system designs and operating characteristics of licensed nuclear power reactors.

I have a Bachelor of Science degree in Engineering Physics from the Case Institute of Technology and a Masters of Science degree in Physics from Union College and a total of 28 years of professional experience, with over 20 years in the nuclear field. My experience includes work on reactor transients and safeguards analysis, nuclear reactor analysis and design, research and development on nuclear reactor and reactor control concepts and investigations of their operational and safety aspects.

I have held my present position with the Commission since December 1975. My previous position, which I held for about two and one half years, was Project Manager in the Gas Cooled Reactors Branch, Division of Reactor Licensing, U. S. Nuclear Regulatory Commission, where I was responsible for the technical review, analysis, and evaluation of the nuclear safety aspects of applications for construction and operation of nuclear power plants. For about ten years prior to that I was Head of the Nuclear Reactor Section in NASA. My section was responsible for the development and verification of nuclear reactor analysis computer programs, conceptual design engineering, and development engineering contracting. Prior to my employment with NASA, I was a nuclear engineer at the Knolls Atomic Power Laboratory for about six years, where I worked on the safeguards and nuclear design of the S3G reactors and the initial development of the nuclear design of the S5G reactors. Previous experience includes system engineering and electrical engineering with the General Electric Company and electronic development engineering with the Victoreen Instrument Company.

GARY G. ZECH

PROFESSIONAL QUALIFICATIONS

DIVISION OF OPERATING REACTORS

OFFICE OF NUCLEAR REACTOR REGULATION

U.S. NUCLEAR REGULATORY COMMISSION

I am a project manager in the Division of Operating Reactors, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission. As such, I am responsible for managing and participating in the safety and environmental reviews associated with licensing actions regarding the design and operation of assigned operating power reactors. This includes planning and coordinating the efforts of other Commission personnel involved in the reviews.

I received a Bachelor of Science degree from the U.S. Naval Academy in 1964. Upon graduation, I attended the Navy's Submarine School and entered the Navy Nuclear Power Program. I attended a 6-month course in nuclear engineering followed by a 7 month training period at the Navy's prototype nuclear power plant (S3G) at West Milton, N.Y. From 1966 to 1973 I served in various engineering assignments on diesel and nuclear powered submarines including the mechanical, electrical and radiological controls areas.

In July 1973, I joined the General Atomic Company of San Diego, California as a Senior Operations Engineer at the Fort St. Vrain High Temperature Gas Cooled Reactor Plant in Colorado. I was responsible for coordinating the construction work and startup test program efforts with the utility, Public Service Company of Colorado.

In August 1974, I joined Stone & Webster Engineering, Corporation of Boston, Massachusetts as a Project Engineer. I was responsible for the system design specifications for Emergency Core Cooling Systems on the Montague 1 and 2 Nuclear Generating Station Project and developed a qualification program for startup test engineers consisted with the ANSI Standard N18.7.

I am a Registered Engineer-In-Training in the Commonwealth of Massachusetts.

I have held my position with the Commission since June 1975.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of PUBLIC SERVICE ELECTRIC & GAS COMPANY, et al. (Salem Nuclear Generating Station, Unit 1)	)	Docket No. 50-272

AFFIDAVIT OF JOHN R. WEEKS

I, John R. Weeks, being duly sworn, do state as follows:

I am employed by the Brookhaven National Laboratory, Department of Nuclear Energy, as Leader of the Corrosion Science Group. A statement of my professional qualifications is attached to this affidavit.

This affidavit addresses the following contentions:

Coleman Contentions

2. The Licensee has given inadequate consideration to the occurrence of accidental criticality due to the increased density or compaction of the spent fuel assemblies. Additional consideration of criticality is required due to the following:

   A. deterioration of the neutron absorbtion material provided by the Boral plates located between the spent fuel bundles;

   B. deterioration of the rack structure leading to failure of the rack and consequent dislodging of spent fuel bundles;

   D. combinations of the above - as it relates to A & B.

In this affidavit, I will address only the anticipated deterioration of the neutron absorption and rack materials. Based on my personal knowledge and experience and on the discussions in section 2.4.1 of NRC Safety Evaluation Report, I do not anticipate these deteriorations to be significant. Therefore, I do not expect the criticality considerations to be significant.

A. No deterioration of the neutron absorption material is anticipated in the Salem spent fuel pool for the following reasons:

1. The Boral plates are in welded cavities, protecting them from environmental degradation.

2. Should water enter the Boral cavities, pitting corrosion due to galvanic action would be anticipated on the aluminum cladding on the Boral at various points where it contacts stainless steel. However, the boron carbide matrix would not dissolve. When pitting progressed into the Boral, the B_4C particles remained embedded in place in the aluminum oxide and hydroxide corrosion products, as described in the proprietary Exxon Report, XN-NS-TP-009.

3. Dissolution of the aluminum oxide and hydroxide corrosion products would not occur in the SFP coolant, since the solubility of these products has been shown to be a minimum at a pH of approximately 5.0, which is close to the pH anticipated in a SFP containing boric acid (4.5).

4. General corrosion (or uniform weight loss) of aluminum would be negligible in the Salem SFP, since the rate of corrosion of the aluminum is a minimum at a pH of approximately 5.0. In my review for the NRC (BNL-NUREG-23021), which I have appended, I estimated it to be less than 1.5×10^{-4} mils/day in neutral water at 125°C. Extrapolating this datum to a pH of 4.5-5.0 and to a temperature of 50°C would reduce the rate by a factor of approximately 4, to approximately 4×10^{-5} mils/day, or 0.5 mils in 40 years.

B. No significant deterioration of the rack materials is anticipated in the Salem SFP for the following reasons:

1. The rack structure is fabricated of type 304 stainless steel, according to the ASME Boiler and Pressure Vessel Code, Section 3. (No credit is taken for the Boral in determining the strength of the rack structure).

2. Stainless steels are protected from general corrosion by a tenacious passivating film. Corrosion rates are too low to measure under SFP conditions.

3. Stress corrosion cracking of stainless steel where it is sensitized by welding and where total stresses are high is possible under SFP conditions. However, welded stainless steel SFP liners are used in all PWR's in the U.S. except Yankee-Rowe. They have been in service in a boric acid environment for periods up to 12 years, and no failures due to stress corrosion in this environment have yet been observed, as determined in a survey I made in 1978. Therefore, while it is not impossible that, at some time, stress corrosion may develop in the heat affected zones of the welds, especially where residual stresses from welding are high, this phenomenon would be rare and localized; therefore, it is highly unlikely that this phenomenon will produce sufficiently severe degradation to affect the structural integrity of the racks.

D. Since neither the racks nor the neutron absorption material are likely to undergo significant deterioration during the design life of the racks, as discussed above, I do not anticipate any problems arising from combinations of these factors.

6. The Licensee has given inadequate consideration to qualification and testing of Boral material in the environment of protracted association with spent nuclear fuel, in order to validate its continued properties for reactivity control and integrity.

Boral material has been exposed in water for periods up to 20 years without any significant deterioration. I recently prepared a review of the subject, BNL-NUREG-25582, which I have appended to this affidavit. In a boric acid environment, I would anticipate no significant degradation of the Boral material. Should spent fuel pool coolant containing boric acid enter the cavity in the racks containing the Boral, an initial corrosion of aluminum would occur, producing some hydrogen. The Licensee has documented actions it would take (semi-remote tooling will be used to provide vent holes) should this occur, since the hydrogen pressure so generated is capable of bulging the stainless steel can. However, the production

of this hydrogen would not lead to significant deterioration of the Boral. After exposure to water, aluminum passivates within a week and essentially no further general corrosion of the aluminum will occur. It is possible, of course, that pitting corrosion would continue at points where the aluminum is in contact with the stainless steel in this environment. This pitting, however, even if it should penetrate the aluminum clad on the Boral, should not lead to massive loss of boron carbide as the boron carbide particles are highly inert in this environment.

Association with the fuel should not lead to significant deterioration of the Boral. The primary radiation from this fuel that would reach the Boral is γ radiation from the fission products. γ radiation has little or no effect on the properties of metals or cermets of the B_4C/Al type. Neutron fluxes, which can lead to loss in the ability of the Boral to control reactivity, are extremely low in a SFP; maximum integrated fluxes from delayed neutrons of approximately 10^9 n/cm^2 in 40 years have been estimated for a SFP. This value is negligible compared to the approximately 4×10^{21} boron^{10} atoms/cm^2 of plate, available to absorb these neutrons.

I, therefore, believe that the Boral material will continue to maintain its properties of reactivity control throughout the forty year design life of the Salem Fuel Pool.

The above statements are true and accurate to the best of my knowledge.

John R. Weeks

Sworn before me this 29th
day of MARCH 1979

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No. 52-8591995
Qualified in Suffolk County
Commission Expires March 30, 19 80

Donald J. Robbins
Notary Public

STATE OF NEW YORK
SUFFOLK County

PROFESSIONAL QUALIFICATIONS

OF

JOHN R. WEEKS

I am currently a metallurgist at Brookhaven National Laboratory, (BNL), where I have been employed since 1953. My present title is Leader, Corrosion Science Group, in the Department of Nuclear Energy. My current responsibilities include experimental investigations on the mechanisms of stress corrosion cracking and pitting corrosion of stainless steels and Inconel, and providing technical assistance to the U.S. Nuclear Regulatory Commission (NRC) in the area of corrosion and coolant chemistry in light water reactors. I am a participating consultant on the NRC Pipe Crack Study Group. I also am Chairman of the BNL Reactor and Critical Experiments Safety Committee, and represent the Department of Nuclear Energy on the BNL Council.

Since joining Brookhaven I have performed and supervised research on materials behavior in both liquid metal and water cooled reactors. From 1970 to 1972 I headed Brookhaven's program on liquid sodium technology. I have been materials advisor to the Reactor Division at BNL since 1959. I was keynote lecturer in 1966 at the International Atomic Energy Agency Symposium on Alkali Metal Coolants, and served in 1967-1969 as a U.S. delegate at the US-UK information exchanges on corrosion of reactor materials. I was a consultant to Aerojet General on the SNAP-8 project.

I was an adjunct associate professor of materials science at SUNY - Stony Brook in 1962-1963, and am currently an adjunct professor of Metallurgy and Nuclear Engineering at the Polytechnic Institute of New York. From 1972 to 1974 I was on assignment to the U.S. Atomic Energy Commission as a senior metallurgist in the Materials Engineering Branch, Directorate of Licensing. In 1974-1975, I served on the AEC (later NRC) Task Force investigating the causes of the stress corrosion problems in BWR piping.

My academic qualifications include a Met. E. degree from the Colorado School of Mines in 1949, a M.S. in 1950, and a Ph.D. in 1953 in Metallurgy from the University of Utah. I am a member of the American Society for Metals, for which I have been Chairman of the Long Island chapter, the Metallurgical Society of AIME, for which I have served as Chairman of the Nuclear Metallurgy Committee, and the American Nuclear Society. I am the author or co-author of approximately sixty-five publications in the areas of my research.

BNL-NUREG -25582
INFORMAL REPORT

CORROSION CONSIDERATIONS IN THE USE OF BORAL IN SPENT FUEL STORAGE POOL RACKS

J.R. WEEKS

JANUARY 1979

DEPARTMENT OF NUCLEAR ENERGY BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

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Office of Nuclear Reactor Regulation
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CORROSION CONSIDERATIONS

IN THE

USE OF BORAL IN SPENT FUEL STORAGE POOL RACKS

J.R. Weeks

December 1978

Corrosion Science Group
Department of Nuclear Energy
Brookhaven National Laboratory
Upton, New York 11973

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TABLE OF CONTENTS

	Page
LIST OF TABLES	ii
LIST OF FIGURES	iii
INTRODUCTION	1
CORROSION OF BORAL	2
PITTING OF ALUMINUM IN CONTACT WITH STAINLESS STEEL	3
CONCLUSIONS AND RECOMMENDATIONS	5
ACKNOWLEDGEMENTS	6

LIST OF TABLES

		Page
TABLE I	BMRR WATER CHEMISTRY.....	7
TABLE II	HFBR SFP CHEMISTRY.....	8

LIST OF FIGURES

		Page
FIGURE 1	Typical Corrosion Pattern for 1100 Al in Water (From ANL-5001).....	9
FIGURE 2	BMRR Reactor Assembly. Hand drawn arrows indicates exposed Boral Sheets. From BNL-600.....	10
FIGURE 3	Schematic of 1/4" Boral Sheets in BMRR, Indicating Location of Punchings.....	11
FIGURE 4	Microstructure of Sample #1 as polished with 600 grit.....	12
FIGURE 5	Microstructure of Sample #2 as polished with 600 grit.....	13
FIGURE 6	Microstructure of Sample #3 as polished with 600 grit.....	14
FIGURE 7	Microstructure of Sample #4 as polished with 600 grit.....	15
FIGURE 8	Microstructure of Sample #5 as polished with 600 grit.....	16
FIGURE 9	Microstructure of Sample #6 as polished with 600 grit.....	17
FIGURE 10	Neutron Attenuation Results on Samples 1-6 (Performed at U. of Michigan, Courtesy of Brooks & Perkins.....	18
FIGURE 11	Aluminum Surfaces in Contact with Stainless Steel After 6 1/2 Months Exposure in the HFBR SFP, 2.5x.....	19

INTRODUCTION

Boral is a cermet of Boron Carbide "B_4C" in aluminum clad in aluminum. It is manufactured in rolled sheets using techniques similar to those used in the production of uranium aluminum fuel elements. The core of the standard Boral contains 35% boron carbide by weight. Cladding material is typical 1100 aluminum. Where it is exposed to water in service, the edges of the Boral are recommended by the manufacturer to be clad with aluminum by welding.

In Spent Fuel Pool (SFP) racks, the Boral is usually not a structural member but is inserted in cavities between the spent fuel storage positions in the racks. In these locations it is sealed by welding to prevent access of water. Inherently, however, the corrosion of the Boral, both the boron carbide-aluminum cermet and the aluminum cladding, should be minimal in a spent fuel storage pool. The cavities into which the Boral is sealed are typically fabricated of aluminum alloys, i.e. type 6061, or stainless steel. In either case, these are the structural members of the SFP racks.

In an SFP, water chemistry tends to be strictly controlled because the SFP water mixes with the reactor coolant during refueling procedures. In SFP's at BWR sites, water chemistry is typical of hat of a BWR i.e. high resistivity neutral water. In SFP's at PWR sites water chemistry typically contains 2 to 3,000 parts per million ppm boron as boric acid, which is there primarily to prevent dilution of the reactor primary coolant during refueling and is not relied on for criticality considerations. The water chemistries and anticipated

corrosion of SFP materials were reviewed in an earlier report. BNL-NUREG 23021, July, 1977.

CORROSION OF BORAL

Corrosion problems have developed in SFP's where water has inadvertently leaked into the cavities containing the Boral. In a BWR pool, swelling of the racks has been observed when water leaked into the cavities through a flaw in the seal weld at the bottom of the cavity.

The swelling observed arises from the rapid initial corrosion of Al by water. Draley and Ruther (ANL-5001, Feb. 1, 1953) have shown that aqueous corrosion of 1100 Al can be described in terms of a steady state slope and an intercept, as sketched in Fig. 1. This intercept was measured by them to be 21 $\pm$ 5 mg/dm^2 "metal corroded" over a range of temperatures (100 - 175°C) and pH (5 - 8.5). This "intercept" corrosion occurs within the first 5 days of immersion in water by a reaction of the type

$$2Al + (3+x)H_2O \quad Al_2O_3.x\,H_2O + 3H_2.$$

Thus 21 mg Al can produce $\frac{21 \times 3}{27 \times 2}$, or slightly more than 1 millimole H_2 per dm^2 of surface. The Brooks & Perkins Report #577 says there are 3.4 x 10^2 dm^2 Boral per tube in SPF racks such as those at Monticello or Brown's Ferry, so one could produce approximately 3.4 X 10^2 x 22.4 = approximately 7500cc H_2/tube, at STP. This is more than enough to produce the necessary 6 psi to bulge the cladding in a void volume of 130cc.

There is no reason to believe, however, that any B_4C will be lost from the Boral by corrosion in the SFP water. In the Brookhaven

Medical Research Reactor, Boral has been exposed to the reactor coolant since January, 1959. Figure 2 shows a schematic of this reactor. The 1/4 inch Boral sheets are in the form of 2 half-cylinders. The upper edge of these sheets is unclad. The vertical edges appear by examination in situ with a periscope to be clad. In July of this year, samples were removed in the form of small punchings, three from each of the half-cylinders as shown on the attached sketch, figure 3. Each of these six specimens was cut in half, and one-half mounted for metallography. The resultant microstructures are shown in figures 4-9. Clearly there appears to be no systematic loss of the boron carbide. The other half of each of these specimens was analyzed by neutron attenuation at the University of Michigan under contract with Brooks and Perkins, the primary supplier. The neutron attenuation results are shown in figure 10. All the results are within 20%, which with the small size of the specimens is probably within analytical error. One specimen, #5, was analyzed wet chemically by Brooks and Perkins to contain 41.3% B_4C in the core, which is in the upper range of boron concentrations for material produced in the 1950's. It, therefore, seems reasonable to conclude that no boron was lost from the core of this Boral by exposure to the BMRR coolant over the 19 1/2 year period. In the location of the BMRR where it is used, there is little measureable neutron flux. Water chemistry in this reactor is outlined in Table 1.

PITTING OF ALUMINUM IN CONTACT WITH STAINLESS STEEL

When aluminum is contacted with stainless steel in impure water, a potential exists for a galvanic attack of aluminum at the point of contact. In a SFP environment, this attack is especially likely in a PWR pool containing boric acid at a pH around 4.5. Further, aluminum

borates can be produced which appear as a white fluffy dispersion in the water at a pH greater than about 4.5. Maintaining the pH below 4.2 causes the white fluffy material to disappear. Corrosion currents at a stainless steel to aluminum galvanic couple in boric acid were measured to average 2 mils per year although the presence of oxygen or hydrogen peroxide increased this value substantially.

A number of references exist showing that pitting corrosion can occur in slightly acid waters at aluminum to stainless steel junctions. English and Griess (ORNL-TM-1030, 1966) report pitting depths up to 45 mils in 12,500 hours (1 1/2 years) in pH 5 nitric acid solutions at 100°C. Lennox et al. (Materials Performance, Vol. 13, #2, page 31, 1974) measured pitting where type 5086 aluminum is coupled to type 304 stainless steel of the order of 30 mils in a year and one-half in Gatun Lake, Panama, and up to 40 mils in two years in the Potomac River at Washington. The general corrosion of this alloy was negligible in both environments.

In the HFBR SFP, water chemistry is similar to that in a BWR SFP except that conductivity may be slightly higher, and the pH slightly lower. Typical data are given in Table 2. Specimens of aluminum and stainless steel in contact with one another have been exposed in the HFBR pool for a period of six months at which time they were examined and then reinserted for continued testing. There appears to be a general discoloration of the aluminum where it contacted the stainless steel and a small amount of pitting around the edges as shown in figure 11. It is highly unlikely, however, that pitting of this magnitude would result in significant loss of the boron should the Boral containing cavities be flooded over an extended period of time.

Venting the upper end of the Boral chambers would probably alleviate any concerns over swelling due to hydrogen generation. It might produce pitting corrosion and some of the white aluminum borate deposits. I would recommend that a surveillance program including aluminum to stainless steel couples be installed in SFP's in which the Boral cavities are vented. Any swelling due to hydrogen production should occur within a week or so of the time the water enters the annulus containing the Boral. However, should a leak develop in one of the seal welds at some future date after the racks are installed, the swelling could occur at that time. For this reason, venting or the capability for future venting, is probably desirable. In general, I think the localized pitting corrosion that might result from venting the Boral cavities in SFP racks would be less of a safety concern than the swelling that might occur should they not be vented. In all SFP's the rack design should prevent contact between Al and the zircaloy fuel cladding, as this galvanic couple (especially in boric acid pools) can lead to hydriding of the zircaloy during storage, as described by A. B. Johnson in BNWL 2256, September, 1977.

CONCLUSIONS AND RECOMMENDATIONS

1. The swelling that has occurred in the Monticello SFP racks and might be anticipated to occur in other similar SFP racks results from initial corrosion of aluminum and not from corrosion of the boron carbide cermet.

2. Venting of these cavities in a BWR pool should not produce significant loss of the boron and should, therefore, be accepted by NRC provided the venting occurs at the upper edge so that any hydrogen pressure from corrosion of the aluminum cladding will not build up to cause swelling of the racks.

3. Venting of the Boral cavities in a PWR rack might produce more pitting corrosion of the Boral. Again, however, it should not lead to major loss of the boron carbide.

4. Anodizing the Boral in these cavities would tend to reduce the hydrogen production in the cavities should SFP water leak in to them. Anodizing would probably not, however, prevent pitting of the aluminum.

5. In any fuel pool in which the Boral cavities are flooded intentionally or inadvertently, surveillance specimens should be present to determine on a periodic basis, i.e. once every few years, what is happening to the Boral in these cavities.

6. In any SFP, galvanic coupling between Al in the racks and the zircaloy fuel cladding should be avoided, to prevent hydriding of the cladding during long term storage.

ACKNOWLEDGEMENTS

The assistance of the BNL Reactor Division staff, R.W. Powell, Head, in obtaining the Boral punchings from the BMRR spent fuel shielding is deeply appreciated. The metallography was performed by K. Sutter of BNL. The neutron attenuation and wet chemistry results were obtained through the courtesy of Mr. R. C. Karzmar of Brooks and Perkins, Inc. More detailed analyses of these specimens are underway at G.E., by A. Jacobs, and at Brooks and Perkins, and will be the subject of a future report.

TABLE I

BMRR WATER CHEMISTRY

Temperature	Inlet	Outlet	T.S.
Reactor ON	100°F	115°F	136°F
Reactor OFF	75-80	75-80	-

(Reactor ON less than 10% of time)

Conductivity	Normal	Regenerate Demineralize	Alarm	T.S.
(μmho/cm @25°C)	<2	2	5	10

Alarmed only once in 20 years, during HX leak. T.S. never exceeded.

TABLE II

HFBR SFP CHEMISTRY

Resistivity meg-ohm-cm	Temp. ^{o}C	ppb Cl^{-}	pH
.24 - .6	30-35	4-20	5.9-7.0

(low pH coincides with low resistivity)

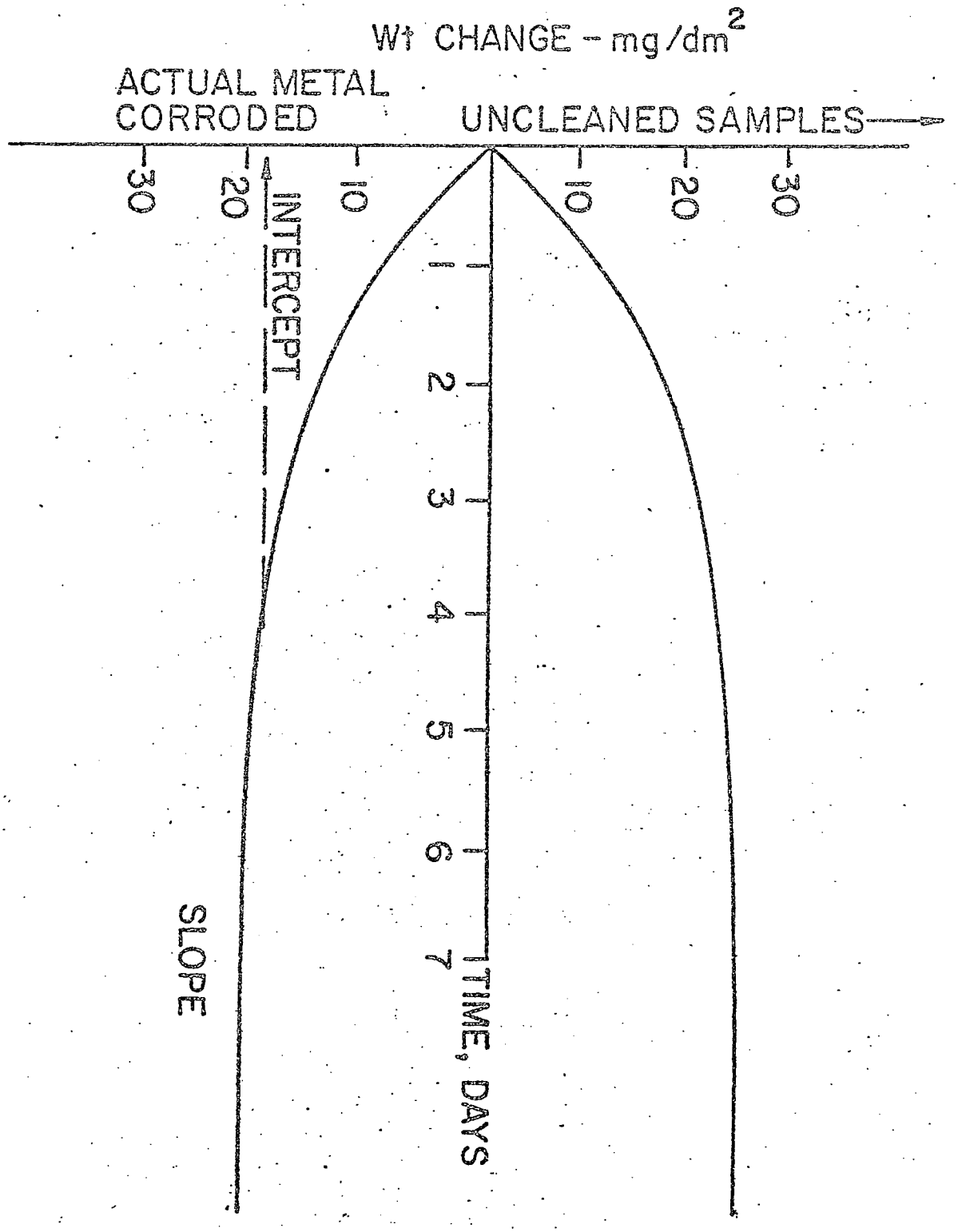


FIG. 1 Typical Corrosion Pattern for 1100 Al in Water (From ANL-5001)

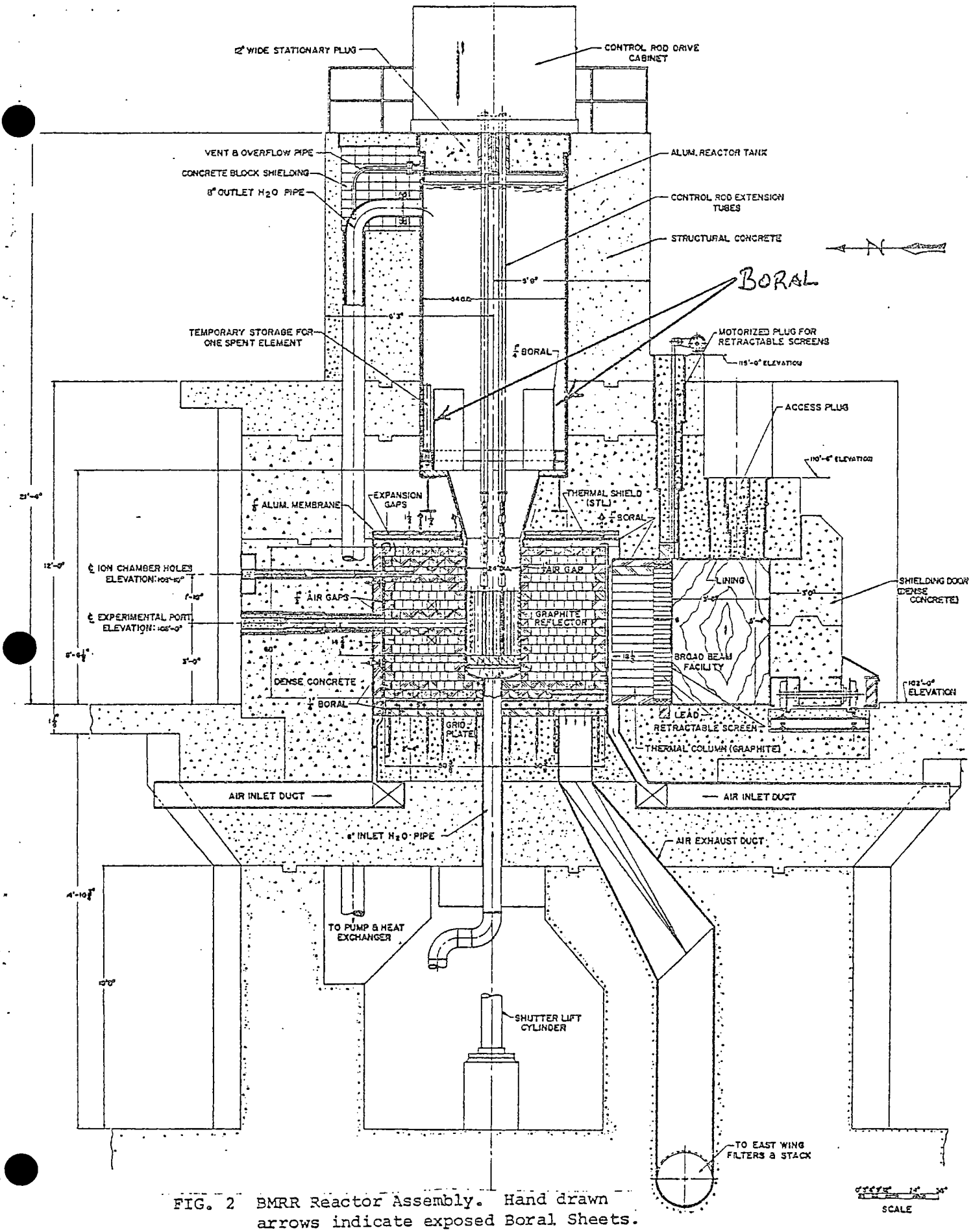


FIG. 2 BMRR Reactor Assembly. Hand drawn arrows indicate exposed Boral Sheets. From BNL-600.

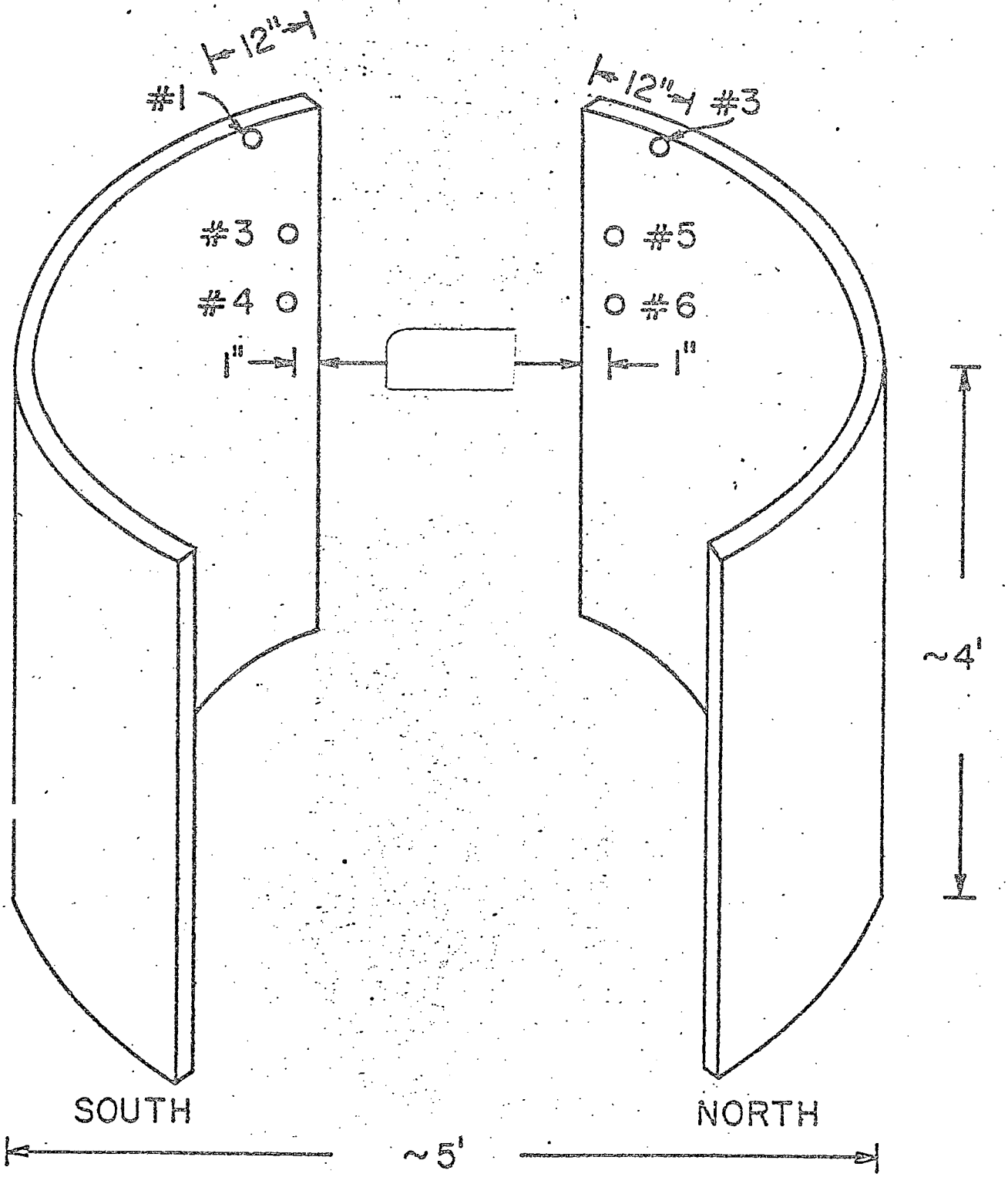
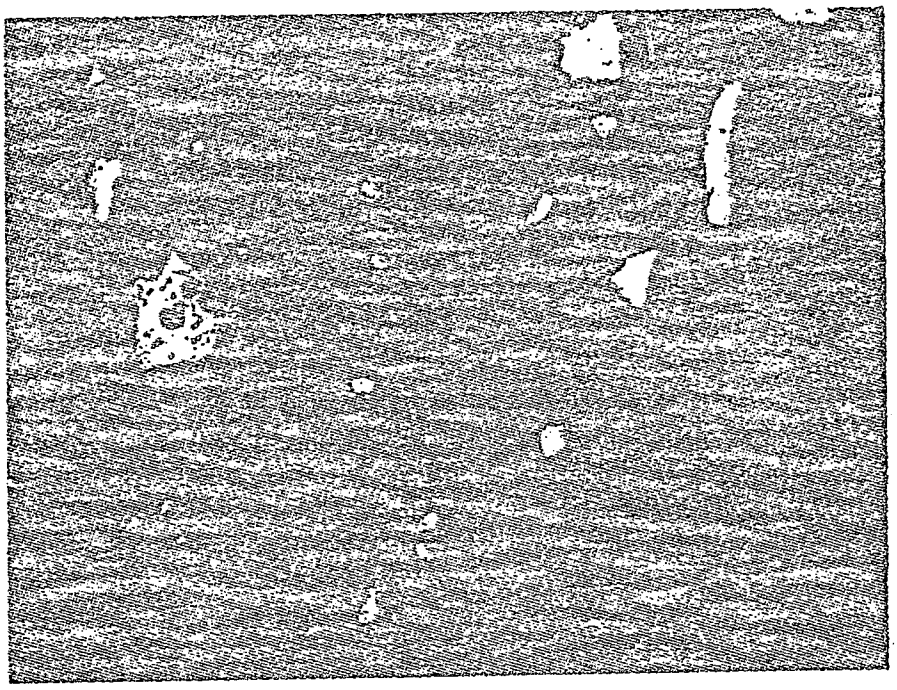


FIG. 3 Schematic of 1/4" Boral Sheets in BMRR, Indicating Location of Punchings



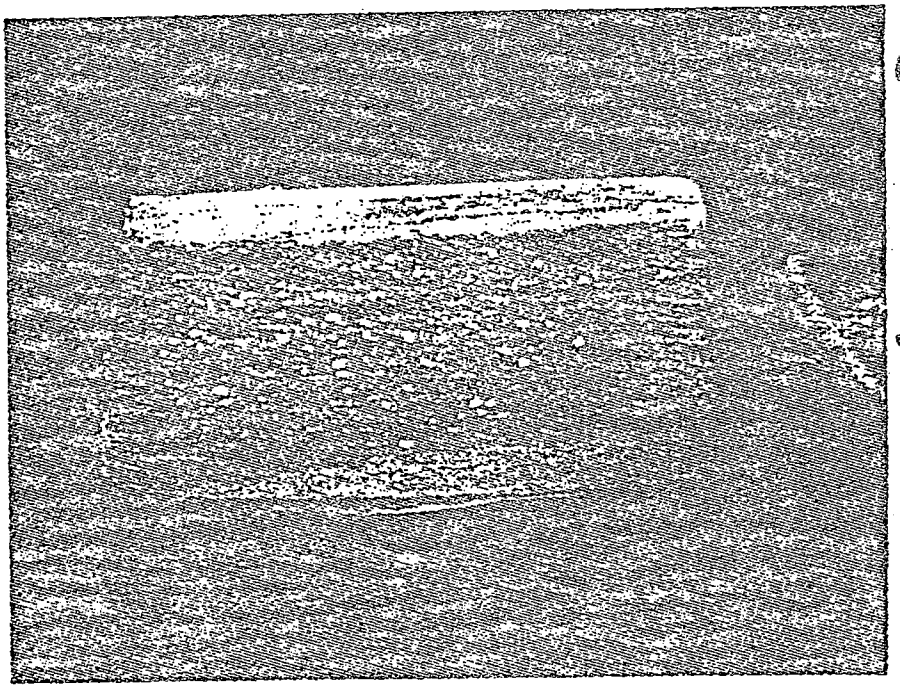
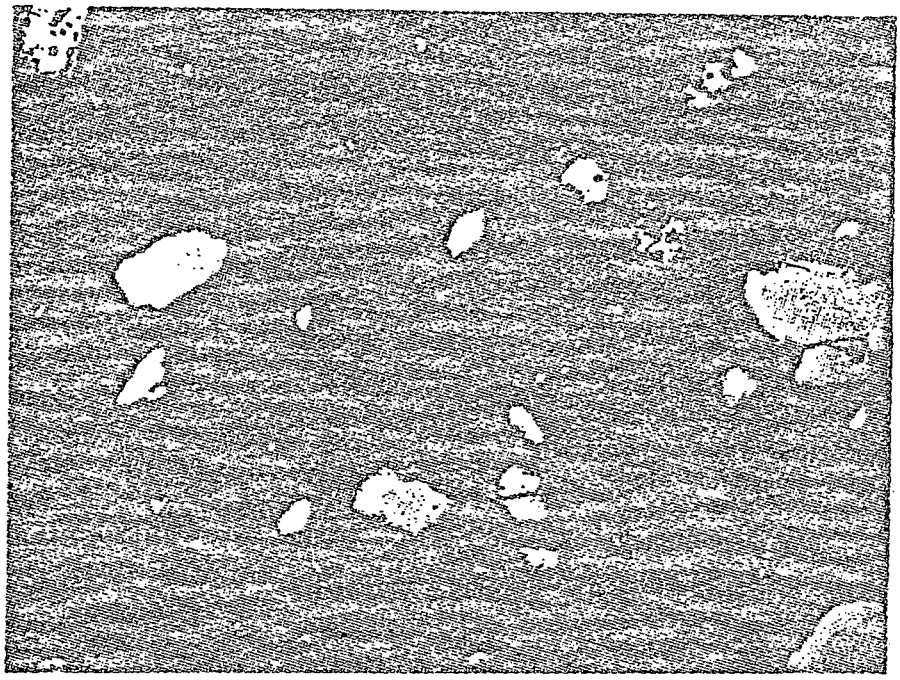


FIG. 4



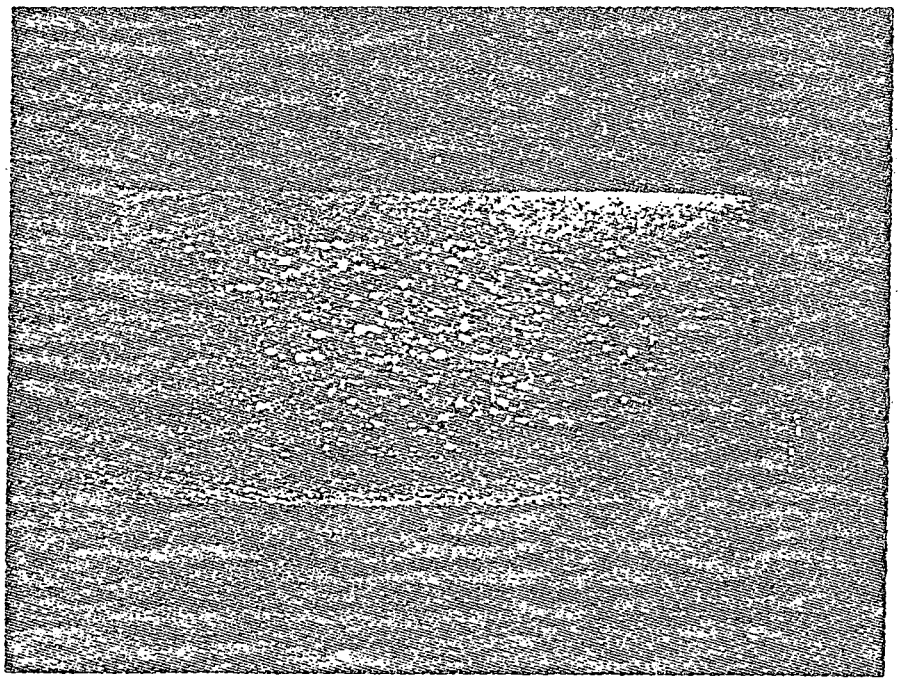
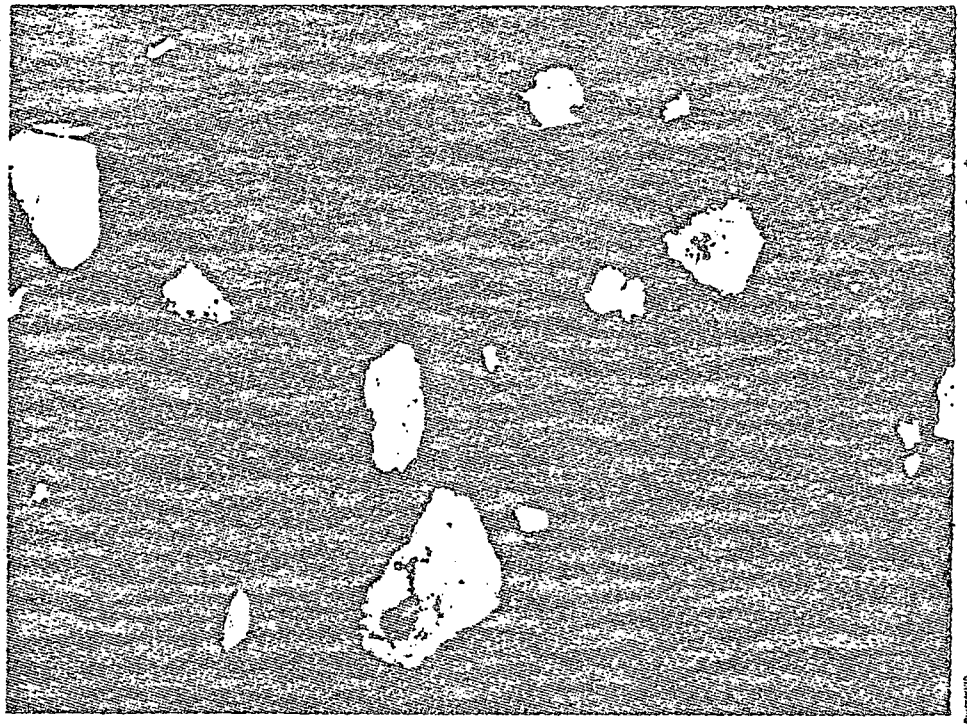


FIG. 5



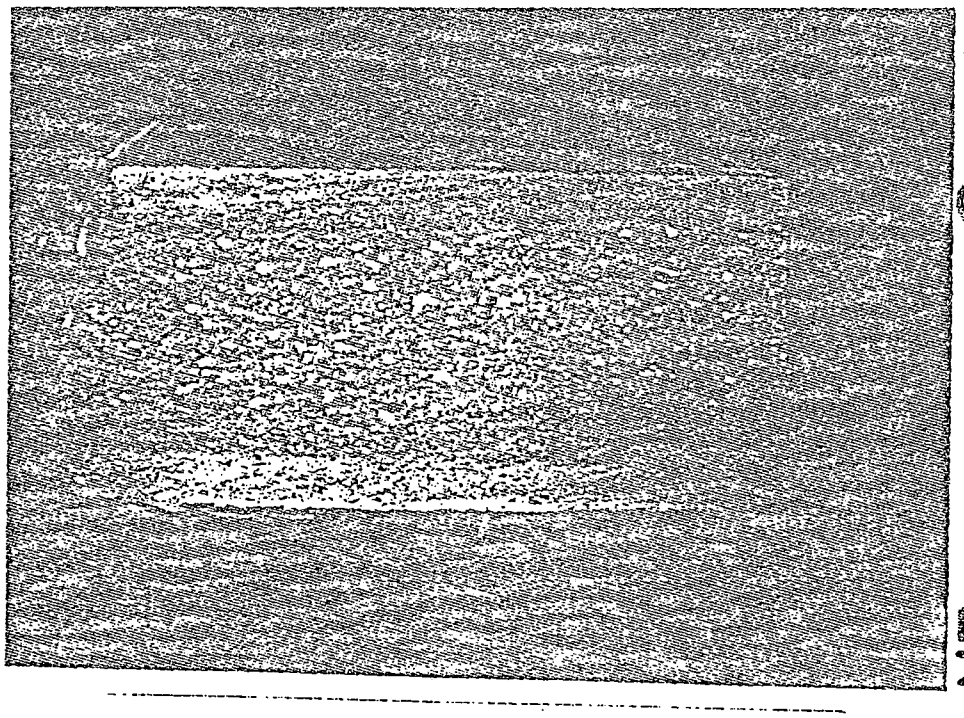


FIG. 6

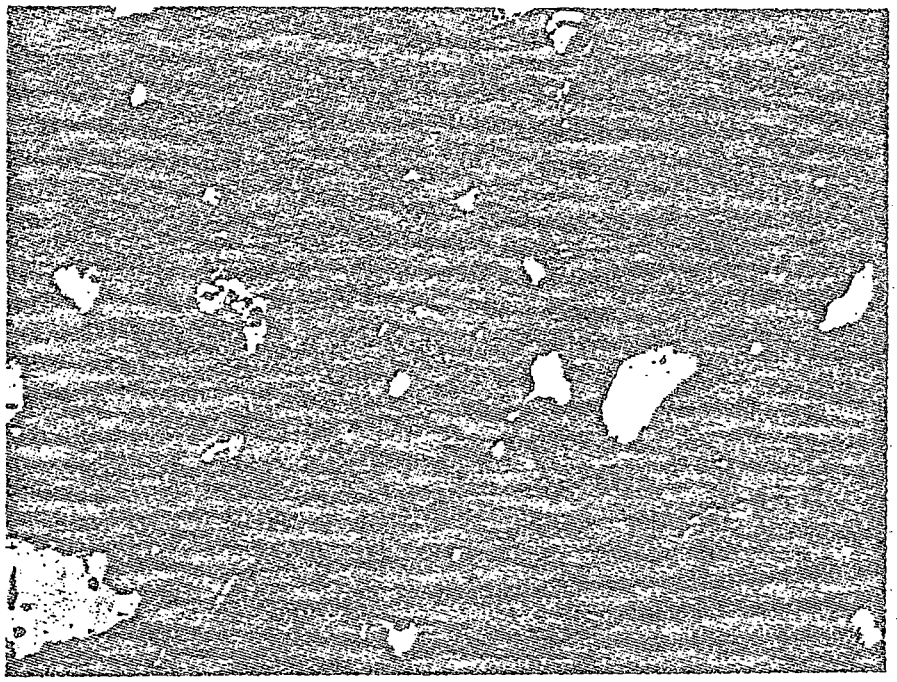
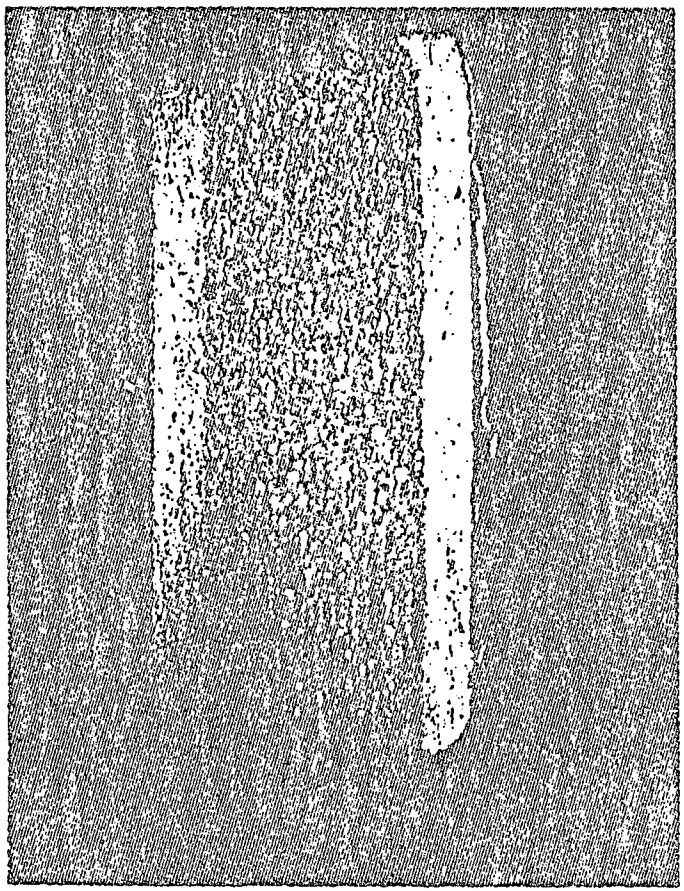


FIG. 7

FIG. 8



X7

Sample #5

X100

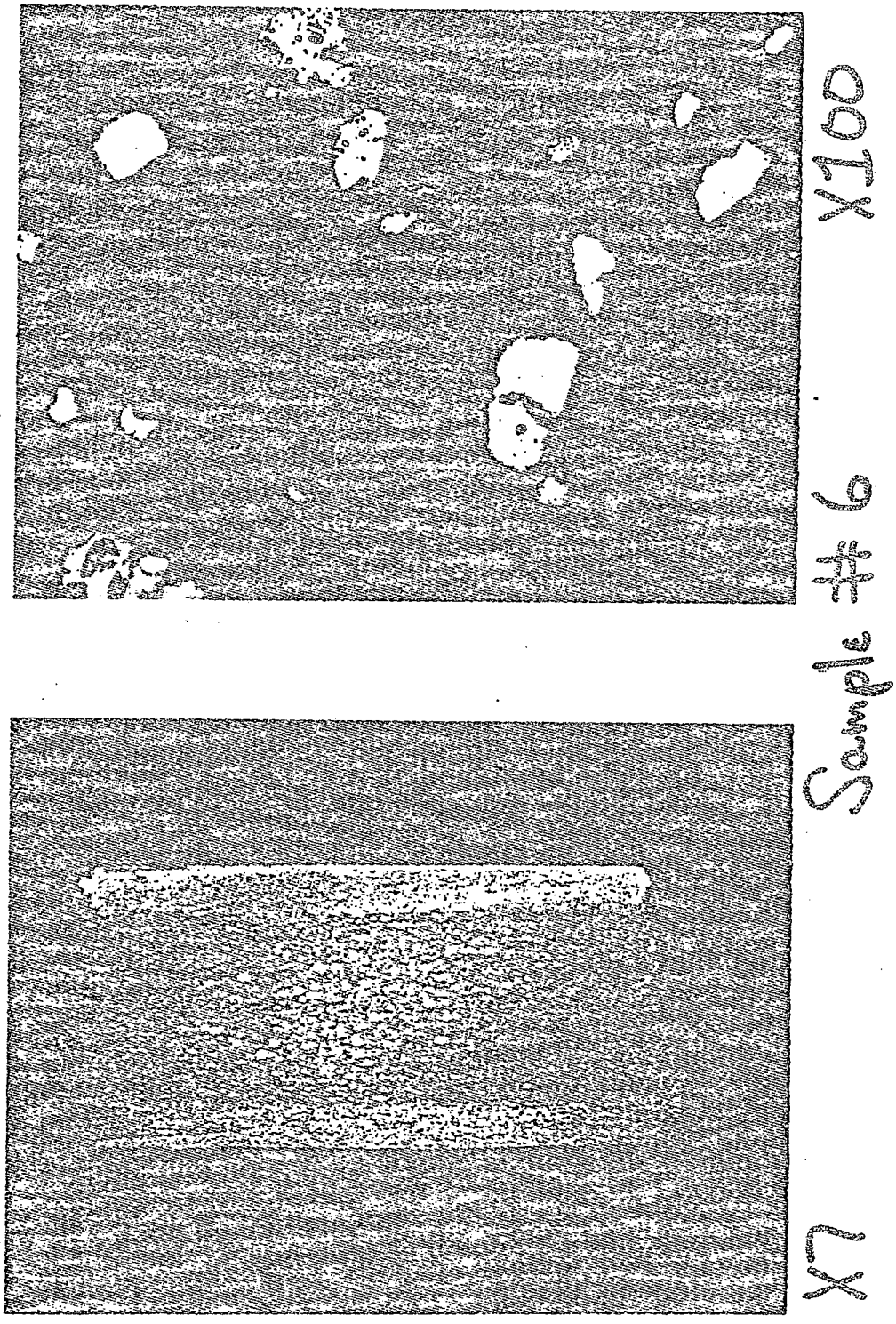


FIG. 9

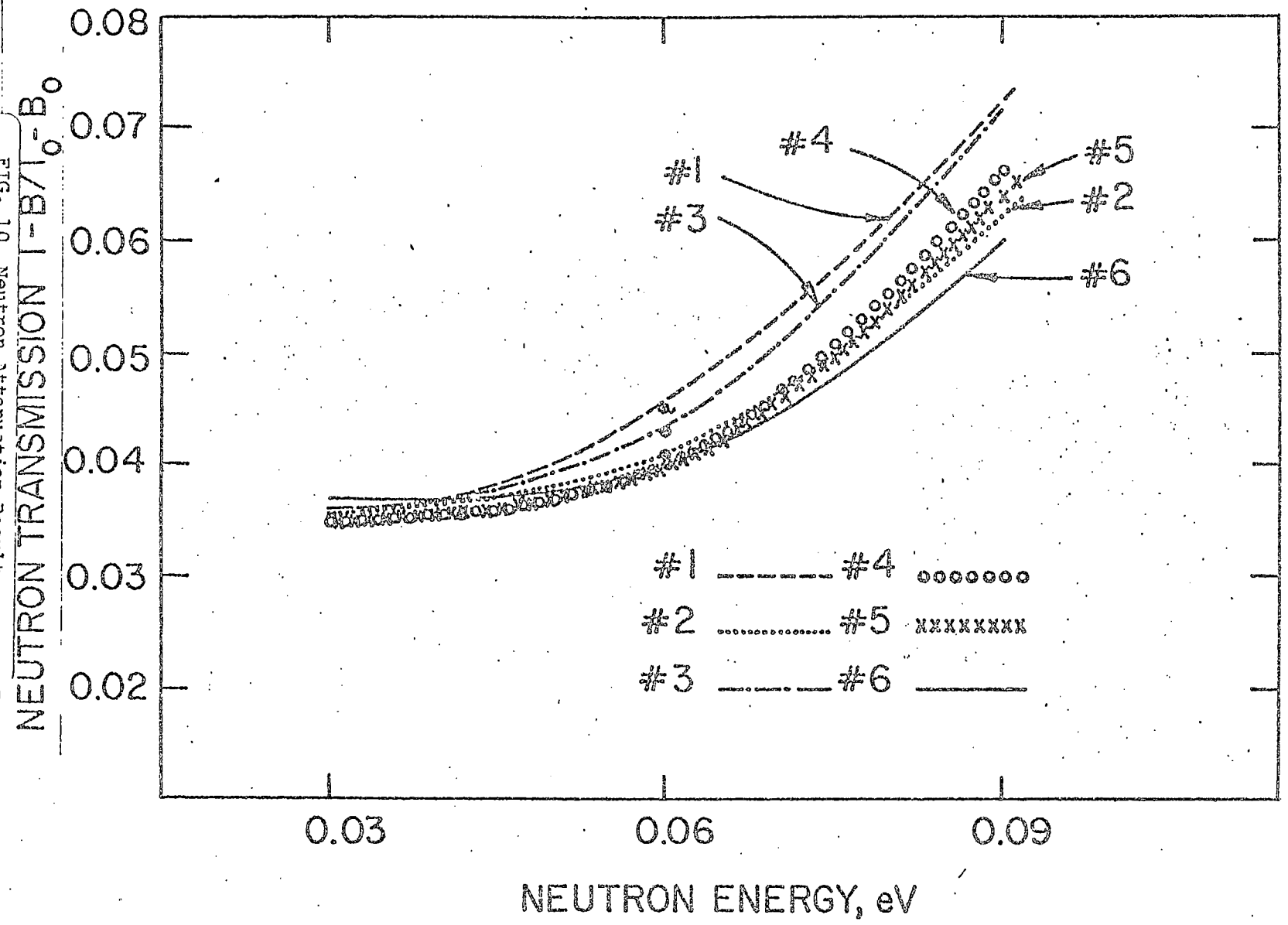


FIG. 10 Neutron Attenuation Results on Samples 1-6 (Performed at U. of Michigan, Courtesy of Brooks & Perkins

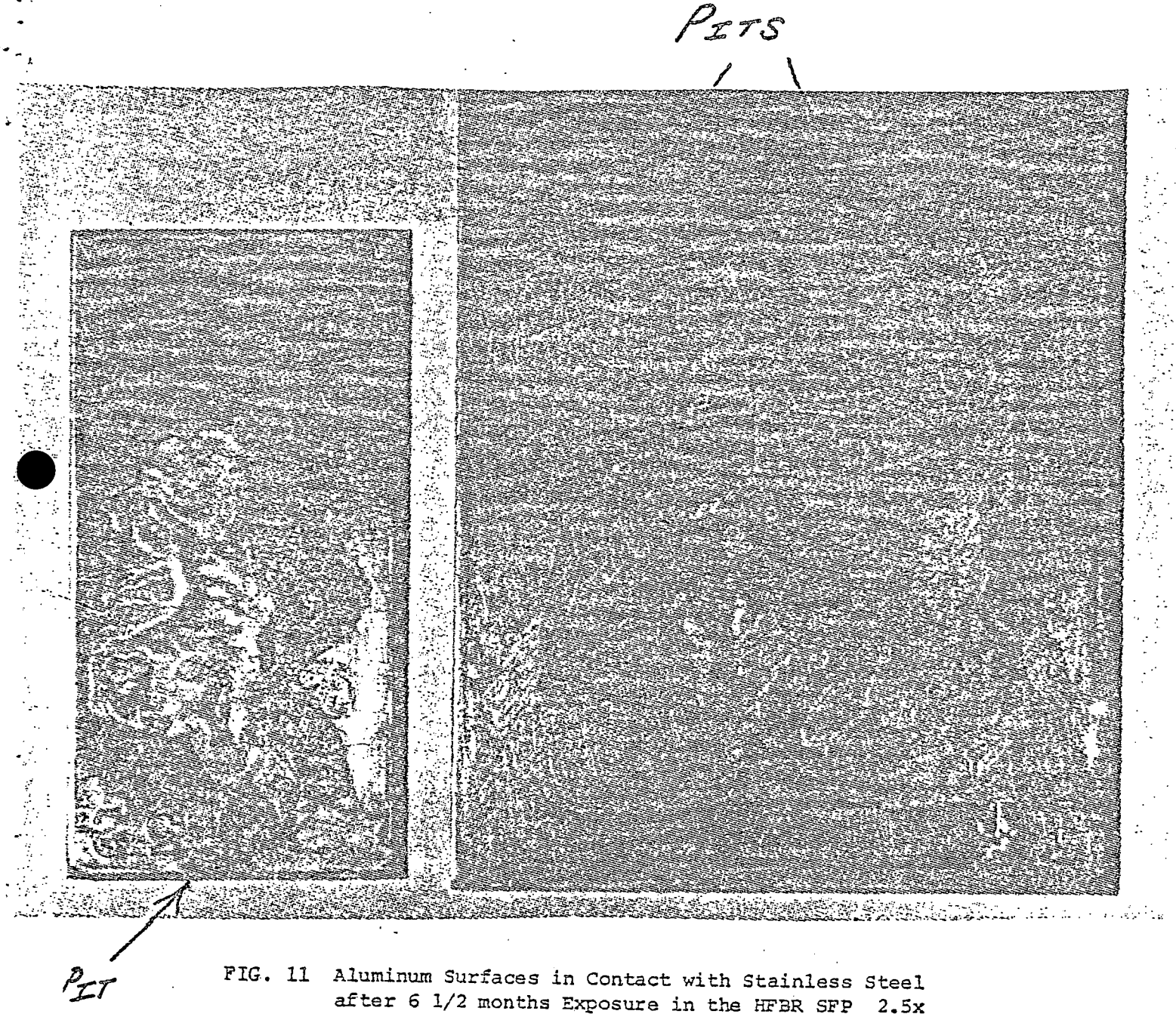


FIG. 11 Aluminum Surfaces in Contact with Stainless Steel after 6 1/2 months Exposure in the HFBR SFP 2.5x

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BNL-NUREG-23021
INFORMAL REPORT

CORROSION OF MATERIALS IN SPENT FUEL STORAGE POOLS

J.R. WEEKS

JULY 1977

DEPARTMENT OF APPLIED SCIENCE — BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

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INFORMAL REPORT

CORROSION OF MATERIALS

IN

SPENT FUEL STORAGE POOLS

J.R. Weeks

July 1977

Corrosion Group
Department of Applied Science
Brookhaven National Laboratory
Upton, New York 11973

TABLE OF CONTENTS

LIST OF TABLES ii

INTRODUCTION 1

I MATERIALS 2

II WATER CHEMISTRY 3

1. BWR Fuel Pool Chemistry 3

2. PWR Fuel Pool Chemistry 3

3. Biocides 4

III CORROSION OF MATERIALS IN FUEL STORAGE POOLS 5

1. Stainless Steels 5

2. Aluminum Alloys 5

3. Zircaloy Cladding 6

4. Other Materials 6

5. Stress Corrosion 6

6. Galvanic Corrosion 7

IV SURVEILLANCE 9

V SUMMARY AND CONCLUSIONS 10

ACKNOWLEDGEMENTS 11

REFERENCES 12

TABLE 13, 14, 15

LIST OF TABLES

TABLE 1 MATERIALS AND WATER CHEMISTRIES IN LWR FUEL STORAGE POOLS ---------- 13 & 14

INTRODUCTION

The current delays in establishing a national fuel reprocessing center have required many of the LWR licensees to expand their fuel storage capabilities either by modification of existing pools or addition of new fuel storage pools. This report reviews the potential corrosion problems that might develop during the long-term (10 plus years) storage of nuclear fuels in these storage pools. A detailed review of the integrity of the fuel in storage pools is being prepared by Johnson for ERDA,[1] which has served as a basis for much of this report. Zircaloy-clad fuels with burnups up to 33,000 MWd/MTU have been successfully stored in fuel storage pools for periods up to 13 years in U.S. pools and 14 years (at lower burnups) in Canadian pools.

I. MATERIALS

Three types of materials are generally in contact with the fuel storage pool water: the pool liner which is commonly stainless steel, the storage racks which are commonly stainless steel or aluminum, and the materials present in the fuel element bundles which commonly include stainless steel, Inconel 718, 17-4 PH, and Zircaloy 2 or Zircaloy 4 cladding. Table 1 lists the materials and water chemistry used in the fuel storage pools at a number of LWR nuclear stations, as available to the writer as of July 15, 1977.

Experience with storing these materials for long periods of time in reactor canals has been reviewed by A.B. Johnson, Jr.[1] Maximum residence in U.S. Pools of spent zircaloy-clad fuel is 13 years. None of these materials should suffer significant corrosion in this environment in periods well in excess of 10 years, as has been borne out by experience.

II WATER CHEMISTRY

Because during the fuel unloading procedure the water in the fuel storage pool and the reactor primary coolant mix, an attempt is made to maintain water purity in the fuel storage pool to approximately the same limits that are set for the primary reactor coolant.

1. BWR Fuel Pool Chemistry

In a BWR this means that high purity demineralized water is typically maintained with a filter-demineralizer to a total heavy ion content of < 0.1 ppm, a pH range of 6.0 to 7.5, and a conductivity of < 1 μmho/cm. The water is sampled daily to measure conductivity, and weekly for other impurities, including chlorides. The demineralizers primarily remove silicates from the water, and are typically checked for their capacity to remove this species once weekly. The primary source of the silicates may be dust from the air; the pools are normally uncovered. On the average, fresh resin beds are installed monthly, primarily because of increased pressure drops from silicate absorption.[2] The primary contribution to the conductivity is dissolved CO_2; when the conductivity exceeds 1 μmho/cm the demineralizers are changed.[2] During a visit in June, 1977, the water in the Vermont Yankee fuel pool appeared extremely clear, with a distinct blue tinge to it, apparently as a result of scattering of the longer light waves by the water and the use of mercury vapor lighting.

2. PWR Fuel Pool Chemistry

In a PWR, the fuel pool frequently contains several thousand ppm boric acid, which is added to other otherwise highly pure water. No neutralization with LiOH is used in the fuel storage pools; a typical pH[3] value is 4.5. A portion of the fuel pool

coolant is continuously passed through a demineralizer resin and impurities, such as halides or sodium ions, maintained below 0.15 ppm. Periodically the demineralizer resins are checked for their ability to remove halides and sodium ions; resins have been developed by Rohm and Haas that are specific for removing halides in the presence of boric acid. The manufacturer's claims in this matter have been confirmed experimentally by one of the reactor vendors.(4)

3. Biocides:

Biocides are not commonly used in fuel storage pools at nuclear power plants. Maintaining the water of the high purity needed for safe storage of fuel appears to inhibit biological growth, and the use of stainless steel liners in the storage pool also tends to control biological growth. The radiation levels from the spent fuel stored in the pool also tend to sterilize the water, although radiation resistant bacteria are known. Finally, the continuous demineralization of a portion of the pool water serves to filter out any biological growth. No biological fouling has been observed in 3 1/2 years operation of the Prairie Island spent fuel pool,(3) in 3 1/2 years operation of the Vermont Yankee, > 5 years operation of the Maine Yankee, and > 10 years operation of the Yankee-Rowe fuel storage pools,(2) and no biocides have been added.

The use of biocides can lead to the presence of chloride ions in the pool which are potentially harmful to the corrosion resistance of the materials stored in the pool, and would be unacceptable during the mixing with the reactor primary coolant that occurs during refueling. They have been used in the ICPT fuel pool at Idaho Falls, which is a painted concrete pool.(1)

III CORROSION OF MATERIALS IN FUEL STORAGE POOLS

The corrosion rates of zirconium, stainless steels and Inconel in water of the quality maintained in the fuel storage pools should be negligible during periods upwards of twenty years. General corrosion rate measurements for these materials in water of this quality and temperature are not generally available, and any estimates of corrosion rates must be extrapolated from measurements at much higher temperatures. The primary difference between the water chemistry in the fuel pools and that in the reactor (other than the temperature) is that the pools are exposed to the air and are presumed to contain dissolved oxygen up to the saturation point. Since all the materials used are passivated by oxide films, the presence of oxygen in the water should not affect their corrosion rates.

1. Stainless Steels

Since the stainless steels are used for the primary piping at substantially higher temperatures and in the presence of oxygen in BWR's where stainless steels are deemed satisfactory for periods up to 40 years, corrosion in the fuel pool should be much less than in the reactor, because of the lower temperature.

2. Aluminum Alloys

The anticipated corrosion of the aluminum alloys, 1100 or 6061, is negligible in water of this quality at temperatures up to the boiling point of water: at 125°C (257°F) a corrosion rate of 1.5×10^{-4} mils/day[5] has been measured for alloy 6061 aluminum, in water of pH 7, which corresponds to a total corrosion of 1.1 mils in twenty years. Since the oxidation rate will continue to decrease slightly over this period, this estimate should be conservative. At lower temperatures, the rate will be even

lower. There is little difference in the corrosion rates of these two alloys at temperatures below 150°C. The anodization of the aluminum components, which is occasionally used, should protect them even further from corrosion.

3. Zircaloy Cladding

The rate of corrosion of zircaloy in fuel storage pool waters is very low. Berry[6] gives a corrosion rate in 500° water of 2×10^{-2} mils/year, and shows it to be continually decreasing up to times in excess of 10 or 15 years. At the lower temperatures that prevail in fuel storage pools, the corrosion rates should be even lower. Morgan [7] describes the corrosion rate of zircaloy in pool water as being sufficiently low to provide an adequate containment barrier for at least 100 years.

The oxygen concentration in the pool water should not adversely affect corrosion of zircaloys. Zirconium and its alloys are protected from aqueous corrosion by a strongly passivating oxide film. The oxygen in the water should serve to promote and maintain this passivation. Further, Uhlig[8] has stated that this passivity is maintained both in strong acids and in strong alkalis.

4. Other Materials

The fuel bundle and storage rack materials may also include type 17-4 PH stainless steel and Inconel 718. Neither of these alloys should undergo measurable general corrosion in fuel storage pool waters.

5. Stress Corrosion

Stress corrosion of stainless steels and zircaloys in fuel storage pools is highly unlikely to occur provided the water

chemistry is maintained within the specified limits. Stress corrosion of sensitized stainless steels that are highly stressed has been observed in oxygenated water acidified to pH 5 nitric acid at temperatures up to 140°F.[9] This is, however, a slow process which took 6 years to develop and occurred only in one highly stressed, highly sensitized area. While it is impossible to rule out completely that stress corrosion of the stainless steel or Inconel components will occur in the fuel storage pool, any such occurrence would be highly localized and rare, and not lead to serious problems with the storage racks or fuel bundle components. No significant difficulties have been observed in fuel bundles examined from a number of reactors. Stress corrosion of 17-4 PH is unlikely to occur if the material has received an 1100°F heat treatment. This heat treatment is commonly specified for this material when it will be exposed to reactor coolants. Components of 17-4 PH given this heat treatment have been in service in the Brookhaven High Flux Beam Reactor (HFBR), which contains high purity D_2O acidified with nitric acid to a pD of 5 and containing greater than 8 parts per million of oxygen, for periods in excess of 12 years without any evidence of stress corrosion or pitting.[10] This water chemistry and temperature (145°F max.) are similar to that prevelant in PWR fuel storage pools.

6. Galvanic Corrosion

Galvanic couples between stainless steels, Inconel and zircaloy do not appear to give rise to any localized corrosion in fuel pool environments, since all of these materials are protected by highly passivating oxide films, and are, therefore, at similar potentials in pure water. Aluminum alloys, which are also protected by passivating films, nevertheless can be pitted in an acid environment such as that present in PWR fuel storage pools, when coupled to stainless steel. The anodization of aluminum fuel storage racks

should minimize this occurrence. In BWR storage pools, the high electrical resistiyity of the water should also serve to prevent galvanic attack.

At the Oyster Creek Nuclear Power Station, aluminum racks were originally placed directly in contact with the stainless steel pool liner. Some of these racks have been removed and examined after approximately 7 years of service in typical BWR pool water.[11] No observable pitting of the aluminum was found at the point where it contacted the stainless steel.[11] At least one nuclear utility (Vermont Yankee) has also elected to provide additional protection against this potential problem by placing stainless steel feet on the racks, which, in turn, are electrically insulated from the aluminum with ABS plastic inserts. These have been determined to be sufficiently far from the radiation source to prevent their decomposition by high energy gamma flux.[2] These organic inserts are, in my opinion, additional insurance that galvanic corrosion will not occur.

IV SURVEILLANCE

A spent UnReprocessed Fuel (SURF) program is under development by the ERDA Division of Waste Management, Production and Reprocessing, to be initiated in FY 1978.[12] Under this program, the characteristics and condition of spent fuel in storage will be evaluated on a continuing basis. Although the details of the examination to be performed in this program have not yet been worked out, the national scope of this program, including periodic examination of a few selected fuel bundles from both PWR and BWR storage pools, will provide additional assurance to the NRC of the continued integrity of fuels in storage throughout the country.

V SUMMARY

Significant corrosion of nuclear fuel components is highly unlikely to occur during storage in fuel storage pools at the reactor sites in periods of upwards of 20 years, provided that the water quality in the fuel storage pools is maintained within specifications, and that chloride levels in the pool water are kept to minimum levels (< 1 ppm). Stress corrosion of stainless steel components or Zircaloy cladding cannot be entirely ruled out because of the lack of understanding of the stress states and the degree of sensitization of stainless steel. Should such a problem develop on the Zircaloy cladding it would be readily detected by routine monitoring of the fuel pool water for radioactivity. Should it develop on the stainless steel or Inconel components of the fuel bundles, it would be highly localized and unlikely to lead to significant overall deterioration. Periodic surveillance of the materials in storage at a number of nuclear utilities is being planned under the auspices of the U.S. Energy Research and Development Administration.

ACKNOWLEDGEMENTS

The assistance of Dr. A.B. Johnson, Jr., of Battelle Pacific Northwest Laboratory, in providing draft copies of his review (Reference 1) and in several useful discussions is gratefully acknowledged. Representatives of the Northern States Power Company, Yankee Atomic Electric Company, Duquesne Power and Light Company, Jersey Central Power and Light Company, and the Portland General Electric Company were very helpful in preparing this review. This work was performed under the auspices of the United States Nuclear Regulatory Commission

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TABLE I

MATERIALS AND WATER CHEMISTRIES IN LWR FUEL STORAGE POOLS

PLANT	MATERIAL	USE	ENVIRONMENT
ARKANSAS (PWR)	304 SS A-276-71 or A-167-74 308 or 308L 304L ASTM-A-167	Rack Electrode Liner	1800 ppm boron as boric acid 120°F
BEAVER VALLEY (PWR)	SS, 17-4 PH	Racks, bolts	2000 ppm boron as boric acid, Cl^-, F^- < 0.15 ppm
BRUNSWICK (BWR)	304 SS E308 17-4 PH - H1150, H1025	Liner, racks Electrodes Bolts	125°F (max 150°F) cond < μmho/cm pH 6.0 - 7.5 Cl^- < 0.2 ppm
DRESDEN 1, 2 and 3 (BWR)	Stainless steel Al-6061-T6 ASTM-B-209	Liner Racks	Demineralized water cuno filters and deep bed demineralizers
FT. CALHOUN	304 SS ASTM-A-276-71 or A-167-74 308 or 308L	Racks Weld	120°F 2000 ppm boron as boric acid
GINNA, R.E. (PWR)	304 SS	Racks	Boric acid
LACROSSE (BWR)	Borated SS and 304 SS	Racks	Demineralized water
MILLSTONE POINT I (BWR)	304 SS	Liner, racks	Demineralized water Filter and demineralizer
MILLSTONE POINT 2 (PWR)	304 SS	Liner, racks	Demineralized water + 2000 ppm boron as boric acid

TABLE I

(continued)

PLANT	MATERIAL	USE	ENVIRONMENT
NINE MILE POINT 1 (BWR)	304 SS	Rack	Demineralized water of BWR primary coolant quality 125°F
OYSTER CREEK (BWR)	Entire rack 304 SS ASTM-A-240 ASTM-A-193 ASTM-A-194 308 SS, ASME SFA 5.9	 Plate, bar sheet Rivets, bolts Nuts Weld material	Demineralized water Undissolved solids < 0.5 ppm
PALISADES (PWR)	304 SS	Racks	122°F - 157°F 2000 ppm boron as boric acid
PILGRIM (BWR)	Same rack design as Vermont Yankee		
POINT BEACH 1 and 2 (PWR)	304 SS	Racks	2000 ppm boron as boric acid 130°F
PRAIRIE ISLAND 1 and 2 (PWR)	304 SS Zircaloy, IN-718	Racks, liner Fuel bundles	Demineralized water (Cl^-, F^- < 0.15 ppm + 2000 ppm boron as boric acid pH 4.5, 120°F
QUAD CITIES 1 and 2 (BWR)	Same rack design as Dresden		
TROJAN (PWR)	304 SS Inconel 17-4 PH - H1100	Racks, liner Grid Mat'l. Bolts and Module threaded feet	2000 ppm boron as boric acid 140°F Cl^-, F^-, 0.15 ppm maximum each

TABLE I

(continued)

PLANT	MATERIAL	USE	ENVIRONMENT
TURKEY POINT 3 and 4 (PWR)	Entire rack 304 SS Free standing rack ASTM-A-240 ASTM-A-276 AWS-E-308-15 AWS-E-308-16	 Sheet, plate Bar Weld wire Weld wire	Demineralized water with 1950 ppm boron as boric acid
VERMONT YANKEE (BWR)	356-T51 ASTM-B-26 Alum. 6061-0 or 5052-H32 Alum. 6061-T651 Alum. 2024-T4 Alum. All aluminum alloys, anodized 304 SS ABS plastic insulators between feet & alum. cans	Grid castings Cans Plates Bolts, Pins Liner, feet	pH 6 - 7.5 (Cu, Ni, Fe, Hg, etc.) < 0.1 ppm 125°F Radionuclide < 10^{-4}
YANKEE ROWE	6061-T6 Alum. Stainless Steel	Rack Liner	130°F, some boron, chlorides < 0.5 ppm
ANION (PWR)	304 SS	Rack	Borated water 105°F

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BNL-NUREG-23021
INFORMAL REPORT

CORROSION OF MATERIALS IN SPENT FUEL STORAGE POOLS

J.R. Weeks

July 1977

Corrosion Group
Department of Applied Science
Brookhaven National Laboratory
Upton, New York 11973

TABLE OF CONTENTS

LIST OF TABLES ii

INTRODUCTION 1

I MATERIALS 2

II WATER CHEMISTRY 3

1. BWR Fuel Pool Chemistry 3

2. PWR Fuel Pool Chemistry 3

3. Biocides 4

III CORROSION OF MATERIALS IN FUEL STORAGE POOLS 5

1. Stainless Steels 5

2. Aluminum Alloys 5

3. Zircaloy Cladding 6

4. Other Materials 6

5. Stress Corrosion 6

6. Galvanic Corrosion 7

IV SURVEILLANCE 9

V SUMMARY AND CONCLUSIONS 10

ACKNOWLEDGEMENTS 11

REFERENCES 12

TABLE 13, 14, 15

LIST OF TABLES

TABLE 1 MATERIALS AND WATER CHEMISTRIES IN LWR FUEL STORAGE POOLS ---------- 13 & 14

INTRODUCTION

The current delays in establishing a national fuel reprocessing center have required many of the LWR licensees to expand their fuel storage capabilities either by modification of existing pools or addition of new fuel storage pools. This report reviews the potential corrosion problems that might develop during the long-term (10 plus years) storage of nuclear fuels in these storage pools. A detailed review of the integrity of the fuel in storage pools is being prepared by Johnson for ERDA,[1] which has served as a basis for much of this report. Zircaloy-clad fuels with burnups up to 33,000 MWd/MTU have been successfully stored in fuel storage pools for periods up to 13 years in U.S. pools and 14 years (at lower burnups) in Canadian pools.

I MATERIALS

Three types of materials are generally in contact with the fuel storage pool water: the pool liner which is commonly stainless steel, the storage racks which are commonly stainless steel or aluminum, and the materials present in the fuel element bundles which commonly include stainless steel, Inconel 718, 17-4 PH, and Zircaloy 2 or Zircaloy 4 cladding. Table 1 lists the materials and water chemistry used in the fuel storage pools at a number of LWR nuclear stations, as available to the writer as of July 15, 1977.

Experience with storing these materials for long periods of time in reactor canals has been reviewed by A.B. Johnson, Jr.[1] Maximum residence in U.S. Pools of spent zircaloy-clad fuel is 13 years. None of these materials should suffer significant corrosion in this environment in periods well in excess of 10 years, as has been borne out by experience.

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In a BWR this means that high purity demineralized water is typically maintained with a filter-demineralizer to a total heavy ion content of < 0.1 ppm, a pH range of 6.0 to 7.5, and a conductivity of < 1 μmho/cm. The water is sampled daily to measure conductivity, and weekly for other impurities, including chlorides. The demineralizers primarily remove silicates from the water, and are typically checked for their capacity to remove this species once weekly. The primary source of the silicates may be dust from the air; the pools are normally uncovered. On the average, fresh resin beds are installed monthly, primarily because of increased pressure drops from silicate absorption.[2] The primary contribution to the conductivity is dissolved CO_2; when the conductivity exceeds 1 μmho/cm the demineralizers are changed.[2] During a visit in June, 1977, the water in the Vermont Yankee fuel pool appeared extremely clear, with a distinct blue tinge to it, apparently as a result of scattering of the longer light waves by the water and the use of mercury vapor lighting.

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In a PWR, the fuel pool frequently contains several thousand ppm boric acid, which is added to other otherwise highly pure water. No neutralization with LiOH is used in the fuel storage pools; a typical pH[3] value is 4.5. A portion of the fuel pool

coolant is continuously passed through a demineralizer resin and impurities, such as halides or sodium ions, maintained below 0.15 ppm. Periodically the demineralizer resins are checked for their ability to remove halides and sodium ions; resins have been developed by Rohm and Haas that are specific for removing halides in the presence of boric acid. The manufacturer's claims in this matter have been confirmed experimentally by one of the reactor vendors.[4]

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Biocides are not commonly used in fuel storage pools at nuclear power plants. Maintaining the water of the high purity needed for safe storage of fuel appears to inhibit biological growth, and the use of stainless steel liners in the storage pool also tends to control biological growth. The radiation levels from the spent fuel stored in the pool also tend to sterilize the water, although radiation resistant bacteria are known. Finally, the continuous demineralization of a portion of the pool water serves to filter out any biological growth. No biological fouling has been observed in 3 1/2 years operation of the Prairie Island spent fuel pool,[3] in 3 1/2 years operation of the Vermont Yankee, > 5 years operation of the Maine Yankee, and > 10 years operation of the Yankee-Rowe fuel storage pools,[2] and no biocides have been added.

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2. Aluminum Alloys

The anticipated corrosion of the aluminum alloys, 1100 or 6061, is negligible in water of this quality at temperatures up to the boiling point of water: at 125°C (257°F) a corrosion rate of 1.5×10^{-4} mils/day[5] has been measured for alloy 6061 aluminum, in water of pH 7, which corresponds to a total corrosion of 1.1 mils in twenty years. Since the oxidation rate will continue to decrease slightly over this period, this estimate should be conservative. At lower temperatures, the rate will be even

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The fuel bundle and storage rack materials may also include type 17-4 PH stainless steel and Inconel 718. Neither of these alloys should undergo measurable general corrosion in fuel storage pool waters.

5. Stress Corrosion

Stress corrosion of stainless steels and zircaloys in fuel storage pools is highly unlikely to occur provided the water

chemistry is maintained within the specified limits. Stress corrosion of sensitized stainless steels that are highly stressed has been observed in oxygenated water acidified to pH 5 nitric acid at temperatures up to 140°F.[9] This is, however, a slow process which took 6 years to develop and occurred only in one highly stressed, highly sensitized area. While it is impossible to rule out completely that stress corrosion of the stainless steel or Inconel components will occur in the fuel storage pool, any such occurrence would be highly localized and rare, and not lead to serious problems with the storage racks or fuel bundle components. No significant difficulties have been observed in fuel bundles examined from a number of reactors. Stress corrosion of 17-4 PH is unlikely to occur if the material has received an 1100°F heat treatment. This heat treatment is commonly specified for this material when it will be exposed to reactor coolants. Components of 17-4 PH given this heat treatment have been in service in the Brookhaven High Flux Beam Reactor (HFBR), which contains high purity D_2O acidified with nitric acid to a pD of 5 and containing greater than 8 parts per million of oxygen, for periods in excess of 12 years without any evidence of stress corrosion or pitting.[10] This water chemistry and temperature (145°F max.) are similar to that prevelant in PWR fuel storage pools.

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Galvanic couples between stainless steels, Inconel and zircaloy do not appear to give rise to any localized corrosion in fuel pool environments, since all of these materials are protected by highly passivating oxide films, and are, therefore, at similar potentials in pure water. Aluminum alloys, which are also protected by passivating films, nevertheless can be pitted in an acid environment such as that present in PWR fuel storage pools, when coupled to stainless steel. The anodization of aluminum fuel storage racks

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At the Oyster Creek Nuclear Power Station, aluminum racks were originally placed directly in contact with the stainless steel pool liner. Some of these racks have been removed and examined after approximately 7 years of service in typical BWR pool water.[11] No observable pitting of the aluminum was found at the point where it contacted the stainless steel.[11] At least one nuclear utility (Vermont Yankee) has also elected to provide additional protection against this potential problem by placing stainless steel feet on the racks, which, in turn, are electrically insulated from the aluminum with ABS plastic inserts. These have been determined to be sufficiently far from the radiation source to prevent their decomposition by high energy gamma flux.[2] These organic inserts are, in my opinion, additional insurance that galvanic corrosion will not occur.

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V SUMMARY

Significant corrosion of nuclear fuel components is highly unlikely to occur during storage in fuel storage pools at the reactor sites in periods of upwards of 20 years, provided that the water quality in the fuel storage pools is maintained within specifications, and that chloride levels in the pool water are kept to minimum levels (< 1 ppm). Stress corrosion of stainless steel components or Zircaloy cladding cannot be entirely ruled out because of the lack of understanding of the stress states and the degree of sensitization of stainless steel. Should such a problem develop on the Zircaloy cladding it would be readily detected by routine monitoring of the fuel pool water for radioactivity. Should it develop on the stainless steel or Inconel components of the fuel bundles, it would be highly localized and unlikely to lead to significant overall deterioration. Periodic surveillance of the materials in storage at a number of nuclear utilities is being planned under the auspices of the U.S. Energy Research and Development Administration.

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DRESDEN 1, 2 and 3 (BWR)	Stainless steel Al-6061-T6 ASTM-B-209	Liner Racks	Demineralized water cuno filters and deep bed demineralizers
FT. CALHOUN	304 SS ASTM-A-276-71 or A-167-74 308 or 308L	Racks Weld	120°F 2000 ppm boron as boric acid
GINNA, R.E. (PWR)	304 SS	Racks	Boric acid
LACROSSE (BWR)	Borated SS and 304 SS	Racks	Demineralized water
MILLSTONE POINT I (BWR)	304 SS	Liner, racks	Demineralized water Filter and demineralizer
MILLSTONE POINT 2 (PWR)	304 SS	Liner, racks	Demineralized water + 2000 ppm boron as boric acid

TABLE I

(continued)

PLANT	MATERIAL	USE	ENVIRONMENT
NINE MILE POINT 1 (BWR)	304 SS	Rack	Demineralized water of BWR primary coolant quality 125°F
OYSTER CREEK (BWR)	Entire rack 304 SS ASTM-A-240 ASTM-A-193 ASTM-A-194 308 SS, ASME SFA 5.9	 Plate, bar sheet Rivets, bolts Nuts Weld material	Demineralized water Undissolved solids < 0.5 ppm
PALISADES (PWR)	304 SS	Racks	122°F - 157°F 2000 ppm boron as boric acid
PILGRIM (BWR)	Same rack design as Vermont Yankee		
POINT BEACH 1 and 2 (PWR)	304 SS	Racks	2000 ppm boron as boric acid 130°F
PRAIRIE ISLAND 1 and 2 (PWR)	304 SS Zircaloy, IN-718	Racks, liner Fuel bundles	Demineralized water (Cl^-, F^- < 0.15 ppm + 2000 ppm boron as boric acid pH 4.5, 120°F
QUAD CITIES 1 and 2 (BWR)	Same rack design as Dresden		
TROJAN (PWR)	304 SS Inconel 17-4 PH - H1100	Racks, liner Grid Mat'l. Bolts and Module threaded feet	2000 ppm boron as boric acid 140°F Cl^-, F^-, 0.15 ppm maximum each

TABLE I

(continued)

PLANT	MATERIAL	USE	ENVIRONMENT
TURKEY POINT 3 and 4 (PWR)	Entire rack 304 SS Free standing rack ASTM-A-240 ASTM-A-276 AWS-E-308-15 AWS-E-308-16	 Sheet, plate Bar Weld wire Weld wire	Demineralized water with 1950 ppm boron as boric acid
VERMONT YANKEE (BWR)	356-T51 ASTM-B-26 Alum. 6061-0 or 5052-H32 Alum. 6061-T651 Alum. 2024-T4 Alum. All aluminum alloys, anodized 304 SS ABS plastic insulators between feet & alum. cans	Grid castings Cans Plates Bolts, Pins Liner, feet	pH 6 - 7.5 (Cu, Ni, Fe, Hg, etc.) < 0.1 ppm 125°F Radionuclide < 10^{-4}
YANKEE ROWE	6061-T6 Alum. Stainless Steel	Rack Liner	130°F, some boron, chlorides < 0.5 ppm
ZION (PWR)	304 SS	Rack	Borated water 105°F

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MR. SMITH: These witnesses are now available for cross-examination.

CHAIRMAN MILHOLLIN: Thank you, Mr. Smith.

Does any party wish to cross-examine these witnesses?

MR. ONSDORFF: Yes, if I may have a second, Mr. Chairman.

MR. WETTERMANN: Is that an indication that the other parties do not plan examination?

MS. MAC ARTHUR: No. We will follow in the same order, I assume.

CHAIRMAN MILHOLLIN: The assumption is we are following the same order.

For planning purposes it might be relevant to inquire how many of the parties can now say whether you might have cross-examination.

MS. MAC ARTHUR: I will have cross-examination.

MR. HLUCHAN: I will have cross-examination.

MR. VALORE: Yes, Mr. Chairman.

Mr. Chairman, can I have some indication as to what time we're going to go to this evening?

CHAIRMAN MILHOLLIN: I suspect we'll break at 5:30. That's a prediction.

You may proceed, Mr. Onsdorff.

MR. ONSDORFF: Thank you, Mr. Chairman.

eb2 CROSS-EXAMINATION

BY MR. ONSDORFF:

Q Mr. Lantz, what work did you do in regard to the criticality calculations done on the Salem project?

A (Witness Lantz) I reviewed the submittal and wrote the SER, the Safety Evaluation.

Q After review of the submittal, to your knowledge did the Nuclear Regulatory Commission do any independent analysis of criticality questions?

MR. SMITH: I object, unless it's related to the contention.

CHAIRMAN MILHOLLIN: What do you mean by independent analysis?

BY MR. ONSDORFF:

Q I believe your direct testimony-- Excuse me.

Your answer to my previous question was after review of the submittal by the Applicant, you drafted the SER.

Was that written material that you did based solely upon your analysis of the submittal, or was there independent work done?

MR. SMITH: Did that answer the Board's question?

CHAIRMAN MILHOLLIN: I'm asking you what you mean by independent work?

MR. ONSDORFF: And I attempted to answer that by indicating that any work beyond reading a submittal that was

eb3 given to him, and upon completing the reading of it he proceeded to draft his portion of the statement.

CHAIRMAN HENDRIE: Very well. You may answer that question.

WITNESS LANTZ: Well, the way we made the approval is on page 2-2 of the SER, the fourth paragraph down. It's the second one from the bottom. It says:

"The above results compare favorably with the results of calculations with other methods for similar fuel pool storage lattices which also assume no irradiated fuel with no burnable poisons or control rods in unborated water."

I have a method for comparing for a given set of circumstances and calculations how well -- how accurate they are.

BY MR. ONSDORFF:

Q Could you be a little more specific about what your comparison factors are to determine that accuracy?

A (Witness Lantz) Yes. In NUREG Document 0448 I have given -- it's spelled out for PWR storage lattices without boron in. My present method is the same as that, where I extended it to the use with boron.

Q Mr. Lantz, are you also familiar with NUREG-0404?

A No, I don't believe so.

MR. SMITH: Will you give the title, please, and show

ab4

it to the panel?

BY MR. ONSDORFF:

Q This was the Generic Environmental Impact Statement on handling storage of spent light water power reactor fuel, March 1978.

A I believe I've seen a draft of it but I haven't seen the final version.

MR. SMITH: Mr. Chairman, I believe you have my copy of that. I wonder if I might have it?

CHAIRMAN MILHOLLIN: Mr. Onsdorff, could you furnish the Board with a copy of the document as to which you wish to cross-examine?

(Document handed to the Board.)

BY MR. ONSDORFF:

Q Mr. Lantz, directing your attention to page 3-8, the first paragraph reproduced on that page, --

MR. WESTERHAM: I'm sorry, I couldn't hear that paragraph number.

BY MR. ONSDORFF:

Q The first paragraph reproduced on page 3-8.

CHAIRMAN MILHOLLIN: This is the paragraph beginning with what sentence?

MR. ONSDORFF: "One of the major considerations in compact storage...."

CHAIRMAN MILHOLLIN: Thank you. That identifies the

eb5 paragraph.

BY MR. ONSDORFF:

Q Mr. Lantz, does the sentence appear there that past design practice used spacers which allowed calculated K effective values of .90 or less?

8.419 MR. SMITH: Object. Relevancy.

CHAIRMAN MEINHOLLIN: Well, we'll permit it, assuming it's going to be connected.

MR. ONSDORFF: I believe it will be.

BY MR. ONSDORFF:

Q Are you familiar with the prior computational techniques which were used in that .90?

A (Witness Lantz) Yes.

Q Now in the Salem project, a K effective value of .95 was utilized; is that correct?

A Yes.

Q Are you familiar with the improvements in computational techniques which allowed the K effective to be changed from .90 to .95?

A This was an evolutionary process over the years. It really started before the expansion of the spent pool fuel, but yes, I am generally familiar.

Q Do you know whether in making that change from the .90 K effective to the .95, the considerations of corrosion and degradation which various plants including Browns Ferry

eb6

and Monticello and Connecticut Yankee -- were those experiences taken into consideration in allowing that increased K effective value? Were they taken into consideration?

A I don't really understand the question. The .95, the K effective of .95 for boron racks is a matter of how much boron is in there, a minimum amount of boron. That's the basis for the .95. And it's not connected with the corrosion aspect. There has to be a minimum amount of boron in those racks to maintain the K effective below .95.

And that's what we tried to insure, that there will be that minimum amount of boron in the racks.

Q What is that minimum amount?

A For Salem?

Q That's correct.

A It's in the SER. It's 2.41 x 10^{21} boron-10 atoms per square centimeter between the fuel assemblies.

Q Can you direct us to where that appears in the document you're referring to?

A Page 2-1.

MR. SMITH: Will you tell him where it's located?

WITNESS LANTZ: It's Section 2.1 on page 2-1.

MR. SMITH: What paragraph?

WITNESS LANTZ: It's the bottom of the-- It's the last sentence in the first paragraph.

BY MR. ONSDORFF:

eb7

Q Do you know how this minimum amount of boron areal density is achieved by the Licensee?

A (Witness Lantz) Yes.

Q How is that done?

A They have a series of tests that they measure in the quality assurance program that they go through to assure that is in there.

Q Are you also familiar with the requirement that the uranium-235 will be limited to a maximum loading of 44.7 grams?

A Yes.

Q Were you responsible for the imposition of that technical specification?

A Yes.

Q What was the reason for that requirement?

MR. SMITH: Objection.

CHAIRMAN MILHOLLIN: This is irrelevant. I sustain the objection.

3d

3B wbl

BY MR. ONSDORFF:

Q Mr. Koch, also directing your attention to NUREG 0404, Volume 1, March, '78, directing your attention to page 3-8, the fourth paragraph from the top of the page, it indicates the major consideration in addition to criticality control. As Project Manager, did you make the -- do the analysis required to consider these other major factors listed in that paragraph?

MR. WETTERHAHN: Objection.

CHAIRMAN MILHOLLIN: Sustained.

MR. ONSDORFF: Could I be heard on that, Mr. Chairman? I feel that these factors in the Generic Environmental IMpact Statement prepared by the Nuclear Regulatory Commission are some of the same concerns which were raised at the time that we filed contentions, and these contentions, dealing with such a seismic concern and basic pool design, were objected to on the basis that they were considered at the initial licensing for the facility operating license. As a result of that, the only thing that the NRC was going to consider was the consequences of a new rack going in the same unchanged building.

I would submit that this statement by the NRC itself certainly tends to contradict that position, that these things were not necessarily -- or required to be considered.

CHAIRMAN MILHOLLIN: The ruling is as stated.

wb2 The question is not relevant to your contention. And the response you just made is not relevant to the ruling on the objection.

MR. ONSDORFF: Well, that is--

CHAIRMAN MILHOLLIN: So you may proceed to ask another question.

MR. ONSDORFF: It may be the case that it's not relevant to our contention because we had contentions to which it would have been relevant.

CHAIRMAN MILHOLLIN: I don't intend to argue about that subject, Mr. Onsdorff.

BY MR. ONSDORFF:

Q Dr. Weeks, directing your attention to your affidavit, Numbered paragraph 6,

"Boral material has been exposed in water for periods up to twenty years without any significant deterioration."

Would you elaborate on where that Boral material has been so exposed?

MR. KORNBLITH: Where is paragraph 6? There is no paragraph 6.

CHAIRMAN MILHOLLIN: Do you mean paragraph D.6., Mr. Onsdorff?

MR. ONSDORFF: D.6., that's correct.

MR. KORNBLITH: There's Contention 6 quoted in

wb3 there. Is that what you're referring to?

MR. ONSDORFF: That's correct. No. 6 below that.

CHAIRMAN MILHOLLIN: So we're talking now about paragraph D, lettered paragraph D?

WITNESS WEEKS: Paragraph D ends before Contention No. 6, sir. This is the response to Contention 6 I believe you're referring to.

BY MR. ONSDORFF:

Q The sentence, "Boral material * * *" which I read. Have you found it?

A (Witness Weeks) Yes, I have found it.

Q Thank you.

And I believe I asked you to elaborate on that 20-year exposure experience.

CHAIRMAN MILHOLLIN: Could you restate the question, please? The Board was not able to find the citation you gave us and listen to the question at the same time. So will you please repeat it for us?

MR. ONSDORFF: Certainly.

BY MR. ONSDORFF:

Q Would you elaborate on that 20-year experience which you discuss in that first sentence of the indicated paragraph?

A (Witness Weeks) Yes. That Boral was used in the-- is still in use in the spent fuel storage area of the

wb4 medical research reactor at Brookhaven Lab. Its edges are unclad, it is exposed to the coolant, and it has been for the entire period of time.

Q And what amount of Boral material is in that pool?

A If I could refer to my Boral report, I have a sketch in it of the approximate dimension of the Boral sheets. If you will look at page 3-11.

MR. SMITH: Would you identify which report?

WITNESS WEEKS: January 1979 report. Corrosion Considerations in the Use of Boral in Spent Fuel Storage Pools. I don't remember the exhibit number; I'm sorry.

MR. SMITH: Exhibit No. 3.

MR. KORNBLITH: What was the figure number again?

WITNESS WEEKS: Figure 3, Page 11. These are the approximate dimensions. They are large sheets, two of them.

BY MR. ONSDORFF:

Q Would you consider this to be a situation comparable to the storage that would be found at Salem-1 project after approval and reracking?

A (Witness Weeks) No.

CHAIRMAN MILHOLLIN: Mr. Weeks, when you say "Boral," do you refer to the same Boral which has been referred to so far in this proceeding?

wb5

WITNESS WEEKS: That's correct. It is a boron-carbide matrix -- a boron-carbide-aluminum matrix clad on both sides with aluminum.

CHAIRMAN KILHOLLIN: Thank you.

BY MR. ONSDORFF:

Q Dr. Weeks, directing your attention again to Exhibit 8, your January '79 report, on page 2--

A (Witness Weeks) Yes.

Q --you indicate, I believe, at the bottom of that page that there's no reason to believe, however, that any of the B_4C will be lost from Boral by corrosion in the spent fuel water; is that correct?

A Yes, that is.

Q What is the basis for that conclusion?

A Boron carbide, B_4C, is an extremely inert material to corrosion by most chemical environments. In fact, one of the standard ways for determining on a wet chemical analysis the amount of boron in a sheet of Boral is to dissolve all the aluminum away in strong acid and the boron carbide is left behind. Then they simply weigh it gravimetrically.

It is inert to just about -- to most of the common acids that are used; certainly much stronger acids than it would ever seen in the fuel pool.

Q Are there additional factors that might exist in a fuel pool in addition to acidic water that could have an

wb6 impact on the Boral?

MR. SMITH: Is the question concluded?

MR. ONSDORFF: Yes.

MR. SMITH: I object. It's vague. What considerations is he talking about?

CHAIRMAN MILHOLLIN: Your question is, Are there additional considerations?

MR. ONSDORFF: I believe that was it.

CHAIRMAN MILHOLLIN: Where? In the fual pool?

MR. ONSDORFF: My question was, Were there additional conditions in the spent fuel pool environment, beyond the acidity, which would impact upon the Boral materials that might have consequences of dislodging the B_4C particles, that you're aware of?

WITNESS WEEKS: There are none that I'm aware of. If I understand the question correctly.

BY MR. ONSDORFF:

Q Directing your attention to page 3 of Exhibit 8, the paragraph entitled "Pitting of aluminum in contact with stainless steel," the first sentence: "When aluminum is in contact with stainless steel in impure water the potential exists for galvanic attack of aluminum at the point of contact."

How do you define "impure water?"

A (Witness Weeks) Water containing any soluble

wb7 ionic species.

Q Have you concluded your answer?

A Yes.

Q Could you be a little more specific, or help out a lay person?

A Well, pure water has a resistivity greater than a million ohms per centimeter. Anything in the water that reduces the electrical resistivity of the water below a million ohms, or below the values for pure water, increases the electrical conductivity of the water and allows corrosion cell currents to be increased, simply because the resistance of the water is decreased.

Q Thankyou.

You indicate that this type of attack is especially likely in a PWR pool containing boric acid at a pH of around 4.5. Do you know the manner in which the pH will be controlled in the Salem spent fuel pool?

A Yes. It is controlled by the hydrolysis of the boric acid that's present in the pool.

Q Which is related to the concentration?

A That's correct.

Q Do you know the conductivity value for the PWR pool containing boric acid at a pH of around 4.5?

A No.

Q Do you know if that would be less than a million

wb8 ohms per centimeter?

MR. SMITH: I object to the question.

CHAIRMAN MILHOLLIN: Sustained.

BY MR. ONSDORFF:

Q You indicate that aluminum voids can appear which would appear as a white fluffy dispersions in the water at a pH greater than 4.5. These are the last two words at the bottom of page 3 and continuing to the first sentence at the top of page 4 of Exhibit 8.

Are these white fluffy dispersions visible to the unaided eye?

A (Witness Weeks) Perhaps I should clarify that sentence a little bit.

This is based on research done by one of the reactor manufacturers. If the pH drops too low, a certain amount of the aluminum oxide or hydroxide on the surface of the material reacts with the boric acid to produce aluminum borate. If the pH is then increased, these soluble aluminum borates precipitate.

What I'm referring to here is that at least laboratory experiments where they can be redissolved by dropping the pH below 4.3.

Q The white fluffy dispersions, would these be the products of corrosion?

A Of a type of corrosion, yes; in that they

wb9

probably would be the reactions of existing corrosion products with the environment to produce the aluminum borate.

Q So the aluminum actually leaves the attachment to the Boral and enters the water itself?

A Under these conditions some of the aluminum oxide in the corrosion film. I would like to clarify that, if I may.

The primary corrosion reaction is the reaction of aluminum with water to produce aluminum oxide or aluminum hydroxide. Some of this oxide already produced is then re-reacted with the boric acid at low pH.

Q Were you present in the hearing room today when Mr. Eckhart testified?

A Yes, I was.

Q Do you recall his testifying that the aluminum corrosion would not result in flaking off of the aluminum material in the corrosion products?

A That's correct.

Q Do you consider this analysis to be consistent with that testimony?

A Yes. But I would like to qualify it; simply because the pH is not that low in the Salem pool.

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CHAIRMAN MILHOLLIN: Mr. Onsdorff, may I ask you a question? Are you planning to tie this possible corrosion activity of the aluminum to the language in your contention which refers to neutron absorption material provided by the Boral plate?

MR. ONSDORFF: I would hope to, Mr. Chairman.

CHAIRMAN MILHOLLIN: Well the Board hopes you will. If you don't, it is not aiding the Board at all in its decision in the case.

MR. ONSDORFF: May I have one second, Mr. Chairman, I'm trying to locate the other report.

(Pause.)

MR. KORNBLITH: Which one is it going to be, so we can find it too?

MR. ONSDORFF: The July '77.

MR. KORNBLITH: Exhibit 7?

MR. ONSDORFF: Yes.

CHAIRMAN MILHOLLIN: Mr. Onsdorff, the Board would ask you to proceed, please.

MR. ONSDORFF: Yes, sir.

BY MR. ONSDORFF:

Q Directing your attention to Page Five of the July '77 study, paragraph number one, stainless steel, that sentence indicates that the stainless steels are doing satisfactory for periods up to 40 years.

agb2

Can you indicate the standard that was used to deem the period to be satisfactory for up to 40 years?

MR. SMITH: I object to that. I don't know where the term "40 years" occurs. Is that Page Five?

MR. ONSDORFF: On Page Five, it's part of a sentence.

MR. SMITH: I have 20 years.

MS. MAC AVOY: I have 20.

CHAIRMAN MILHOLLIN: The Board has 40.

BY MR. ONSDORFF:

Q Well, Dr. Weeks, is it 20 or 40?

A (Witness Weeks) My copy says 40.

MR. SMITH: I'll accept 40.

(Laughter.)

BY MR. ONSDORFF:

Q I understood you wrote it.

A (Witness Weeks) That's right.

Q Does your recollection also say 40?

A Yes, stainless steels are used for primary piping in both BWRs and PWRs and where their design life is 40 years. This has been accepted by the NRC Staff for quite a few years now.

Q In other words, this is an extrapolation as opposed to 40 years of actual operating experience?

A Yes.

MR. KORNBLITH: Could you explain your last answer to

agb3

me? What is the 4 years of operating experience that you're referring to that you're extrapolating?

WITNESS WEEKS: What I was referring to, Mr. Kornblith, was the corrosion rates of stainless steels in both BWR and PWR reactor coolants have been deemed by measurement to be satisfactory to permit the use of these materials in those reactors for their design life, which is 40 years. Obviously, we don't have 40 years experience with any operating nuclear reactor.

MR. KORNBLITH: But we have more than four years.

WITNESS WEEKS: Oh, yes.

MR. KORNBLITH: I thought the question involved an extrapolation from four years.

WITNESS WEEKS: No, I don't think so.

CHAIRMAN MILHOLLIN: Can we have the question read back to make sure you understood the question you're answering?

(Whereupon, the Reporter read from the record, as requested.)

MR. KORNBLITH: I'm sorry, I misunderstood the question.

BY MR. ONSDORFF:

Q Approximately halfway through the paragraph the statement is made:

"The primary difference between the water chemistry in the fuel pools and that in the reactor,

agb4

other than the temperature, is that the pools are exposed to air and presumed to contain dissolved oxygen up to the saturation point."

Do you envision any connection or relation with dissolved oxygen pertaining to the problems of corrosion in the spent fuel pool such as the Salem 1 project?

A (Witness Weeks) Well dissolved oxygen will affect the corrosion, the electrochemical potential of a number of materials, yes.

Q Which is, then, different than the experience with stainless steel in the reactor situation?

A In the boiling water reactor, there is also oxygen present in the primary coolant.

Q Have they had any stress corrosion cracking in such stainless steel fixtures?

A Yes, they have.

Q Do you know what the cause of that cracking was?

MR. SMITH: I object. I don't know what cracking we're talking about. Are you talking about the fuel pool?

CHAIRMAN MILHOLLIN: Does the witness understand the question?

WITNESS WEEKS: Yes, I understand the question.

CHAIRMAN MILHOLLIN: The witness may answer the question.

WITNESS WEEKS: In my professional qualifications, I

agb5

noted that I have been and I am a member of the NRC's pipe crack study group. The current understanding of the cracking in the -- that I think you are referring to is that it is occurring or has occurred in special instances in the heat-affected zones of welds where there is a combination of residual stresses from welding, applied stresses from operating pressures and thermal stresses, and a sensitized material that was sensitized by the heat input from the welding process.

BY MR. ONSDORFF:

Q The stainless steel became sensitized, is that your testimony?

A (Witness Weeks) The stainless steel does tend to become sensitized in a narrow band adjacent to the weld material.

Q And is that phenomenon possible with the rack structures at the Salem 1 project due to the welding that will be done in fabricating those rack structures?

A Yes, it's possible.

Q Is stainless steel in a spent fuel pool environment susceptible to rust?

A No.

Q Could such sensitized steel cracking at the Salem project have an impact on the leak-tightness calculation made with 95 percent confidence level?

MR. SMITH: Does the witness understand the question?

agb6

WITNESS WEEKS: Yes. I would like to ask for some clarification. You're referring to the leak-tightness of the compartments containing the Boral?

BY MR. ONSDORFF:

Q That's correct.

A (Witness Weeks) Yes, it could.

Q Now Dr. Weeks, directing your attention to Page Seven of the July '77 report, the numbered paragraph at the bottom, Galvanic Corrosion, the comment is made:

"Aluminum alloys..." -- this is approximately halfway through the paragraph -- "...which are also protected by passivating films nevertheless can be pitted in an acid environment such as that present in PWR fuel storage pools when coupled to stainless steel."

Is this the type of environment that will be found with the Salem 1 spent fuel pool environment?

A Only if the Boral-containing compartments were flooded, yes.

Q Excuse me, I didn't quite hear your entire answer.

MR. SMITH: Will the Reporter repeat it?

(Whereupon, the Reporter read from the record, as requested.)

BY MR. ONSDORFF:

Q Would that flooding occur as a result of venting?

agb7

A (Witness Weeks) It's my understanding that they would only be vented if they had already flooded by some other mechanism to cause the swelling reaction.

Q Except for the portion which was not flooded as a result of the buildup of hydrogen gas, is that correct?

MR. SMITH: I object. The question is vague.

CHAIRMAN MILHOLLIN: Restate your question more specifically.

BY MR. ONSDORFF:

Q The compartment which was flooded, as you referred to in your previous answer, as the result of a leak would not be entirely flooded as a result of the buildup of hydrogen gas, is that not correct?

A (Witness Weeks) The hydrogen gas would not build up instantly. It might be entirely flooded and then the water displaced by the hydrogen gas produced by the corrosion process.

Q Would it be an advantage to anodize the aluminum surface of the fuel storage racks at the Salem 1 project, in your opinion?

MR. SMITH: I object on the grounds of relevancy.

CHAIRMAN MILHOLLIN: We'll permit the question.

WITNESS WEEKS: You asked if it would be an advantage. I think in one of these reports, and I forget which now, I stated that anodization might prevent the hydrogen formation process. I do not think, however, it would prevent the pitting

agb8

reaction.

So, from the point of view of protecting the neutron poison capability of the Boral, it would have no advantage. From the point of view of minimizing swelling, should water inadvertently get in there, there would be an advantage, but this would have to be weighed by the Licensee against the disadvantage of having to take the things apart to do the anodization.

BY MR. ONSDORFF:

Q You're referring to the racks which have already been fabricated, is that correct?

A (Witness Weeks) Yes.

MR. ONSDORFF: Mr. Chairman, I have a very few questions which might go on for another 10 or 15 minutes.

CHAIRMAN MILHOLLIN: Very well.

MR. ONSDORFF: But since we've reached the hour --

CHAIRMAN MILHOLLIN: No, we haven't reached any hour. The Board intends to go on at least until 6:00 so you may proceed.

MR. ONSDORFF: In that case, then, at this point I would rest. I need rest.

CHAIRMAN MILHOLLIN: Very well.

Mr. Valore, do you have any questions at this time?

MR. VALORE: Do I understand that Mr. Onsdorff has finished his cross-examination?

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CHAIRMAN MILHOLLIN: It's the Board's understanding that he has no further questions on cross-examination, so you may proceed, Mr. Valore.

MR. ONSDORFF: In clarification of the Board's understanding --

CHAIRMAN MILHOLLIN: If you would like to move at some further time to begin our cross-examination again, you may do so.

MR. ONSDORFF: Thank you, sir. It was my physical limitation.

CHAIRMAN MILHOLLIN: You may so move the Board.

MR. ONSDORFF: Thank you.

BY MR. VALORE:

Q The document that Mr. Onsdorff referred to, NUREG 0404 Volume 1, the Draft Generic Environmental Impact Statement, in reviewing that document at Page 3-9, Table 3.4, I noticed that Salem 1 is not --

MR. SMITH: Will you let the witness get that, please?

MR. VALORE: Sure.

BY MR. VALORE:

Q I notice that Salem 1 is not included in the table of proposed increases in reactor storage pool capacity. I also note that the document is dated March '78 and that the Salem application was November 18, 1977.

Now would it be that Salem isn't included because of a

agb10 time lag between the document going to the printer, or was this document still in the hands of the NRC before going to the printer on November 10, 1977?

CHAIRMAN MILHOLLIN: That's irrelevant to the contention and the witness need not answer the question.

MR. VALORE: Your Honor, it's a foundation question based on something that comes up on the next page.

CHAIRMAN MILHOLLIN: Well why don't we go to the next page?

BY MR. VALORE:

Q On the next page of that document, 3-10, summary examples are given of the type of procedures which may be employed, such as adding storage racks, reducing spacing between fuel assemblies and the third summary example on that page indicates employing high neutron absorber materials and reducing spacing between fuel assemblies. And there is cited there the example of the Pilgrim 1 plant which will use a Boral absorbing material.

My question was why the Salem 1 proposal wasn't also included as an example.

MR. SMITH: I object.

CHAIRMAN MILHOLLIN: I fail to see the relevance of whether the Salem plant is included or not with respect to Contention 2, Mr. Valore. What makes a difference whether this report refers to Salem?

agbll

MR. VALORE: Well we've had some previous testimony about the differences between boiling water reactor and pressurized water reactor environments, and the Pilgrim 1 is a boiling water not a pressurized water reactor.

And I'm attempting to explore on cross-examination whether there is some deliberate reason here for not including the Salem 1 proposal in the generic study. We may be dealing with some novel technology here based on the fact that, as I can make the cross-examination out, the rack that is being delivered to Salem 1 apparently, to the best of the witnesses' knowledge, has not been employed at any other nuclear power plant.

Now therefore, if we have a prototype, in effect, a new design prototype that's going to be used in Salem 1, I'd like to explore if possibly it was left out intentionally.

MR. SMITH: Mr. Chairman, the document is the testimony and the exhibits, not the document that Mr. Valore is talking about.

MR. WETTERHAHN: Mr. Chairman, I would join in the objection and note there is no foundation for the question. There is no indication that any of the panel members wrote this document. Just because they read it is no reason to assume that they know why something presumably was left out or put in.

CHAIRMAN MILHOLLIN: Can you tie the possible reason

agb12 for leaving out Salem 1 to the contention, Mr. Valore? I mean, the Board is interested in finding out anything which you can develop which is useful to us. It's just that we're becoming pessimistic in seeing the connection.

MR. VALORE: I am, too, your Honor and you'll appreciate this is not my contention. And my cross-examination, as I indicated before, would only be -- would be limited to only those things that occurred to me as a result of the cross-examination of the other Intervenor.

As he cross-examined, it struck me that Salem 1 wasn't in this document, and I was just trying to explore what I think is relevant, why it isn't. It is a planned increase. The application was filed before the document was printed, although I can appreciate there may be a printing lag problem here.

MR. KORNBLITH: Certainly documents like this don't get written overnight.

MR. VALORE: I appreciate that, but I don't know what your time lag is. My office time lag is about a week on some things.

CHAIRMAN MILLOLLIN: Well why don't you ask the witness a question which gets to the connection which you see between this contention and what you're trying to arrive at here.

MR. SMITH: Mr. Chairman, in the interest of time, if that is the reason for Mr. Valore's question, I believe, my understanding is it was a typographical error that Salem was

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left out.

(Laughter.)

CHAIRMAN MILHOLLIN: Well perhaps the witness should answer that for the record, if he can.

BY MR. VALORE:

Q Is it correct that Salem 1 was left out of the Generic Environmental Impact Statement because of a typographical error?

A (Witness Zack) I don't know.

MR. SMITH: I thought that was my understanding. I can't clear it up

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MR. VALORE: I have no other questions on cross-examination.

CHAIRMAN MILHOLLIN: Very well, Mr. Valore. Thank you.

Does any other party have cross-examination?

MS. MacARTOR: A few questions.

MR. WEITZMANN: After that I would have a few questions.

CHAIRMAN MILHOLLIN: Very well. Proceed.

BY MS. MacARTOR:

Q The safety report of the NRC, I would ask whichever of the witnesses is responsible for the question would please answer, because I'm not sure that I'm certain at this point which one of you gentlemen is the particular one to ask.

Let me find the safety report, if I may.

(Pause)

Page 2-13, the welds. Have you been here during this hearing, all three of you?

A (Witness Weeks) I have.

A (Witness Bech) I'll address that, if I may. Mr. Lantz arrived this morning around noon. Mr. Weeks and myself have been here.

Q I see.

Well, the welds for leak-tightness have been

wb2 discussed. They're addressed on page 2-13. And I would like your assessment of the statement that the welds for leak-tightness are to be tests.

A (Witness Weeks) Can you tell me where that statement is made, please?

Q Down at the bottom, the last sentence,

"Leak-tightness tests will be conducted."

Have those tests not yet been conducted?

A To the best of my knowledge they have.

Q And what are the results?

A They were-- I really don't know the detailed results. I hesitate to answer the question.

Q On page 2-14, at the very bottom of the section, just above the middle of the page, it speaks of the possibility of long term storage, and says that the effects of pool environment on the racks, fuel cladding and pool liner are under continued investigation.

How will this continued investigation be conducted?

And the second part of the question is, How will the results be applied to Salem-1 as they become available?

A I think the most significant continued investigation with respect to Salem-1 will come from the results of the materials monitoring program that they licensee has committed itself to perform. There are similar programs at a number of other reactor sites, both PWR and BWR, around the

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country. All of this information will be coming in.

My group at Brookhave has, within the scope of its contract with NRC, to make it our business to keep abreast of developments that are going on in this area.

Q Earlier we were talking about the same sort of question, as to just how the results of the continued surveillance program are triggered by either the licensee or the NRC. Are you the person to ask? They referred me to NRC staff on that question.

A I'm not sure I fully understand your question.

Q Well, let's take an example.

Suppose the sample coupons that are being tested in the pool show a change in condition; which, at the present time, we don't anticipate. But the testimony was this afternoon that unexpected things do happen.

A That's right.

Q What's the procedure for this to be called to the attention of NRC to ensure that any proper changes are made as a result of seeing some change in the sample?

A (Witness Zech) I believe I can answer that.

The licensee, of course, has the responsibility for the integrity of the racks. We've done an evaluation as they have, which came to certain conclusions. The conclusions as indicated in that paragraph are that we don't expect any -- maybe just to paraphrase: we don't expect any adverse

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degradation or any results other than what are anticipated.

Now if the licensee finds in their surveillance program that something is occurring that is not expected, it is definitely their responsibility to investigate it further, to advise us of it. This is part of their responsibility in their license to do so. And we also have a resident inspector from our Office of Inspection and Enforcement at the site.

So there are various vehicles which are in place for both them to pursue it further and to also advise us.

Q Now these plants that we were speaking of earlier with the licensees that have given reports back that the racks performed as expected, have they given any reports of surveillance to the NRC?

A I'm not aware of any.

Q Would you be aware of any? Or would that be someone else in NRC?

A It wouldn't have come in directly to me, no.

A (Witness Weeks) If there were a corrosion problem I think it would be referred to our group at Brookhaven.

Q How about any other deterioration other than corrosion?

MR. SMITH: I object, unless the question can be made more specific.

MS. MacARTOR: Well I can't be unless I have some

Wb5 further information.

WITNESS WEEKS: It would depend on what the problem would be. Brookhaven works in certain areas. It's possible that they would be asked to evaluate certain things that are occurring. And we also, of course, have personnel on our staff capable of pursuing the investigation of certain problems.

BY MS. MacARTOR:

Q On page 2-15, at the beginning of the second paragraph, it says,

"There's no evidence at this time to indicate corrosion will occur."

Is there any significance to the phrase "at this time?" Do you anticipate finding any?

A (Witness Weeks) No, I don't anticipate finding any.

Q So that this phrase is a scientist's caution?

A Yes.

Q Do you have any other experience at similar facilities other than these specific plants that you were talking about a minute ago that would relate to the deterioration of the Boral or the rack structure?

A Not that haven't been covered either in earlier testimony at this hearing or in the several exhibits, including the two that I wrote.

Q I'm not sure whether we had the question answered

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as to what the extrapolation was from, when you spoke of the forty years' experience and we got into a discussion of what it was from. But how many years of experience was that extrapolation made from?

A I really can't say. Stainless steels have been used in the chemical industry and in the nuclear reactor industry from essentially from the time of their invention in the 1930's. But under the specific conditions that would obtain in a nuclear reactor, I cannot say precisely.

Q So when you wrote that section you were not using specific data?

A The applicants for licenses commonly quote some data obtained by the various steel producer and nickel company research company laboratories that have long term data. But I just don't know precisely for how long this data exists. Certainly in nuclear reactors at this time we have over twenty years' experience.

Q But have you yourself checked those data?

A I've looked up the references cited in some specific instances, yes.

Q Now we had testimony from the licensee as to the effect of gamma rays on Boral. What is your experience? Is there an effect on Boral of gamma rays?

A I don't know of any effect of gamma rays on metals or metal carbides. In this Boral that is discussed at some

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length in my report, Exhibit 3 I think it was, that was in our own reactor, that is immediately adjacent to where our spent fuel is stored. So it has been extensive radiation at one time or another, gamma radiation. And there is just no visible deterioration.

Q Is this a phenomenon of being an inorganic material?

A Yes.

Q And the polymer, which did have an effect from radiation in one situation, is an organic material?

A That's true. And organic materials are known to be much more sensitive to gamma radiation than inorganic.

MS. MacARTOR: Could I have one minute, please?

(Pause)

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MS. MAC ARTOR: One more question, Mr. Chairman, or one more line. I think it is one question.

BY MS. MAC ARTOR:

Q Is there a backup system for the cooling if there should be a failure in the cooling water?

MR. SMITH: Object.

CHAIRMAN MILHOLLIN: Sustained.

MS. MAC ARTOR: That's all the questions, Mr. Chairman.

CHAIRMAN MILHOLLIN: Very well.

Is there any cross-examination from the Licensee?

MR. WETTERHAHN: Just one or two.

BY MR. WETTERHAHN:

Q You answered a question from Mr. Onsdorff to the effect that it is possible that you could get stress corrosion cracking in the spent fuel pool. Your answer was Yes?

A (Witness Weeks) That was my answer.

Q Did you use "possible" in the sense that you couldn't entirely absolutely rule it out?

A Yes, I did.

MR. SMITH: Objection. Leading the witness.

MR. ONSDORFF: That's overbearing I believe. It is not within the bounds of good cross-examination.

CHAIRMAN MILHOLLIN: Overruled.

WITNESS WEEKS: Yes, I did. My affidavits I believe

eb2 state that I think such instances would be isolated and rare.

MR. METTENHAM: Thank you very much.

Is there redirect at this time?

MR. SMITH: There's one question on redirect.

REDIRECT EXAMINATION

BY MR. SMITH:

Q Dr. Weeks, on page 3 of your affidavit, the paragraph that follows numbered paragraph 6, there's the sentence that the Boral material is exposed up to 20 years. And Mr. Onsdorff asked you a question relating to whether or not this was a similar environment. And I believe your answer was No.

Could you tell us what type of environment this was in, and how it compares to the environment that Salem would see?

A (Witness Weeks) Yes, I could.

The environment that I'm referring to here for the 20 year use was in essentially high purity water, no boric acid present, nor was it coupled to or encapsulated in stainless steel, both of which would obtain in the Salem fuel pool

Q I see.

MR. SMITH: No further redirect.

CHAIRMAN MILHOLLIN: Is there recross?

(No response.)

Are there board questions?

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EXAMINATION BY THE BOARD

BY DR. LAMB:

Q Dr. Weeks, did you hear the discussion earlier today concerning venting and the amount of hydrogen which could be produced?

A (Witness Weeks) Yes, I did.

Q The reason for pursuing that question was to determine whether the Exxon people or you can envision any risk from the point of view of flammability or explosion arising as a result of hydrogen released.

Do you anticipate that this could happen?

A No, I don't,sir. Because the hydrogen released would be of the order of-- I believe Mr. Eckhart gave a number, a certain number of cubic feet per cell; that's all four sides of a cell.

In the first place, this would only happen on one side of a cell at a time. And the volume ofthe room in which this fuel pool sits is very large. It's a high-ceilinged, L-shaped room, so that the chance of reaching a flammable or explosive limit of a few cubic feet in a room that probably is hundreds of thousands of cubic feet of air is remote.

Q So as one who is knowledgeable about the mechanism of production of this hydrogen, that does not -- that would not concern you?

A Well, the hydrogen would be produced probably over

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a period of a week or so after the water enteres. However, a fair portion of it might be released over a brief period of time following the drilling to do the venting. So that that might all come out in, say, five or ten minutes or so, depending on the size of the hole.

But the quantity is just so small.

Q So that you do not anticipate any hazard from that?

A No, I do not.

Q Now you also heard, I imagine, the questions I raised with respect to other possibilities for swelling or jamming of fuel in the cell, --

A Yes.

Q -- because of either growth of corrosion products or bulging, or both.

And I wanted to ask you to address yourself to that problem and whether you visualize that there will be a problem at all, or could be.

A By "bulging" I interpret you to mean the small bulges introduced by internal corrosion that Mr. Eckhart was talking about, or a large swelling due to hydrogen production.

Q No, I was talking not about the hydrogen production but about the small bulges in the formation of corrosion products which mechanically might cause swelling.

A Starting with the formation of the corrosion products, I believe the aluminum corrosion products typically

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occupy about two to two and a half times the volume of the aluminum that was corroded. That, depending upon the amount of water molecules and aluminum oxide, this would be a maximum of-- I think he said the total Boral thickness if 91 mills, so that would be a maximum increase of 200 mills, and there's over half an inch clearance, so I don't see how that mechanism could block motion of the fuel.

As far as the small bulges are concerned, those that have been observed -- and I'm not sure I fully understand the mechanism by which they were formed in Mr. Eckhart's tests -- are very small, a matter of a few mills. I do not anticipate major swelling of the order of a quarter to half an inch from this kind of mechanism, which is what one would need -- not what one would need, but what it would take to block motion of the fuel.

Hopefully the coupon monitoring program will give us this information, will warn us that something like that is about to happen.

Q Right.

With respect to the corrosion tests which were conducted by Exxon and which have been reported and which involve the extrapolation from one year to 40 years, are you in agreement with the manner in which those extrapolations were done?

A Traditionally, corrosion rates follow a straight line plot on a semi-logarithmic scale. I know there have been

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corrosion rate measurements on aluminum, and that is what is corroding here, for a period of three to five years or longer that show the -- and about 100 degrees Centigrade -- that show the corrosion rate is continuing to decrease over that entire period of time.

We have aluminum reactor vessels on both of our reactors at Brookhaven, and aluminum clad fuel elements. We have seen no evidence of acceleration of corrosion after periods of -- well, up to 20 years. The surfaces, the aluminum surfaces on the Boral punchings that were removed and described in my report have negligible oxide on the surface.

Q So you feel that the semi-logarithmic extrapolation such as they did is not an unreasonable approach?

A I feel it is not unreasonable, and if anything, I feel it may be overconservative. The amounts may be substantially less even than that.

Q You mentioned the corrosion testing program a few minutes ago, and so that leads to another question which I had.

Are you familiar with or knowledgeable about the monitoring program which will be conducted at Salem 1?

A Yes.

Q Did you help design that program?

A No, I did not.

Q With respect to the number of samples and the length of the program, the duration of it and the methods, are you

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in agreement with all of these?

A I'm reasonably in agreement-- Yes, I'm in agreement that the frequency of examining specimens is quite adequate. It is not far different from what I recommended in a memo that I wrote to NRC on nother unit.

Q So you feel that this is a viable program for keeping track of what will be happening from the corrosion point of view?

A I think so, yes, sir.

Q Thank you very much.

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BY CHAIRMAN HIGGINS:

Q I have only one question for Dr. Weeks. I take it you were here during the questions I asked concerning what I thought was, well, a confusing portion of the licensee's testimony which had to do with the question of corrosion on the one hand and swelling on the other, and the apparent decision to accept the possibility of swelling in return for the likelihood that corrosion would be reduced. I would like to ask you for your opinion on that subject, more specifically with reference to how you view the licensee's decision.

A (Witness Weeks) I addressed this in Exhibit 3 on the top of page 5, not necessarily specifically on this unit but in a generic way.

Q Just a second, sir. We'll have to find that.

(Pause)

A It's the '73 report, page 5, the middle of the top paragraph, beginning with the words "However, should the leak develop in one of the seal welds at some future date after the racks are installed the swelling could occur at that time. For this reason venting or the capability for future venting is probably desirable. In general I think the localized pitting corrosion that might result from venting the Boral cavities in spent fuel pool racks would be less of a safety concern than the swelling that might occur should they not be vented."

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Now the licensee and the Exxon people have testified that venting is possible, and that should swelling occur with a fuel element in place sufficient pressure can be relieved by venting so the fuel element can be removed. And should it occur when the fuel element is not in place they will simply not use that location in the rack.

So I see no reason why that is not accepted as far as the NRC. And I would so recommend to the NRC.

I'm not sure that correctly answers your question.

Q Well I might ask you whether if you were in the position of the licensee you would have chosen the alternative that the licensee has chosen?

A Not being in that position, sir, I hesitate to so state.

(Laughter)

Q YOu would not care to speculate on what you might have done had you been in the licensee's position? Is that your answer?

A I think I should not speculate under oath, sir.

Q Very well. Thank you.

MR. SMITH: If there is no further questioning, I would like to have the panel excused.

CHAIRMAN MILHOLLIN: With thanks from the Board the panel may be excused.

MR. SMITH: They will not be returning?

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MR. ONSDORFF: Mr. Hluchan is absent, but he indicated to me that he had to be away for another legal commitment; not for lack of interest. He wanted to reserve all his rights. I don't know whether he has but he may have cross-examination.

MS. MacRAE: He had indicated earlier that he had cross-examination, and I don't know what it consisted of.

MR. SMITH: Mr. Chairman, I didn't talk to Mr. Hluchan, but-- Dr. Weeks and Mr. Beck can be here in the morning, but I know that Mr. Lantz does have a personal appointment, and I would appreciate it if he could be excused.

CHAIRMAN MILHOLLIN: Does anyone know whether cross-examination might require an answer from Mr. Lantz?

MR. ONSDORFF: Just from my discussion with Mr. Hluchan I don't believe Mr. Lantz was his prime-- I don't believe he was going to delve into Mr. Lantz's area of concern. I can't represent that with a 95 or 100 percent confidence factor. But our discussions led me to believe that.

CHAIRMAN MILHOLLIN: The Board will excuse Mr. Lantz and ask Mr. Smith to make his witnesses available tomorrow morning for any cross-examination which Mr. Hluchan may have.

MR. ONSDORFF: And I envision completing my rest

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and making my motion tomorrow morning.

CHAIRMAN MILHOLLIN: If you make a motion we'll rule on it tomorrow.

MR. ONSDORFF: Thank you.

Are these same witnesses planning to testify with respect to Contention No. 1?

MR. SMITH: Mr. Zech is.

CHAIRMAN MILHOLLIN: Very well.

(Witness Lantz excused)

CHAIRMAN MILHOLLIN: At this time the hearing is adjourned until tomorrow morning at--

MR. WETTERHAHN: Perhaps we could start, instead of at nine, at eight-thirty, and there's a good possibility that we may be able to finish this entire, or at least all the contentions and cross-examination.

MR. VALORE: Mr. Chairman, that's a bit of a hardship on me, although if I'm the only one it's a hardship on I'll be here at eight-thirty, because I have no desire to delay the proceeding. But I do have legal appointments this evening, and-- Well, I've said my piece.

MS. MacARTOR: I would be something of a hardship on me. I try to do a half hour of all my other cases before I set out for here.

CHAIRMAN MILHOLLIN: Well, would nine o'clock be a reasonable time?

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MR. VALORE: That would be much better.

MR. ONSDORFF: I would appreciate it.

CHAIRMAN MILLICHAP: Very well, we'll meet again at nine o'clock in the morning.

MR. VALORE: Might I ask, Mr. Chairman, if at this time, based on any travel plans any of the Board members have, we could have any idea of what time we would quit tomorrow evening? If it's impossible to give me a time I will understand.

CHAIRMAN MILLICHAP: I can't give you a time right now.

The hearing is hereby adjourned until nine o'clock tomorrow morning.

(Whereupon, at 6:15 p.m., the hearing in the above-entitled matter was recessed, to reconvene at 9:00 a.m., the following day.)