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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the matter of:

METROPOLITAN EDISON COMPANY, et al

Docket No. 50-289 OLA

(Three Mile Island Nuclear Station,
Unit No. 1)

Location: Middletown, PA Pages: 522 - 687

Date: Wednesday, July 18, 1984

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Atomic Safety and Licensing Board Panel

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Metropolitan Edison Company, et al. :
(Three Mile Island Nuclear Station, Unit No. 1) : Docket No. 50-289 OLA
Evidentiary Hearing :

- -x

Auditorium, Olmstead Building
Penn State/ Capitol Campus
Middletown, Pennsylvania

Wednesday, July 18, 1984

The above-entitled hearing commenced at 9:07 a.m. pursuant to adjournment.

BEFORE:

SHELDON J. WOLFE, Administrative Judge, Chairman
DAVID L. HETRICK, Administrative Judge, Member
JAMES C. LAMB, III, Administrative Judge, Member

APPEARANCES:

BRUCE CHURCHILL, Esquire
WILBERT WASHINGTON, Esquire
DIANE BURKLEY, Esquire
(For the Licensee)

LOUISE BRADFORD
(For Three Mile Island Alert)

MARY E. WAGNER, Esquire
(For Nuclear Regulatory Commission Staff)

THOMAS Y. AU, Esquire
(For Commonwealth of Pennsylvania)

C O N T E N T S

WITNESSES: David G. Slear; F. Scott Giacobbe

WITNESSES: Conrad E. McCracken; Paul C. Wu

E X H I B I T S

NUMBER	FOR IDENTIFICATION	IN EVIDENCE
NRC Staff		
1	576	583
2	577	584

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P R O C E E D I N G S

JUDGE WOLFE: All right; the Board has been conferring and determined that we have, Mr. Churchill, supplemental questions of your panel regarding the question how Licensee established the similarity between the archival test samples or tube samples and the tubes taken from the steam generators.

Now, it's up to you whom you wish to recall or have take the witness stand. I would think that it's Messrs. Slear, Giacobbe, Wilson and Mr. Lee, if he is available, or whomever you wish to call or recall for the purpose of additional questions by the Board.

MR. CHURCHILL: Would you like me to make a presentation, or would you just like to have them take the stand for more questions from the Board?

JUDGE WOLFE: What do you mean by presentation?

MR. CHURCHILL: You posed a question. Would you like us to prepare an answer to that, or would you just like the witnesses to come up and answer questions from the Board?

JUDGE WOLFE: We've already posed certain questions to Licensee's panel. I think this is merely -- rather than not knowing what the specifics are of the thrust of additional Board questions, it would perhaps be better for you to just have them take the stand. We can do that now, or to give your witnesses a bit more time to mull over the general area we're concerned about, we can proceed with the taking of Staff's

direct testimony.

MR. CHURCHILL: Could we just have a moment, Your Honor?

JUDGE WOLFE: Certainly.

(Pause.)

MR. CHURCHILL: Your Honor, we can recall Mr. Giacobbe and Mr. Slear right now. I think those are the two that are probably best suited for the questions you have.

JUDGE WOLFE: I don't like to interrupt Staff's presentation. Maybe at the conclusion of Staff's testimony, we can ask you to have your witnesses take the stand. Why don't we try to get some timing here.

MR. CHURCHILL: Your Honor, may I interject at this point?

JUDGE WOLFE: Yes.

MR. CHURCHILL: Mr. Giacobbe and Mr. Slear are, I believe, the best ones for these questions and they do happen to be the ones that are here. The others have gone home. They are no longer in town. Mr. Slear will not be here past the end of the day today. He has another commitment tomorrow.

Would it be possible to take them today?

JUDGE WOLFE: All right. We will proceed right off with recalling Messrs. Slear and Giacobbe. The Board has not completed conferring on all the issues we wanted to get into supplementalwise, so we will take a short recess. We will

recess until 9:45, and then we will begin with a recall of your witnesses.

(Recess.)

JUDGE WOLFE: On the record.

Mr. Churchill, do you have all of your witnesses?

MR. CHURCHILL: Yes. I would like to call Mr. Giacobbe and Mr. Slear.

(Pause.)

MR. CHURCHILL: I understand Mr Slear is on the phone and will be right here, Your Honor.

JUDGE WOLFE: We will have a short recess.

(Recess.)

JUDGE WOLFE: All right, gentlemen. Messrs. Slear and Giacobbe, you remain under oath.

Whereupon,

DAVID G. SLEAR
and
F. SCOTT GIACOBBE

were called for examination and, having been previously duly sworn, were examined and testified further as follows:

JUDGE WOLFE: We have supplemental Board questions to ask of you.

JUDGE HETRICK: Mr. Giacobbe, yesterday in response to a question by Judge Lamb regarding, I believe, expansion of archival tubing followed by subsequent determinations of hardness, Judge Lamb asked you if those samples were, as far

as you could tell in testing, identical with the tubing samples removed from the steam generator; and you said: "that's correct".

I'm looking at transcript page 465 of yesterday's proceeding. What did you mean by saying "that is correct" in response to the use of the word "identical"?

WITNESS GIACOBBE: When you look at the properties that were important for the qualification program, you look at the elongation and the yield strength of the material. What we had done was, we had surveyed the entire mechanical property range for the tubes used in our steam generator. We actually had the test reports. We had the heat numbers. We reviewed all of those documents and checked what the range of properties were for the tubing that was in our steam generator.

We then also on some of the samples we removed from the steam generator, we again tested that tubing, did the exact same tests as they were given originally, the mechanical test where you actually pull a tube in a tensile machine and measure its elongation, yield strength and ultimate tensile strength. We compared that data to the data that was written down on the original test reports.

In all cases of the tests that we did, the tubing met the original properties as listed on the test reports.

What we then did was selected archive material that had the yield strength comparable to the tubing in the steam generator, such that when you did the expansion process, which

yield strength is a parameter of concern because it affects the strength of the joint, we had material in the qual program that was within the range of yield strengths for the tubing that was in our steam generator. That's what I meant by identical.

JUDGE HETRICK: Later in the day, transcript page 515, I asked you about the sample size in this test, and your response what that you thought that it was 27 tubes from the steam generator; is that correct?

WITNESS GIACOBBE: The number of tubes we removed from the steam generator -- and I have not confirmed that number; I still believe it is approximately 27 tubes -- we did not mechanically test all 27 tubes.

JUDGE HETRICK: At the time I asked the question about how large the sample was, you interpreted my question as the number of tubes, and that's what I meant. But was it entire tubes, small sections? What mechanical shapes and sizes did you have available?

WITNESS GIACOBBE: There were a variety of sizes of tube samples removed from the steam generators. There were tube samples that were approximately 12 inches long removed from the upper tubesheet region of the steam generator, and there were also samples removed down to -- we removed lengths of tubes that were taken all the way down to the tenth tube suppport plate, which is --

(Inaudible discussion between the witnesses.)

JUDGE WOLFE: Mr. Slear, would you just add what your statement is. Go ahead.

WITNESS SLEAR: The length of the tube sample down to the tenth tube support plate would be approximately 16 feet long.

JUDGE HETRICK: But did all of these samples include the upper ends of these tubes?

WITNESS GIACOBBE: When you say upper ends --

JUDGE HETRICK: Then end that was actually in the upper tubesheet.

WITNESS GIACOBBE: Oh, yes. All samples included material from the upper tubesheet region. Each and every one of the 27 tubes did encompass material from the upper tubesheet.

JUDGE HETRICK: Is there any effect on the tube properties from the operation of removing them from the tubesheet?

WITNESS GIACOBBE: No, there is not. I could describe the process if that would help you.

WITNESS SLEAR: I am somewhat familiar with the removal. You basically drill out the first quarter inch of the tube because you have to get down below the seal welded area, and then you slit axially along the old rolled area and basically relieve any load in that section.

From then on, some of these tubes are actually pulled out by hand. There is a mechanical cut done at the length. However long you want to take a sample, you do down

to that distance in the steam generator and make a 360 degree mechanical cut. Then you loosen it from the upper part of the tubesheet. Then you relax the roll by the axial slit that I described.

In some cases the tubes are grabbed down below that area and basically pulled up as far as you can and then you have them cut off, and then you pull it up another distance, and then you cut it off.

Many of these tubes were just pulled up by hand and required very little force, because, as you are aware, before kinetic expansion there is a gap in the tubesheet. The distance between the tube and the tubesheet is open somewhat except for the rolled area. There is not a great deal of corrosion products in there, and they came out fairly easily. So there were not a lot of loads and prying of tubes to get them out. I can't imagine that we affected their properties at all.

JUDGE HETRICK: Except for the small section that was removed because of the weld --

WITNESS SLEAR: That's essentially lost because we drill it out. Although, that's the top, perhaps, one-eighth to one-quarter of an inch of the tube and, in fact, is above any section of interest in terms of mechanical properties.

When you think of the six-inch qualification length or that location in the tube, that is many, many inches

below that area.

JUDGE HETRICK: These tubes were typical of those that experienced corrosion cracking; is that correct?

WITNESS GIACOBBE: Yes, definitely.

WITNESS SLEAR: They were identical. Clearly, some of the tube samples had corrosion cracks and that's why they were chosen. We also chose tube samples without corrosion cracks by eddy current indication in order to ensure that we were not making an error and, in fact, that there was damage in tubes that eddy current wasn't seeing.

So we had tubes with eddy current indications of defects and we had tube samples without eddy current indications of defects. So we had, essentially, a fairly broad cross-section of samples of tubing. Some was affected and some wasn't affected by the damage mechanism.

JUDGE HETRICK: So am I correct in assuming that when you use the word "identical" in this context, you mean representative?

WITNESS SLEAR: I think representative is -- any mechanical property has a range of values even for the same tube. You can test the same tube three or four different specimens, and at a nominal 45,000 psi yield stress, you could get values, I presume, down to 44 or 43, and there may be some values up to 46 depending on exactly where in that tube you test. So it is a nominal type measurement that we're making,

whether it's hardness or yield strength or ductility.

JUDGE WOLFE: What standard or sampling guide compelled you to believe that the number "27" was a sufficient and adequate sample? Why not 30; why not 25; why 27?

WITNESS SLEAR: There was no specific sampling guide that led us to the number "27". The tube samples were taken, I believe, in three different batches. Is that correct, Scott?

WITNESS GIACOBBE: That's correct, three separate segments.

WITNESS SLEAR: Basically, as we would evaluate the first round of tube samples and identify additional information that we wanted, we would go in after additional tube samples. In the end, we ended up pulling out 27 tubes. There was no statistical guide used to conclude that that was sufficient. But certainly from an industry standard point of view, you usually pull out one or two tubes and evaluate the information and make your judgments based on that.

We felt we had gone quite further than the majority of people who have steam generator damage when we had taken out 27 tubes. And in addition, it's not just 27 tubes; it's many, many feet of tubing. I think it's about 100 feet of tubing.

WITNESS GIACOBBE: I think it's also important to realize that we very definitely had a plan for the number

of tubes we took out. We first needed to confirm our eddy current examination, so we pulled tubes that had a number of eddy current defects so we could get a correlation.

We also needed to look at tubes in various regions to see whether or not the damage was different from region to region. We also needed to pull samples from inside the free span region. So consequently we pulled those long lengths of tubes which are more difficult to pull. So what we did was done with a purpose.

The overall number wasn't the criteria. It was getting the information we needed to do a valid failure analysis and eddy current confirmation.

JUDGE HETRICK: Are these tubes that would otherwise have been taken out of service?

WITNESS SLEAR: Some would have been taken out of service and some would not. Some of these tubes did not have detectable eddy current indications, and we never found a defect in some of these tubes that were taken out.

JUDGE HETRICK: There were tubes taken from both steam generators?

WITNESS GIACOBBE: That is correct.

JUDGE HETRICK: Is there any reason to think that the physical operation of removing these tubes in any way altered their properties to make them appear either better or worse than the representative properties of the tubes that remained

and which were expanded in the steam generator?

WITNESS SLEAR: I can't think of any conceivable means where we would have changed the properties we've been discussing in terms of the mechancial properties of the tube.

WITNESS GIACOBBE: I will go on and say one thing further. Before we did mechanical testing on an individual tube, the region we selected was examined. We checked the dimensions to make sure that there wasn't any deformation of that tube in that region. So we do have that additional confirmation that the tube still has the same wall thickness and the same diameter as that which we believed was in there.

So if one had done something during the removal operation to change the mechanical properties, I would expect it to show up as a change in the dimension of that tube.

JUDGE HETRICK: So you feel safe in concluding that this set of tubes that you removed from the generator retained properties truly representative of the tubes that remained?

WITNESS GIACOBBE: That is correct.

JUDGE HETRICK: Now, as I understand it, some of these tubes were used in conjunction with the tubesheet mockup and underwent the kinetic expansion process; is that correct?

WITNESS GIACOBBE: That is correct.

JUDGE HETRICK: Were all of those expanded tubes set up in the same way in the sense that it was the portion of the tubes that had undergone corrosion cracking and that those

regions were placed in the mockup tubesheets in a way representative of actual kinetic expansions in the generator?

WITNESS GIACOBBE: Yes. We did a number of things with actual TMI tubes. There are actual expanded TMI tubes in the corrosion test program. In addition, we actually expanded a tube with a known defect and then sectioned that tube, examined that defect to look for any evidence of any extension of that crack. We did find there was no extension of any cracks. There was no change in the dimension of the crack.

JUDGE HETRICK: Now, as I understand it, in the actual repair process there were occasional tubes which did not meet your qualifications and were subsequently removed from service; is that right?

WITNESS SLEAR: I think you need to clarify the statement: "did not meet our qualification". What did you refer to?

JDUGE HETRICK: Let me try to rephrase it. Were there some tubes in the actual repair process which were expanded, inspected, and subsequently removed from service?

WITNESS SLEAR: To my knowledge, the only two tubes that had been removed from service -- associated with the kinetic expansion repair process -- were removed from service because of a slight leakage past the joint that we have just identified several weeks ago.

I know we took additional tubes out of service after the kinetic expansion process and repaired a bunch of plugs after the plugging process due to the leak tests we were doing. But I don't recall an instance where that was done because of a leakage past the joint. It was done for other reasons not associated with load-carrying and leak tightness of the joint itself.

JUDGE HETRICK: Let's go back to the tubes that were removed and subjected to tests. Is there one or more of them that might be characterized as having worst-case type of conditions?

WITNESS GIACOBBE: From a corrosion standpoint, worst-case, we pulled some tubes that had a worst-case condition from the number of eddy current signals that we observed during the testing of that tube and consequently pulled that tube out and made a correlation between the eddy current signal and what actually existed there.

So we pulled some tubes with a fair amount of damage on them, yes. The number of cracks varied from tube to tube, and we pulled some tubes with near the maximum number of cracks we found in any particular tube.

JUDGE HETRICK: All right; this set of tubes that were removed, as we established, at least some were subjected to kinetic expansion with a mockup tubesheet. Other kinetic expansion tests you made made use of archival tubing. Both

sets of tubes underwent sets of tests.

But as I understand from yesterday's testimony, only certain of those tests were used on the actual tubes that had been removed. As I recall, done of those were subjected to pull-out tests; is that right?

WITNESS SLEAR: Yes. To my knowledge, we did not subject an actual TMI tube to a pull-out test in the context of kinetically expand it in a tubesheet and then pull it out of the tubesheet.

JUDGE HETRICK: What other tests were performed on archival tubes that were expanded but were not performed with actual tubes that had been expanded in these mockup tests?

WITNESS SLEAR: The testing associated with the mockup tests that were done with archival tubing and was not done with TMI tubing were the pull-out and leak tests that we did with the 10 tube mockups. We also, early in the qualification program -- sort of like a pre-qualification program -- were doing hardness tests on archival tubing, and I don't believe -- well, we may have hardness readings from the expanded -- we apparently did not do hardness tests on actual TMI-1 tubing throughout the qualification program.

So I think the answer to your question is: hardness tests, pull-out tests and leak tightness tests.

JUDGE HETRICK: Would you describe for me briefly the leak tightness test that you just mentioned?

WITNESS SLEAR: The leak tightness tests had to do with placing 10 tubes in a mock tubesheet and subjecting that tubesheet to thermal cycles representative of up to 15 years of service, which at 38 cycles a year there is about -- 15 times 38 -- 600 cycles.

The tubes were then pressurized on the primary side, and leakage through to the secondary side of this little mockup was measured in a very controlled and carefully monitored method. It was even sensitive to temperature changes in the room. So we had to keep track of temperature changes as to what changed the volume.

So we basically installed the tubes in a mockup, thermally cycled the mockup, and then subjected the mockup to a number of days with hydrostatic pressure where we monitored leakage and then calculated the leakage on a per tube basis at the very low levels that you've probably seen in our qualification program.

JUDGE HETRICK: Would it have been feasible to do that kind of test with the actual tubes?

WITNESS SLEAR: It would have been feasible; however, we could not have done it at Foster Wheeler, because, as Dr. Pai indicated, they do not have the ability to handle hot samples. They were responsible, if you will, for the qual program. It probably would have created that kind of problem in terms of dual responsibility between B&W and Foster Wheeler.

But it's certainly feasible. It would have resulted in -- you know, removing the tubing is an evolution that takes a fair amount of time. So we would have gotten quite a bit of man-rem exposure to get sufficient tubing to run the testing with actual TMI tubing.

Our judgment, which we still believe is correct today, was that the data we have developed to compare the properties of the tubing to the original tubing itself allowed us to conclude -- and Foster Wheeler supported us on this -- that the key parameters associated with the tubing properties could be adequately modeled, if you will, by using archive tubing.

JUDGE HETRICK: Would you reiterate for us what you mean by key parameters.

WITNESS SLEAR: To my knowledge with regard to tubing properties, the key parameters are ductility and yield strength. Dr. Pai also indicated geometrical parameters which are important in terms of the gap between the tube and the tubesheet, i.e., the radial or diametral gap between the tube OD and the ID of the hole in the tubesheet.

There are other items of interest such as the corrosion products in the tubesheet itself and the effect it may have on either leakage or load-carrying capabilities. We mocked up the geometrical similarities. We put in big gaps and little gaps between the tube and the tubesheet. We heat-treated the

tubesheets in order to ensure that the corrosion products formed on the surface of the tubesheet holes were expected to be -- I believe it's magnetite, which is the type of corrosion product we should have in the TMI-1 steam generators--and then also the tube properties that I discussed, ductility and yield strength. We have tubes in the test program whose ductility and yield strength essentially brackets the ductility and yield strength of those tubes in the TMI-1 steam generator.

JUDGE HETRICK: These tube samples that were removed and subjected to expansion did undergo corrosion testing; is that right?

WITNESS GIACOBBE: That is correct. They were part of the long-term corrosion test program.

WITNESS SLEAR: Which, as you will recall, included some load-carrying evidence, if you will, and we cycled those to normal type loadings, which included up to about a load of 100 pounds tension. We certainly didn't expose them to the 3,000 pounds tension required for a steam line break.

JUDGE HETRICK: Well, that's related to my next question. After the long-term corrosion tests, were any of these samples subjected to large transient stress?

WITNESS GIACOBBE: They were not.

WITNESS SLEAR: Although, I guess it's useful to point out again that in that long-term corrosion test program we had c-rings from the actual TMI-1 tube samples. Those c-rings

are at yield stress, which is -- you know, when you're at 3,000 pounds in the qual program, you're essentially at yield stress on the tubes.

So we had samples or pieces of tubes stressed to the level you would expect the material to be stressed at during situations where you have a transient. But the tube itself, due to the limitations of the mockup, was only loaded to approximately 1,100 pounds.

JUDGE HETRICK: Would it have been feasible to do what I suggest?

WITNESS GIACOBBE: The geometry of the sample and the test fixture that we utilitzed to load this test would not be capable of loading the tube at 3,000 pounds. We would have to modify the test rig and fixture to do so. I'm not sure that's possible. I don't know without consulting with the testing laboratory.

JUDGE HETRICK: So you do not know whether this was considered?

WITNESS GIACOBBE: The long-term corrosion test program was not designed to test the mechanical strength of the joints but rather to test stress conditions on the transition region and how they respond to the actual reactor cooling environment. So the two programs were not designed to achieve the same objectives.

JUDGE HETRICK: So what I'm getting at would have

been a follow-up mechanical testing subsequent to these corrosion tests?

WITNESS SLEAR: I think certainly it could have been had we changed the fixture, but I think the answer to your previous answer was that we didn't consider that it was necessary and, therefore, we didn't pursue it.

We have done a lot of extra things which you normally don't do, but in this case we had evaluated and concluded in our minds that the data that we had was adequate. Frankly, it didn't cross our minds to consider loading these tubes to design basis type loads.

JUDGE HETRICK: Were determinations of residual stresses made on both types of tubes, that is archival tubes expanded versus actual tubes expanded?

(Witnesses perusing documents.)

WITNESS SLEAR: If you'd give us a few minutes, we'd like to look at the failure analysis report. It contains a table of contents that indicates some residual stress with plastic strain measurements were included in the program to assess tube damage, which would lead us to believe that we may have made that type of measurement on actual TMI tube samples, but we need to look for a minute.

(Pause.)

WITNESS GIACOBBE: In reviewing the data, we have, in fact, done residual stress measurements on actual removed

samples from TMI. However, these tests were done on the original roll and roll transition regions, not on the kinetically expanded region.

JUDGE HETRICK: Could you reiterate for me the techniques used in determining residual stress?

WITNESS GIACOBBE: Two techniques were utilized to assess residual stress. One technique was to do hardness measurements and make a qualitative assessment as how that would affect residual stress.

The other technique was to utilize an X-ray diffraction to actually measure residual stresses in the surface of the tube.

JUDGE HETRICK: I wonder if we might be able to identify any other potential areas of testing the types of tests that were done with kinetically expanded archival tubes and were not done with kinetically expanded tubes that had been removed from the steam generator.

WITNESS SLEAR: I think the X-ray diffraction was done at Penn State, and that was done with archival tube samples also.

WITNESS GIACOBBE: On the kinetically expanded joint.

WITNESS SLEAR: On kinetically expanded?

JUDGE HETRICK: Yes, that was my question.

WITNESS SLEAR: Yes.

JUDGE HETRICK: As I recall, there was available a full scale steam generator at Babcock and Wilcox's plant. I recall it in connection with pull-out testing. Could you tell me about that steam generator and about what tests were done?

WITNESS SLEAR: The steam generator was very similar to the one at TMI-1, and certainly the tubes were once again inconel 600 with properties similar to ours. The steam generator was utilized primarily in terms of developing the process in trying to minimize man-rem exposure.

But in addition to that, as far as load-carrying capability for the tubes, we expanded some tubes in that steam generator and then applied load to them in order to document that they didn't -- you know, we were getting the kind of load-carrying capabilities we expected. I don't recall the exact numbers. I think it's documented in some of our reports.

We also put strain gauges on tubes that were being kinetically expanded and used that information in order to conclude what, if any, change in preload occurred during the kinetic expansion.

We also put strain gauges on the tubesheet and on the steam generator vessel itself in order to ensure that from a structural point of view we were not causing an overstress condition in the steam generator from a structural component

point of view.

There are a number of other process steps. The primary use, as I indicated when I started, was really to develop the process. The process involved many, many different steps; and each time before we would bring that step to TMI-1, we would go to the steam generator out in Indiana and test it out and try to improve it from an efficiency point of view, et cetera.

JUDGE HETRICK: What was the history of that particular steam generator?

WITNESS SLEAR: That steam generator was manufactured for a plant which was subsequently cancelled. I believe B&W basically owned it and was letting it sit there for scrap purposes. It had not been torn apart or anything, and, in fact, portions of it hadn't been totally built yet; although the tubes had been installed.

It was essentially, I think -- I think the weld around the lower plenum was not welded yet to the lower tube-sheet. So it had been in the manufacturing process. The project had been cancelled. They had stopped work on it. It essentially had been in a storage condition at TMI -- I mean, at B&W's Mount Vernon, Indiana manufacturing facility for a number of years.

JUDGE HETRICK: Was it established that it was in good condition, such that it was adequate for these tests?

WITNESS SLEAR: Yes, sir. The answer is: yes.

JUDGE HETRICK: We have established that the ductility and yield strength are key parameters in evaluating materials for kinetic expansion. The purpose of this line of questioning has been to establish the basis for the conclusion that tests on archival materials would adequately represent tests on actual materials in the steam generator.

All of the discussion has been rather qualitative. We haven't talked about numerical values of yield strengths, for example, nor have we talked about standards for making these decisions which ultimately had to be quantitative decisions.

I wonder if I could ask you on the record to present the summary picture that would represent or describe the basis for making that decision that the material properties were truly representative.

WITNESS SLEAR: I think we can do that fairly easily if you give us a few minutes to get to the right page in these two reports that we have in front of us.

JUDGE HETRICK: Fine.

WITNESS SLEAR: Thank you.

(Witnesses perusing documents.)

WITNESS GIACOBBE: I have in front of me the results of the mechanical testing, as listed in TDR 341, and in that document we list the mechanical properties from three heats of material in actual tube samples removed from the steam generator.

The material in the steam generator was manufactured to an industry standard ASTM, B-163. The properties as defined in that ASTM standard indicate that the material should have a minimum yield strength of 35,000 psi and a minimum tensile strength of 80,000 psi, and a minimum elongation of 30 percent.

All the tubes in the steam generators were manufactured to that spec, and in fact do meet those mechanical properties, as evidenced by a review of the mill test report for that material. The samples which we removed and tested indicated that we had -- the one sample had a yield strength of 53,000 psi and a tensile strength of 101,000 psi.

As a matter of fact, two samples that we removed from two different heats had those properties. It was 33 percent elongation on the second sample.

Our third sample that we tested was a tube which had a known crack in the tube. We wanted to test what would happen if you did a tensile test around a sample with a known crack. The results of that test were -- I have to explain this a little bit.

If you were to assume full cross-section and take

no credit for the loss of cross-section caused by the crack, the yield strength of that tube came out at 38,000 psi, still above the nominal 35,000.

If you then went back and subtracted from your calculations the amount of cross-section removed by the crack, the material would then have a calculated yield strength of 50,000 psi. That was for a crack that was about 25 percent of the circumference of the tube.

We later went back and looked at what the actual yield strengths of the heats of material that those tubes had come from, and we find that in one instance the yield strength was 45,430, as reported on the test report, and the other was 50,000, as reported on the test report. And so, as you can see, the material still meets, or is actually above the minimum property of yield strength.

I don't have before me the other data for tensile strength, but for yield strength it still meets or exceeds the reported property for that particular yield of material.

(Pause.)

JUDGE HETRICK: Staff has proposed a number of license conditions which would be part of the proposed license amendment, and, in particular, I focus on condition number 4. I have a copy of the safety evaluation report, NUREG 1019, page 46.

In part it says, "If leakage exceeds the base line leakage rate by that minimum increase," and namely that is

p3

expected to be about 0.1 GPM -- "the plant shall be shut down and leak tested."

Now, if a leakage rate were to exceed the amount stated here, how soon would that be known; how soon would the plant be shut down, and how good is the assurance that a leak will be detected in time to meet the criterion that I think has been referred to as leak before break, as I recall?

WITNESS SLEAR: As far as how soon would the leakage be detected, I believe the transport time between the leakage increase and the time when the meter in the RM-A5L shows an increase is on the order of a few minutes at most.

JUDGE HETRICK: We discussed that the other day.

WITNESS SLEAR: Right.

As far as shutting the plant down, the process for a slight increase, which is what this would be, is to conduct an orderly plant shutdown so you would not do things which subject the plant to a transient such as tripping the turbine, etcetera.

It is my understanding that within perhaps 8 hours to 12 hours the plant would be in a cold shutdown condition in conducting an orderly shutdown such as that. The shutdown would start immediately after confirming that they actually had a leak rate which required the plant to be shut down; so we wouldn't trip the plant; we would conduct an orderly shutdown, and within 8 to 12 hours I believe the plant would be in cold

shutdown condition.

I think the last part of your question had to do with what is the assurance that that is fast enough.

JUDGE WOLFE: You can assume that we would ask that as the next question, if we didn't.

WITNESS SLEAR: The testing that we have done to date has indicated that at least from a corrosion point of view we don't have a rapid corrosion mechanism ongoing with the chemistry under control, including during the period of cooling down. We have not seen any degradation in the tubing, itself, and very minor increases in leakages from two of the joints, which we have subsequently plugged.

So there is no evidence of a rapid corrosion mechanism that would crack the tubes very fast, in terms of hours or anything like that.

In addition, we have analytically assessed the growth of the cracks from a mechanical damage point of view, and concluded that loads during the cooldown, which would be ongoing, propagate the cracks only very slightly, and have not identified a rapid mechanical propagation of the cracks.

Therefore, I think in the absence of a rapid propagation of the defect, it is certainly expected that a shutdown that occurs over the number of hours that I described would be fast enough. Certainly if, for example, there is a marked increase in the leakage in a tube rupture, the plant is shut

down in a faster manner than I described, in accordance with the operating procedures.

Once you have exceeded I think it is 50 gallons per minute, I believe you trip the plant and you conduct a faster cooldown, but for the scenario you described the plant is shut down in an orderly fashion, if we didn't see increasing leakage.

Even if in the middle of a cooldown we were seeing increasing leakage, we would continue to control the plant in accordance with the procedures; and, to my knowledge, the procedures are perfectly adequate in terms of even handling the tube rupture if it would occur; but we don't expect it to occur.

JUDGE LAMB: During the orderly shutdown, does your instrumentation inform you if the leak rate increases?

WITNESS SLEAR: Certainly. It's on-line all the time. And, certainly, once that instrument has indicated to the operator that he needs to shut the plant down, he is going to be paying particular attention to it and be noticing any increase; so I think on a minute by minute basis -- basically, there is a hot test program, and every five to ten minutes we were recalculating the leak rate. We could watch the leak rate increase. Everybody was watching it. I would expect it to be the same situation if we were shutting down in the situation you described.

JUDGE WOLFE: A question to you, Mr. Churchill: has the licensee agreed to the staff's proposed conditions to the license amendment?

WITNESS SLEAR: Do you want to answer it?

JUDGE WOLFE: I thought this was a legal question. If it is a factual question, the witness can answer it.

MR. CHURCHILL: Well, it's a question for management. It is my understanding that we have, but I would like to confirm that; yes, all right.

WITNESS SLEAR: Yes. The answer to your question is yes; we will agree to the licensing conditions.

JUDGE WOLFE: Miss Bradford, is there cross-examination of the supplemental Board questions?

MS. BRADFORD: Yes, there is, Judge Wolfe.

CROSS-EXAMINATION

MS. BRADFORD: Mr. Giacobbe, we talked earlier about the heats of metals that are found in the steam generator, that there is, indeed, a wide range of heats; is that correct?

WITNESS GIACOBBE: Yes. I think the other day we put the sum at around 60 different heats of metal.

MS. BRADFORD: Do you have a copy of the licensee's reference document 45?

WITNESS GIACOBBE: Do you know the title of that document?

MS. BRADFORD: Yes. It is TMI Steam Generator

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Corrosion Test Program, Final Report.

WITNESS GIACOBBE: I have it now.

MS. BRADFORD: Would you turn to page 14 of that document, please?

WITNESS GIACOBBE: I have it.

MS. BRADFORD: First let me ask you: the test that this document describes was performed on archival tubing; is that correct?

MR. CHURCHILL: Excuse me. Do you have an extra copy of that document for counsel?

MS. BRADFORD: No, I don't. I'm sorry.

MR. CHURCHILL: Your Honor, may I look at the copy that the witness has?

JUDGE WOLFE: Certainly.

MR. CHURCHILL: Thank you.

WITNESS GIACOBBE: This test program utilized both TMI actual removed tubing as well as archival tubing. Just looking at this table, I can't tell you whether that is archive tubing or not. I have to go back to the full set of tables where I believe it lists each tube heat and whether it is archive or not; but clearly you can see at least -- specimen 2-144 says "actual TMI-1 exposure" so that is an actual TMI tube.

Tube specimen 2-158 says "model blower exposure," so that is clearly not a TMI tube.

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The rest of them I can't tell you from just looking at this table.

MS. BRADFORD: I direct your attention to the text at the bottom of the page. Would you read that for me, please?

WITNESS GIACOBBE: The last paragraph?

MS. BRADFORD: Yes.

WITNESS GIACOBBE: "During the test program the strip specimens from the archive heat were machined from a single piece of M2320 tubing. However, when the supply of specimens ran out, more specimens were machined but from another tube of the same heat. The second set of specimens was not as susceptible to IGSCC as the first set when tested using an anodic polarization test. These specimens behaved more like the laboratory heat M5442. The reason for this is unclear. Again, the second tube may have been subjected to a slightly different temperature during the final anneal, or it might have been at the annealing temperature for a different length of time. Further tests,such as effect of preconditioning and effect of heat treatment, are needed to clarify this result."

Do you want me to go on?

MS. BRADFORD: No, that's fine. Thank you.

Then that paragraph that you just read suggests that the various heats of metals respond differently, and

this paragraph suggests that even within the same heat there are different responses; is that correct?

WITNESS GIACOBBE: Clearly, in any corrosion phenomenon you are going to get variations from heat to heat and within the same heat, because of the complex nature of corrosion. It is going to occur at random sites; depending on the conditions at the random sites, it may or may not occur.

So I think that even in our failure analysis in looking at whether corrosion occurs, we determined it wasn't really a heat-sensitive phenomenon; it was really the local conditions that produced the corrosion.

I think the test program kind of bore out that phenomenon.

MS. BRADFORD: Do the varying heats of metals have the sensitization, the degree of sensitization found in varying heats of metals, are they affected by anything other than the chemical -- what I'm trying to get at is: would they play a part in a failure of the structure? That is other than a chemical failure.

WITNESS GIACOBBE: No, not other than a chemical failure. The degree of sensitization is strictly related to a chemical phenomenon. The chemical properties are not affected by that.

MS. BRADFORD: Do you have available to you a copy of reference document 20?

WITNESS GIACOBBE: Yes, I'm sure I do.

JUDGE WOLFE: The caption of that document, Miss Bradford?

MS. BRADFORD: The title on the document is "Once-Through Steam Generator Kinetic Expansion Qualification - Evaluation of Pull-out and Leakage Data."

WITNESS GIACOBBE: We have the document. What page?

MS. BRADFORD: Page 7.

JUDGE WOLFE: That was a document prepared by B&W; is that correct?

MS. BRADFORD: Yes, it is.

WITNESS GIACOBBE: That is essentially a page of calculations?

MS. BRADFORD: Yes.

WITNESS GIACOBBE: We have it.

MS. BRADFORD: I do not understand any of the calculations. I want to set that straight. Then, in addition, many of the calculations on the copy that TMIA received has been blanked out. However, there appears on the bottom of that page a sentence which says, "Since 257 is greater than 105.76, this test indicates that the sample came from different properties; i.e. different" --

WITNESS GIACOBBE: I believe that word was "populations."

MS. BRADFORD: Populations; excuse me.

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"The difference in means is substantially significant." Is that correct?

WITNESS SLEAR: It says "statistically significant."

MS. BRADFORD: Statistically.

Would you turn to page 9 of this same document?

WITNESS SLEAR: I would like to read the introduction to make sure I understand what this document is about, if you will bear with me for a moment.

MS. BRADFORD: Sure.

(Witness perusing document.)

WITNESS SLEAR: I'm up to page 9, and assume you want to focus me on the bottom sentence once again where it talks about --

MS. BRADFORD: I wonder if you would read that into the record.

WITNESS SLEAR: It says, "Since 286 is greater than 34.56, this test indicates that the samples came from different populations; i.e., the difference in means is statistically significant."

This entire calculation, as I read the introduction, is basically a statistical evaluation of data from both pull-out loads and leakage tests that were done at Foster Wheeler, aimed at documenting whether or not the objectives that we had set for the program had, in fact, been satisfied. I frankly am not a statistician, and I am not sure what the

words, "the difference in means is statistically significant" relate to. I think it is a statistical -- I know this is a statistical evaluation of data, and the words that the "samples came from different populations," I frankly am not able to explain to you.

MS. BRADFORD: This is a -- Mr. Slear, is this a compilation of the data in the pull-out and the leachate --

MR. CHURCHILL: Your Honor, I would like to object to this line of questioning until at least there is an explanation given as to how this relates to the direct questioning by either Judge Lamb or Judge Hetrick. Obviously this is a document the witnesses are not familiar with, and we haven't been notified of this ahead of time. It is unclear even to the witnesses as to the relevance of this.

MS. BRADFORD: Mr. Giacobbe read from TDR 341 in response to one of Judge Hetrick's questions, and was then describing the difference between the variations, I believe, between the archive -- between the tests on archive material and the tests done on the actual tubing.

It seems to me that these documents, that were actual tests, themselves, and were the statistical data that came from these tests, were the bases for this document, which is TDR 341; and it is for that reason that I am questioning on these documents.

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MR. CHURCHILL: It is my understanding that TDR 341 predated this document by approximately a year. Also the mere fact that there is some statistical variation in the data tells us absolutely nothing. We haven't even had an explanation from the cross-examiner of what kind of data this is. The variation doesn't necessarily have to be because it is from the same or different heats. It could have been variations in this data because they were subjected to different environmental conditions, different stresses, anything.

Right now we see absolutely no relationship between this question and anything that Your Honors have asked on this brief question extension.

JUDGE WOLFE: The Board is at a disadvantage with these various documents, the two documents that have been alluded to. We don't know what the dates are; we can't very well make a judgment without somebody telling us what the dates are on the documents.

What was it the panel referred to; TDR 341, is that correct, Mr. Giacobbe?

WITNESS GIACOBBE: Yes.

WITNESS SLEAR: The date on TDR 341, revision zero, is 7-22-82 for the final approval signature, and 6-25-82 for the originator's signature. The date on the B&W document is -- that is reference document number 20. The date on that is March 18, 1983 as a release date for that particular

document. And I would point out that the conclusions from the document -- the results are satisfactory. As I get back into the details it is just difficult for me to understand them. I'm not a statistician.

JUDGE WOLFE: That is it as to dates. What is your argument?

MR. CHURCHILL: Well, Your Honor, we also are at a disadvantage. Ms. Bradford is going --

JUDGE WOLFE: I'm not going to say that this is proper or improper cross-examination. The Board did ask for supplemental testimony. At most, the Board is at fault, if you can call it fault. But we decided we needed more clarification in the development of the record.

Let's look at the documents. You may have an argument that what --

MR. CHURCHILL: I made several arguments, Your Honor.

JUDGE WOLFE: I don't care about several. I'm just taking one at a time now.

MR. CHURCHILL: My argument, Your Honor, was based on her comment that this document, which she is now attempting to use for cross-examination, was used as the basis for a document that Mr. Giacobbe read from in response to one of Dr. Hetrick's questions.

JUDGE WOLFE: Yes.

MR. CHURCHILL: I reacted to that by saying that I thought that the document could not have been the basis, because I thought it in time came after the document that Mr. Giacobbe read from; and, in fact, now that they have testified as to the dates of those documents, that is true. This could not have been the basis for the document, 341, that Mr. Giacobbe read from because it is, in fact, dated later than that document. It is dated in early 1983, and the other document was in '82.

WITNESS SLEAR: I would like to clarify something about the dates. As you go through the pages of this document, you do run across some pages with dates on them where they were prepared in 12-82. The argument still stands that it is after the date of the TDR 341, but there are some pages in this that have dates on them of 12-82 instead of 3-83.

JUDGE WOLFE: Any comment on that particular argument, and then we will take the other arguments successively?

MS. BRADFORD: As you know, TMIA has a very limited background with which to assimilate all of the information, and the documents that were made available to us are, of course, the only ones that we can rely on. These several tests, I presumed, were the bases for the various reports that GPU has issued.

JUDGE WOLFE: I can see that at least insofar as the dates on these two documents, we have had testimony on

that. Now you see the error in timing, do you not?

MS. BRADFORD: That is correct.

JUDGE WOLFE: That being so, do you agree that Mr. Churchill's objection is well-taken; and if not, why not?

MS. BRADFORD: His objection to these documents being examined as basis for TDR 341 seems to be correct. However, the relevance to the follow-up cross-examination is that both witnesses were being examined by Judge Hetrick on the various tests which were conducted by the various laboratories, which formed the bases for their decision to do the repair.

JUDGE WOLFE: All right. It being established that the B&W document that Ms. Bradford is referring to is dated subsequent to TDR 341, query: why is the date of any great importance?

It might be of importance if the B&W document was issued prior to TDR 341. Why can't she use the document for cross-examination even if it was issued subsequently?

MR. CHURCHILL: Your Honor, my objection was not initially that the document dates were different, but that it required some qualification as to how her cross-examination relates to Judge Hetrick's questions, because it is my understanding that she is only allowed to cross-examine on the new information that was elicited by the Board questioning.

We haven't been able to even figure out what this

data is all about or how it has any relevance at all whatsoever to what I understood the thrust of the questioning to be. What I understood the thrust of the questioning to be was how do you know that the actual TMI tubes were either representative of the other TMI tubes or were sufficiently representative of the archival tubes such that the archival tube results could be relied upon.

Now, it may very well be, Your Honor, that this document goes to that, but she was unable to explain that it did. I don't see how it does. I don't have a copy of it. All she said was that there was a statistical variation in some results, and we don't know if those results are from the same or different heats or because the samples may have been subjected to different experimental conditions. She hasn't established that.

I think we have a right to insist that the bounds of her cross-examination be properly adhered to.

MS. BRADFORD: Judge Wolfe, the document --

JUDGE WOLFE: I misunderstood your argument then, Mr. Churchill. That's why I was limiting you to your first argument. In listening to your argument on the dates of the documents, I thought that was of moment. Apparently it was not.

Go ahead.

MS. BRADFORD: It was not I who identified the

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document as statistical data. I believe it was Mr. Slear. However, the document refers to a ten-tube sample which were subjected to the pull-out and leakage tests. It seems to me that that was exactly the thrust of Judge Hetrick's questions.

JUDGE WOLFE: This document relates to a B&W test on TMI-1 steam generator tubes, both as to the archive sample and the defective tubes from TMI-1.

MS. BRADFORD: No, the --

JUDGE WOLFE: Why are we even looking to that document as a focus of cross-examination? I don't follow that. I don't think that there has been any nexus shown between what is in that document and what the Board's questioning of this panel was all about.

Is this where you are going now or not?

MR. CHURCHILL: Yes, sir. I don't understand the nexus. There may be a nexus, but it is her responsibility to explain it. I haven't seen it, and she hasn't provided a copy of the document to me.

JUDGE WOLFE: Well, all right.

Go ahead, Ms. Bradford. You see my quandry and the basis of Mr. Churchill's objection.

MS. BRADFORD: I understood Judge Hetrick to be questioning whether, indeed, the tests done on archive materials were representative of the actual steam generator tubing material, and he was questioning on the various tests. One

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of the tests identified as not having been performed on the actual steam generator tubing was in fact a pull-out and leakage test. Now this document purports to be the results -- or a compilation of the results of that data which was gathered from the tests on the archival tubing.

JUDGE HETRICK: I understand you to say most recently that this document concerns tests on archival tubing.

MS. BRADFORD: I assume it is archival since we heard from the witnesses --

JUDGE WOLFE: Why do you presume that?

MS. BRADFORD: We heard from the witnesses in response to Judge Hetrick's question that these tests -- that is the pull-out and leakage tests -- were not conducted on actual steam generator tubing. Since this concerns those very tests, I must assume that these were conducted on archive tubes.

JUDGE HETRICK: All right, that would be consistent. Did you find in the document a definition of these two populations for which the significant difference is asserted?

MS. BRADFORD: No, I did not. It was for that reason that I asked the witness to review the document because there seems to be differences there, and I noted the differences, and it seems to be unexplained.

JUDGE HETRICK: But as we agree,it is a difference of some sort having to do with tests solely on archival tubing. It couldn't be a difference possibly between archival and

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actuals?

MS. BRADFORD: No, no; that's not what I understand this document to mean. These were the only tests done on the pull-out loads of any tubing, whether archival or actual; so these are the only tests that exist. At least on the face of this document, there seems to be some problems with that test, which was not even on actual steam generator tubing; it was on archive tubing.

JUDGE WOLFE: Is there anything in that document that you have been referring to, the B&W document, on the face sheet or anywhere on that document, that specifically identifies that this archival testing was done for and on behalf of TMI-1?

MS. BRADFORD: One moment; if I could just have a moment to review this.

(Pause.)

MS. BRADFORD: On the cover sheet of this document in the upper left-hand corner there appears a contract number, and next to that in another box there appears the word "plant" and under that is written "TMI-1."

JUDGE WOLFE: Absent the Board having seen the document, but from what you present as appearing up in the corner, and that being a B&W document, there does seem to be a basis for allowing you to cross-examine further.

Objection overruled.

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WITNESS SLEAR: I think now that I have looked further at the formulas at pages 6 and 9 you are referring to statements that basically say that this test indicates that the samples come from different populations. If you look at the formula, it is a comparison of the mean pull-out load for three blocks, Block C, D and E, with the mean pull-out load for G.

They are, in fact, different populations.

When we developed the qualification program we had a number of blocks, each with ten tubes in them. We labeled the blocks with A, B, C, D, E, F, G, H and SP-1. Blocks C, D and E were subjected to, I believe, the normal process of thermal cycles, etcetera.

There were other things done with Blocks A, B, G, H and SP-1. Some of those blocks didn't receive thermal cycles. Some of those blocks had pull-out loads taken and elevated temperatures, and there may have been some other differences.

The bottom line is they are different sample populations, if you will. And if you relate that to the front of the document, it basically says in the summary of results that we met the load-carrying objective of 3,140 pounds with the statistical confidence we were looking for, and we exceeded very slightly the objective we had for leakage on the pound per hour per tube. But the aggregate leakage is very,

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very small.

Even if each tube leaks at the leakage that we documented in the test program, the expected plant leak rate with all tubes leaking at that amount would be 0.031 gallons per minute, which is insignificant.

So I think the statistician did his work and he concluded that he had met the objectives. To try to take out of context these words that they are from a different population, at least in the two instances you pointed out, that's an expected result because they were different test lots, and they did see different activities perhaps; i.e., one test block, I think A probably, wasn't even thermal-cycled. It was just expanded and pulled out immediately.

MS. BRADFORD: And this whole sample in page 8 --

WITNESS SLEAR: Page 8 refers to Block G, that the pull tests were done at 330 degrees Fahrenheit instead of being done at ambient temperature.

MS. BRADFORD: Perhaps you can help me, Mr. Slear. This document refers to block -- the number of mock-up tests?

WITNESS SLEAR: Yes, ma'am. We had a number of ten-hole test blocks in the program.

MS. BRADFORD: And each block was subjected to a different set of tests?

WITNESS SLEAR: There was a total of eight blocks. I believe blocks C, D and E received what we call a normal

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process, and that gave us 30 data points.

There were obvious technical questions that needed to be answered in the program, one of which was if you elevate the temperature, would you expect to see a decrease in pull-out loads; and we tested that by elevating the temperature of Block G and conducting the pull-out test at an elevated temperature.

MS. BRADFORD: And the result of that test?

MR. CHURCHILL: Your Honor, I object. I think it has been established that the variation in the data, in the test results that were analyzed in this document, are due to subjecting these samples to varying conditions. The only relevance to the questions of the Board would be on questions of whether there are variations in material properties of the archival samples, indeed, from the actual TMI samples.

Now, if this had shown that within the same heats the mechanical properties were so different that this would somehow cast doubt on that conclusion, that I think would be relevant to the Board's questioning.

Now it has been established by the testimony of these witnesses that the variations are there because they had different tests. They weren't testing the similarities of properties within the same heat; they were subjecting samples to various tests to find out what happens, for example, when the parameter of temperature is varied.

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I did not detect any such questions along those lines from the Board; and, in fact, if this line is allowed to go on, all she is doing is merely going to have free rein to roam at will through the entire qualification program, which, as we discussed yesterday, is not the subject of this hearing. It is only to the extent that some parts of it might be relevant to some of the issues, as, for example, the issue that we have just been discussing, the adequacy of extrapolation between archival and TMI tubes.

JUDGE WOLFE: This cross-examination does go beyond the Board's supplemental examination. Objection sustained.

MS. BRADFORD: Very well.

Mr. Slear, you discussed earlier in response to Judge Hetrick's questioning the tests which you conducted for leak rate; that is the various testing you put your sample blocks through to test for leak rates. Is that correct?

WITNESS SLEAR: Yes, that's correct. Judge Hetrick had asked what tests were done with archival materials, and I discussed the fact that the leak rate and the pull-out tests, among some, were done with what we are calling archival tubing.

MS. BRADFORD: And at that time you discussed the tests that were done at Foster Wheeler that discovered that the annulus size or geometry was an important parameter?

WITNESS SLEAR: I didn't describe the test. We hired Foster Wheeler because they understood this process, and

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from years of development they knew that annulus size would be one parameter which needed to be understood in terms of what is the annulus size and what is the variation of the annulus size, and then ensure that any qualification program factored in the variations that we expect in the annulus size between the tube and the tubesheet.

MS. BRADFORD: Are the annular gaps at TMI one of a uniform size?

MR. CHURCHILL: Objection, Your Honor. I did not hear any Board questions that went to the questioning of annular gap sizes. The question was: are the tubes from TMI and the archival tubes sufficiently representative in their mechanical properties that the test results can be relied upon?

MS. BRADFORD: I understood Judge Hetrick's question to go to the fact of when the archival tubing was tested, were all the tests performed representative of the conditions that the actual tubing would be subjected to.

JUDGE HETRICK: Miss Bradford, could I have that characterization of my question once again?

MS. BRADFORD: I understood -- Mr. Reporter, would you read that back please?

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

JUDGE HETRICK: I think that is a slightly broad characterization. I am more concerned about whether it was

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representative of the materials rather than all the conditions. It seems to me that one thing I did not address was the annular gap between the tube and the tubesheet.

JUDGE WOLFE: I'll sustain the objection.

MS. BRADFORD: I have no more questions.

JUDGE WOLFE: I'm sorry, Miss Bradford.

JUDGE HETRICK: She said she had no more questions.

JUDGE WOLFE: Mr. Au?

MR. AU: Yes, I have a couple of questions.

CROSS-EXAMINATION

MR. AU: Of the 27 tubes removed from the steam generators, how many were actually mechanically tested?

WITNESS GIACOBBE: There are three heats that were tested to -- hang on a second; let me look at the documents.

I believe it is three tubes and three heats.

WITNESS SLEAR: I would like to point out that what that is going to tell you is that in terms of quantitatively documented yield stress we have numbers from, I think, at least three tubes. I anticipate it is from at least three tubes.

One of the tests we did to evaluate cracks or the absence of cracks in the tubes was a reverse bend where we slit the tube actually into very narrow strips and reverse bent that. We may have done that 50 or 60 or even 100 times, so there are many, many samples from TMI tubes which have been

subjected to a great deal of strain and in fact did not crack. That doesn't give you a quantitative assessment of yield stress or ductility, but certainly qualitatively there are many more samples than it would seem we have quantitative data on when it comes to at least ductility.

WITNESS GIACOBBE: The actual is three heats, the three different heats for testing, for mechanical testing.

MR. AU: How were these tubes selected to be representative of each heat?

WITNESS GIACOBBE: I am not sure I understand your question. We pulled different heats out. We only had those tubes and those heats, so if we had three heats, I don't know how many tubes in each heat. We tried to pull as many different heats as possible, but I don't have the exact breakdown.

So we took what we had and we found a suitable section. We measured it to make sure it hadn't been deformed in any way, and then utilized that sample.

You have to remember that some of these samples may have only been 20-inch samples. Some of them may have been 16-foot. I don't know the length of any particular sample that we have shown that we have done mechanical testing on.

MR. AU: You had no criteria to determine which one tube of that sample to choose to do the mechanical testing other than the physical criteria?

WITNESS GIACOBBE: We pulled tubes for specific

purposes. As I stated before, we pulled random heats, and so consequently the mechanical properties are on a random sample.

MR. AU: How are the archival tubes stored?

WITNESS GIACOBBE: Now or when we pulled them; I'm not sure I understand you.

MR. AU: The archival tubes, the ones that you used.

WITNESS SLEAR: I have seen archive tubing samples at Alliance Research Center. They are basically setting in bins exposed to oxygen or atmosphere, if you will, in a warehouse which is reasonably protected from the environment; but it is basically a warehouse situation where they are stacked. It is a controlled area. It is covered, and they specifically keep track of them to make sure that they know what tube came from what heat, plus the tube may be marked. But it is a controlled situation in terms of knowing what the tubes are, but it is not any kind of inert or atmospheric control type situation. It is basically just a storage situation under lock and key.

MR. AU: Let me see if I understand your earlier testimony. It's from the mechanical tests of the three tubes that you determined the representative mechanical properties of the actual tubing removed?

WITNESS GIACOBBE: Plus a 100 percent review of all the material test reports for each of the tubes in the

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steam generators.

MR. AU: Thank you.

JUDGE WOLFE: Ms. Wagner?

MS. WAGNER: Staff has no questions.

JUDGE WOLFE: Redirect?

MR. CHURCHILL: No, sir.

JUDGE WOLFE: The witnesses are excused.

(Witnesses excused.)

JUDGE WOLFE: We will have a ten-minute recess, and, Miss Wagner, you can put your panel on right after the recess.

(Recess.)

JUDGE WOLFE: All right, Ms. Wagner.

MS. WAGNER: As a preliminary matter, the Staff intends to introduce excerpts from its Safety Evaluation Report and Supplement.

Would it be appropriate to pre-mark those documents at this time?

JUDGE WOLFE: Yes.

MS. WAGNER: I would like to mark as Staff Exhibit 1 for identification a document consisting of a cover page entitled "Safety Evaluation Report." In the upper right-hand corner it says "NUREG-1019."

The document consists of a cover page and pages 2, 4, 13, 14, 15, 16 and 20.

I have got three copies for the reporter. I would ask that this be marked for identification as Staff Exhibit 1.

JUDGE WOLFE: All right.

(Whereupon, the document was marked as Staff Exhibit No. 1 for identification.)

MS. WAGNER: As Staff Exhibit 2 for identification I have a document entitled, in the upper right-hand corner, "NUREG-1019, Supplement No. 1, Safety Evaluation by the Office of Nuclear Reactor Regulation."

JUDGE WOLFE: Does that bear a date on the face page?

MS. WAGNER: Not on the cover, it does not. The

document consists of a cover sheet and pages 11, 12 and 18 from that document.

I would ask that that be marked as Staff Exhibit 2 for identification.

JUDGE WOLFE: The exhibit may be so marked.

(Whereupon, the document was marked as Staff Exhibit No. 2 for identification.)

JUDGE WOLFE: You may offer them into evidence if you plan to do it through these witnesses.

MS. WAGNER: I was planning to offer them through these witnesses.

MR. CHURCHILL: Could I have the page numbers on Exhibit 1 again?

MS. WAGNER: Yes. It is a cover page and pages 2, 4, 13, 14, 15, 16 and 20.

MR. CHURCHILL: The reason I was asking is, page 2 just seems to have parts of two sections on it, as well as page 4. I was wondering if page 3 was missing.

MS. WAGNER: No. It was our intent to just have 2 and 4.

MR. CHURCHILL: Okay. Thank you.

MR. AU: Excuse me; do you have copies of the exhibit for the other parties?

MS. WAGNER: I don't have copies of the excerpted pages for you, but if you don't have a copy of the Staff's

safety evaluation, I'm sure I can get you an extra copy of the entire document.

MR. AU: We just wanted to see if you had the excerpts.

JUDGE WOLFE: All right, Ms. Wagner.

MS. WAGNER: Is it time to swear the witnesses? I would introduce the documents after the witnesses are sworn.

JUDGE WOLFE: Your name, please, the gentleman on the left?

MR. McCRACKEN: Conrad McCracken.

JUDGE WOLFE: And your name?

MR. WU: Paul Wu.

Whereupon,

CONRAD E. McCRACKEN
and
PAUL C. WU

were called for examination and, having been first duly sworn, were examined and testified as follows:

JUDGE WOLFE: How are we proceeding, Ms. Wagner? This is your only panel. Shall we proceed then with what, Contention --

MS. WAGNER: 1.a. What we have done is, this panel has submitted testimony on both Contention 1.a and Contention 1.b, two pieces of testimony.

The first document would be the one that I would first move into evidence. We treat the four issues of

Contention 1.a sequentially in this document.

That would be the way I would intend to proceed, and then turn it over to her for cross-examination on that; and then, at the conclusion of that, go on to our testimony on Contention 1.b.

JUDGE WOLFE: All right.

DIRECT EXAMINATION

MS. WAGNER: Mr. McCracken, would you state your name and current position with the Nuclear Regulatory Commission?

WITNESS McCRACKEN: Conrad Earl McCracken. I am the Section Chief of the Chemical and Corrosion Technology Section, Nuclear Reactor Regulation.

MS. WAGNER: Would you briefly describe your role in the Staff's review of the steam generator tube repair at TMI-1?

WITNESS McCRACKEN: Yes. I had the overall technical lead for review of the corrosion problem and repair of the TMI-1 steam generators.

MS. WAGNER: Are you familiar with a document entitled "Testimony of Conrad E. McCracken and Paul C. Wu on TMIA Contention 1.a"?

WITNESS McCRACKEN: Yes, I am.

MS. WAGNER: Was this testimony prepared by you or under your supervision?

WITNESS McCRACKEN: Yes, it was.

MS. WAGNER: Do you have any changes or corrections to this testimony that you would like to make at this time?

WITNESS McCRACKEN: I have one typo on page 17.

MS. WAGNER: Would you point that out?

WITNESS McCRACKEN: On line 7 of the first paragraph, the word "transition" is mispelled; the "i" and the "s" are transposed.

MS. WAGNER: Do you have any other changes or corrections that you would like to make at this time?

WITNESS McCRACKEN: No, I don't.

MS. WAGNER: As you just corrected it, is this document true and correct to the best of your knowledge?

WITNESS McCRACKEN: Yes, it is.

MS. WAGNER: Do you adopt this testimony as your testimony in this proceeding?

WITNESS McCRACKEN: Yes, I do.

MS. WAGNER: Mr. Wu, would you state your name and position with the Nuclear Regulatory Commission?

WITNESS WU: My name is Paul C. Wu. I am a Chemical Engineer in the Chemical Engineering Branch of the Nuclear Regulatory Commission, the NRR Office.

MS. WAGNER: Would you briefly describe your role in the Staff's review of the steam generator repairs at TMI-1?

WITNESS WU: My involvement in the TMI-1 steam generator repair evaluation was to assess the chemistry and

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corrosion aspect of the steam generator repair; and, in addition to that, assist the section leader in coordinating the overall review within our branch and other branches in NRR.

MS. WAGNER: Are you familiar with a document entitled "Testimony of Conrad E. McCracken and Paul C. Wu on TMIA Contention 1.a"?

WITNESS WU: Yes, I am.

MS. WAGNER: Was this testimony prepared by you or under your supervision?

WITNESS WU: Yes, it was.

MS. WAGNER: Do you have any changes or corrections to the testimony that you would like to make?

WITNESS WU: No, I don't.

MS. WAGNER: Is this document, as corrected by Mr. McCracken a minute ago, true and correct to the best of your knowledge?

WITNESS WU: Yes.

MS. WAGNER: Do you adopt it as your testimony in this proceeding?

WITNESS WU: Yes, I do.

MS. WAGNER: Mr. McCracken, are you familiar with the document that I have just marked as Staff Exhibit 1 for identification?

WITNESS McCRACKEN: Yes, I am.

MS. WAGNER: Have you read this document?

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WITNESS McCRACKEN: Yes, I have.

MS. WAGNER: Was Staff Exhibit 1 for identification prepared by you or under your supervision?

WITNESS McCRACKEN: Yes, it was.

MS. WAGNER: Could you briefly describe the subject matter of NUREG-1019, and, in particular, the subject matter of Staff Exhibit 1 for identification?

WITNESS McCRACKEN: The subject matter of NUREG-1019 is the Staff's evaluation of the Licensee's actions to return their steam generator to the original licensing condition and the discussion of how we found that acceptable.

The excerpts which you have marked as Staff Exhibit 1 are the specific pages that we have referred to in our testimony which we're offering here today.

MS. WAGNER: Mr. Wu, are you familiar with the document that has been marked as Staff Exhibit 1 for identification?

WITNESS WU: Yes, I am.

MS. WAGNER: Have you read this document?

WITNESS WU: Yes, I did.

MS. WAGNER: Mr. Chairman, I would ask that Staff Exhibit 1 for identification be introduced into evidence at this time.

JUDGE WOLFE: Any objection?

MR. CHURCHILL: No objection.

MS. BRADFORD: No objection.

MS. WAGNER: Mr. McCracken, are you --

JUDGE WOLFE: Just a moment. You had offered it, had you not?

MS. WAGNER: Yes.

JUDGE WOLFE: Any objection? Mr. Churchill said no. Ms. Bradford said no.

MR. AU: No objection.

JUDGE WOLFE: All right. Absent objection, Staff Exhibit 1 is admitted into evidence.

(Whereupon, the document marked as Staff Exhibit No. 1 was received in evidence.)

MS. WAGNER: Mr. McCracken, are you familiar with the document that has been marked as Staff Exhibit 2 for identification?

WITNESS McCRACKEN: Yes, I am.

MS. WAGNER: Have you read this document?

WITNESS McCRACKEN: Yes, I have.

MS. WAGNER: Was Staff Exhibit 2 for identification prepared by you or under your supervision?

WITNESS McCRACKEN: Yes, it was.

MS. WAGNER: Could you briefly describe the subject matter of the document?

WITNESS McCRACKEN: The subject matter is the same as I had discussed for Exhibit 1. It is an excerpt from the

Staff Safety Evaluation Report, Supplement No. 1, and it relates to a specific area in the testimony where we refer to it.

MS. WAGNER: Mr. Wu, are you familiar with the document marked Staff Exhibit 2 for identification?

WITNESS WU: Yes, I am.

MS. WAGNER: Have you read this document?

WITNESS WU: Yes, I have.

MS. WAGNER: Mr. Chairman, I would ask that the document marked Staff Exhibit 2 for identification be admitted into evidence at this time.

JUDGE WOLFE: Any objection?

MR. CHURCHILL: No objection.

MR. AU: No objection.

MS. BRADFORD: No objection.

JUDGE WOLFE: Absent objection, Staff Exhibit 2 is admitted into evidence.

(Whereupon, the document marked as Staff Exhibit No. 2 was received in evidence.)

MS. WAGNER: That concludes my direct examination of these witnesses on TMIA Contention 1.a.

(Pause.)

MS. WAGNER: Sir?

JUDGE WOLFE: Yes.

MS. WAGNER: There is one further thing I had better attend to before I turn these witnesses over.

I would ask that the document entitled "Testimony of Conrad E. McCracken and Paul C. Wu on TMIA Contention 1.a" be bound into the record as if read.

JUDGE WOLFE: Any objection?

MR. CHURCHILL: No objection.

MS. BRADFORD: No objection.

MR. AU: No objection.

JUDGE WOLFE: Judge Hetrick has some questions to address to you, Ms. Wagner.

JUDGE HETRICK: In reading the prepared testimony on Contention 1.a it occurred to us that there were a couple of points that might possibly be beyond either the scope of hearing or the scope of the contention. I would refer in particular to page 5, question 5, and page 15, questions 18 and 19.

The reason for questioning -- the first one had to do with loss of pretension resulting in increased compressive forces and tube bowing, and the second question had to do with fracture mechanics analysis and hardness versus toughness. I was concerned that we're getting a little far afield.

Could you satisfy my concern?

MS. WAGNER: To take the second set of questions first, questions and answers 18 and 19 are really provided as background in answering that particular sub-issue and was not intended in any way to reintroduce the issue of fracture mechanics into this case.

There may be some other material within the testimony that is also there in the nature of background, that we thought might be helpful by way of background only.

I do not believe that those questions and answers are a necessary part of the Staff's presentation if they would be interpreted as in any way enlarging the scope of this proceeding.

JUDGE WOLFE: You may find that there will be cross-examination on these points. What would be your position then; that the cross-examination is beyond the scope of this hearing, or would you not object?

MS. WAGNER: Well, of course, I would have to see the questions at the time, but I believe that some limited cross-examination on these questions would be appropriate since the Staff has included them.

JUDGE WOLFE: Well, it's your case. We just wanted to assure ourselves on that.

How about question and answer 5 on page 5, the same position as this question, that it seeks to elicit background?

MS. WAGNER: Give me just a minute to find the reference as to why I have included this question 5.

(Pause.)

MS. WAGNER: May I consult with my witnesses?

JUDGE WOLFE: Yes.

(Counsel Wagner conferring with witnesses.)

JUDGE WOLFE: Not that I mind hearing objections and ruling on them, but --

(Pause.)

JUDGE WOLFE: You had made an offer that this be incorporated into the record as if read. We had some questions for you. I haven't yet ruled on incorporating this into the record as if read.

So what is your response to question and answer 5 on page 5?

MS. WAGNER: On question 5 we were intending to be responsive to TMIA's allegation as set forth in its Statement of Facts and Summary Disposition -- in response to our Summary Disposition.

JUDGE WOLFE: That's not before us now, is it?

MS. WAGNER: Well, on page 20 of the Board's Memorandum and Order of June 1, --

JUDGE WOLFE: Just a moment. What page again, please?

MS. WAGNER: Page 20 of the Board's June 1 Memorandum and Order, at the bottom of the page, paragraph 88 -- paragraph 8.a of TMIA's -- I believe it is their Statement of Facts, but I'm not positive. But anyway, it says, "As the Staff points out, due to the loss of pretention the leakage rate through various threshold cracks may be reduced, SER-21. Thus, decreased leaks may mask cracks which additional compressive loads and bowing could cause to mouth open."

We did not read the Board's Order as ruling that outside the scope of this issue, so we included question 5 and answer 5 to address that point.

JUDGE WOLFE: This reading then relates to 1.a at page 23, in other words?

MS. WAGNER: That's correct, in an attempt to be fully responsive to the Board's concerns.

JUDGE WOLFE: All right.

MS. WAGNER: On questions 18 and 19, since we don't feel that they are a necessary part of the Staff's case but merely background, and since we have had some difficulty with scope of cross-examination, proper scope of cross-examination, I would ask that questions and answers 18 and 19 be deleted from our proposed testimony before it is accepted into the record formally.

JUDGE WOLFE: This is, obviously, Staff's written direct testimony. You request leave to delete that from this testimony?

MS. WAGNER: That's correct.

JUDGE WOLFE: All right. Staff's request to delete question 18, answer 18, question 19 and answer 19 on page 15 of this written direct testimony dated June 29, 1984, the testimony of Conrad E. McCracken and Paul C. Wu on TMIA Contention 1.a, is granted. Those two questions and answers will be deleted from that written direct testimony.

Further, this testimony, without objection and with the deletion of these two questions and answers, is incorporated into the record as if read.

(Whereupon, the Staff's testimony of Conrad E. McCracken and Paul C. Wu on TMIA Contention 1.a follows:)

June 29, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)	
)	
METROPOLITAN EDISON COMPANY, ET AL.)	Docket No. 50-289
)	(Steam Generator Repair)
(Three Mile Island Nuclear Station,)	
Unit No. 1))	

TESTIMONY OF CONRAD E. McCRACKEN
AND PAUL C. WU ON TMIA CONTENTION 1.a

Q.1 Please state your names and positions with the NRC.

A.1 My name is Conrad E. McCracken. I am the Section Chief of the Chemical and Corrosion Technology Section, Chemical Engineering Branch, NRC Division of Engineering. A copy of my professional qualifications is attached.

My name is Paul C. Wu. I am a Chemical Engineer in the Chemical and Corrosion Technology Section, Chemical Engineering Branch, NRC Division of Engineering. A statement of my professional qualifications is attached.

Q.2 What is the purpose of this testimony?

A.2 The purpose of this testimony is to address those surviving portions of TMIA Contention 1.a which were identified on p. 23 of the Board's Memorandum and Order of June 1, 1984 (June 1 Order),

specifically, the rationale underlying certain license conditions proposed by the staff, and issues associated with acceptability of the kinetic expansion repair process.

Q.3 Describe the overall rationale which is used by the staff to determine if license conditions are to be proposed subsequent to any steam generator repairs.

A.3 Many factors are involved in a determination to propose license conditions. The underlying basis for any proposed license condition, subsequent to a steam generator repair, is to provide additional verification that the probability of a steam generator tube rupture remains extremely low, consistent with the requirements of GDC 14.

Steam generators, as fabricated and installed, have tube wall thicknesses which exceed the requirements of Section III of the ASME Boiler and Pressure Vessel Code. Typically, at tube wall degradations of approximately 70% (30% tube wall remaining) it has been demonstrated both analytically and experimentally that the Boiler and Pressure Vessel Code requirements are met and that steam generator tube integrity will be maintained for design basis accident conditions. Because the code itself contains a built-in conservatism of approximately a factor of 2, additional margin to failure exists for design basis accidents even if a tube is degraded in excess of 70% through wall.

Criteria for plugging degraded tubes that are to be removed from service are contained in draft Regulatory Guide (R.G.) 1.121 (August 1976). The staff has established a conservative plugging criteria of 40% tube wall degradation (i.e., 60% tube wall remaining), which is part of the plant technical specifications. The 40% plugging criteria includes an uncertainty allowance for determination of the depth of degradation and a corrosion allowance for continued degradation during the next operating period. The combined uncertainty and degradation allowance provide a margin during the next operating period of approximately 30% degradation before reaching the code allowable of approximately 70% degradation.

Typically, in making a determination as to the need for license conditions subsequent to steam generator repairs, the first step is to make a determination that the steam generator has been repaired so that the probability of tube rupture is extremely low. This is accomplished by assuring ourselves that either the steam generator has been returned to its original licensing basis or, if not, that other compensatory measures, such as lower allowable primary to secondary leak rates, are provided. A determination is also made as to whether the source of degradation has been removed. If the source of degradation is still present, a rate of degradation is established and, based on the rate of degradation, an ECT examination frequency is established which will provide reasonable assurance that degradation will not exceed approximately 70% through wall prior to the next scheduled ECT inspection.

In summary, the staff typically proposes license conditions for repaired steam generators that provide adequate assurances that the probability of tube rupture remains extremely low during the next operating period. The license conditions proposed are based on the established rate of degradation during subsequent operating periods.

Q.4 In its June 1 Order at page 23, paragraph 1, the Board asked the Staff to address the rationale underlying certain proposed license conditions in NUREG-1019, with attention to four enumerated concerns of the Board. Paragraph 1.a. of the June 1 Order lists as a Board concern "[r]eliability of leak rate measurements." Please explain the rationale associated with the Staff's proposed license condition on leak rate measurements.

A.4 The subject of leak rate measurements is addressed in proposed license condition No. 4, as follows:

Proposed License Condition No. 4:

The licensee shall confirm the baseline primary-to-secondary leakage rate established during the steam generator hot test program. If leakage exceeds the baseline leakage rate by more than 0.1 gpm, the plant shall be shutdown and leak tested. If any increased leakage above baseline is due to defects in the tube free span, the leaking tube(s) shall be removed from service. The baseline leakage shall be reestablished, provided that the present Technical Specification limit of 1.0 gpm is not exceeded (SE Section 3.3).

Rationale for Proposed License Condition No. 4

The purpose of this license condition is to provide a rapid determination as to the source of any increased primary to secondary leakage so that appropriate repairs can be made. As discussed in Supplement No. 1 to NUREG-1019, pg. 18, the licensee's leak detection methods will detect primary to secondary leakage at levels significantly below the shutdown limit of 0.1 gpm above background. At power operating conditions, depending on reactor coolant system radionuclide concentrations, leakage increases of 0.01 to 0.001 gpm have been detected at other operating plants using the same measurement techniques. These leak measurement accuracies will also apply to TMI-1.

Q.5 The Staff has noted that, due to the loss of pretension, the leakage rate for various threshold cracks may be reduced. Will the loss of pretension on some tubes result in increased compressive forces and tube bowing which can cause tubes to mouth open, as alleged by TMIA?

A.5 The effect of loss of pretension is discussed at p. 20 of NUREG-1019 and p. 12 of Supplement No. 1 to NUREG-1019. Compressive forces sufficient to cause tube bowing can occur only during heatup from a cold shutdown condition. Bowing, if it occurs, will limit the compressive forces which exist. However, the tubes will remain in compression during the heatup and under compression, cracking, if present, is not anticipated to propagate.

Q.6 Paragraph 1.b. of the June 1 Order lists as a Board concern the "method of determining frequency of ECT tests." Please explain the rationale of the Staff's proposed condition on ECT tests.

A.6 The frequency of ECT tests is addressed in proposed license condition No. 3, as follows:

Proposed License Condition No. 3

The licensee shall conduct eddy-current examinations, consistent with the inspection plan defined in Table 3.31, either 90 calendar days after reaching full power, or 120 calendar days after exceeding 50% power operation whichever comes first.

Rationale for Proposed License Condition No. 3

The frequency of eddy-current inspections of the steam generator tubes is governed by the plant Technical Specifications. The guidance for performing inservice inspection is provided in Regulatory Guide 1.83 "Inservice Inspection of PWR Steam Generator Tubes". The frequency of inspections is typically between 12 and 24 months of operation to allow flexibility of conducting steam generator tube inspections concurrent with scheduled outages, such as refueling.

Both the Technical Specifications and Regulatory Guide also stipulate that unscheduled inspections are required when the plant Technical Specification primary to secondary leakage limits have

been exceeded. The Regulatory Guide further stipulates that in cases where tube degradation is excessive more frequent inspections may be required.

Consistent with the Technical Specifications and Regulatory Guide guidance, the post repair tube inspection frequency and leakage limits have been tightened so that, in the unlikely event of reinitiation of corrosion, it would be detected in a timely manner and corrective action taken.

The frequency of future inspection is contingent on the results of the initial 90 to 120 day inspection. If continued degradation is detected an additional midcycle inspection may be required. In any event, another inspection after 12 to 24 months of operation is required by the plant Technical Specifications.

Q.7 Are the proposed TMI-1 license conditions equally as restrictive as those required for other plants which have had steam generator degradation problems?

A.7 The proposed TMI-1 license conditions, when compared to the overall staff rationale in establishing license conditions, see Response to Q.3, are as restrictive or more restrictive than those which are typically implemented after steam generator repairs. In most cases, license conditions are implemented only for primary to secondary leakage rate limits and frequency of ECT inspections. Leakage rate limits and ECT frequency are typically implemented as license

conditions because most steam generator degradation is secondary side initiated and the source of the contaminant cannot be totally eliminated. Therefore, continued corrosion is anticipated. More frequent ECT inspections and lower leak rate limits are therefore implemented to ensure that inspections are conducted at a frequency which provides reasonable assurance that the GDC continue to be met, even in the presence of active degradation.

In contrast, at TMI-1, where the corrodant has been identified, its source removed, and laboratory tests conducted showing no measurable corrosion progression in water chemistry simulating the maximum expected chemical concentrations, there are reasonable assurances that active degradation is not in progress. Therefore, imposition of a 90 to 120 day ECT inspection is a more conservative approach than is typical when a continuing corrosive contaminants source is not present. The proposed 0.1 gpm primary to secondary leakage rate license condition is equal to the most restrictive limit implemented at any other plant.

Q.8 Why didn't the staff propose an earlier ECT, such as 30 to 60 days, rather than 90 to 120 days?

A.8 As indicated in Response to Q.7, the frequency of ECT is determined based on the anticipated rate of corrosion in the presence of continuing contamination. Therefore, imposition of a 90 to 120 day ECT inspection is conservative when the contaminant source has been eliminated and reasonable assurance exists that the corrosion is not progressing.

Q.9 Paragraph 1.c. lists as a Board concern the "method of determining power ascension limitations." Please explain the rationale associated with the Staff's proposed condition on power ascension limitations.

A.9 The subject of power ascension limitations is addressed in proposed license conditions Nos. 1 and 2, as follows:

Proposed License Condition No. 1:

The licensee shall complete its precritical test program in essential conformance with the program described in its Topical Report 008, Rev. 2, and shall submit the results of that test program and a summary of its management review, prior to initial criticality.

Proposed License Condition No. 2:

The licensee shall complete its postcritical test program at each power range (0-5%, 5%-50%, 50%-100%) in essential conformance with the program described in Topical Report 008, Rev 2, and shall have available the results of that test program and a summary of its management review, prior to ascension from that power range and prior to normal power operation.

Rationale for Proposed License Conditions No. 1 and No. 2

The rationale for license conditions Nos. 1 and 2 is that, in any repair effort, a possibility exists that something might have been

missed. The intent of test programs is to verify that the repairs have been adequately completed and to reveal problems which might have been missed. GPUNC Management review at each stage of the test program ensures maximum licensee attention to the test program and its results. Having the test results available to the NRC prior to proceeding to the next phase provides the opportunity for NRC to respond if unanticipated results are detected.

Q.10 What is the basis for proposed license conditions Nos. 1 and 2?

A.10 Proposed license conditions Nos. 1 and 2 are not intended to limit power ascension. Rather, these proposed license conditions are intended to require that test results be made available to the NRC at each stage of the test program. The staff does not consider power ascension limitations to be required as part of the OTSG repair program, because the steam generators have been repaired to their original license basis, which is consistent with full power operation. The power ascension limitations which the licensee discussed in Topical Report 008 were formulated by the licensee. Because the licensee elected to perform a slow, step-by-step power ascension, the staff, conservatively, proposed a license condition that provides the staff an opportunity to review the results prior to power escalation to a new level.

Q.11 Paragraph 1.d. of the June 1 Order lists as a concern of the Board the "adequacy of simulation of operating conditions by long-term corrosions tests." Please explain the rationale for the Staff's proposed license condition on long-term corrosion tests.

A.11 Long-term corrosion tests are required by proposed license condition No. 6, as follows:

Proposed License Condition No. 6:

The licensee shall provide routine reporting of the long-term corrosion "lead tests" test results on a quarterly basis as well as more timely notification if adverse corrosion test results are discovered (SE Section 3.5).

Rationale for Proposed License Condition No. 6

The long-term corrosion lead test program is being conducted utilizing specimens of actual tubing removed from TMI-1 OTSG's. Chemistry conditions simulate the worst case conditions which are anticipated during subsequent operations plus agressive water chemistry utilizing continued additions of sodium-thiosulfate on tube specimens which were not peroxide cleaned. Because this test program leads actual plant operation by more than a year, rapid notification and assesment of results from the corrosion lead test program provides advance indications of potential problems so that corrective actions can be initiated in advance of anticipated problems.

Q.12 What is the significance of the long-term corrosion lead test program?

A.12 The long-term corrosion tests are designed to simulate operational parameters which include load cycling as well as thermal cycling.

Water chemistry simulates the maximum chemical concentrations expected under normal reactor operations plus agressive water chemistry utilizing continued additions of sodium-thiosulfate on tube specimens which were not peroxide cleaned.

Test samples were made of actual TMI-1 steam generator tubes to be sure that any aging effects on the tubes during prior operation were included in the tests. The tubes included known eddy-current defects as well as tubes without known eddy-current defects. A minimum of 4 different heats of material were tested with samples from various elevations within the steam generator. Tube specimens were taken from unexpanded TMI-1 tubing as well as those taken from expanded TMI-1 tubing.

Test chemistry control includes vacuum deaeration, addition of hydrazine, and hydrogen overpressure to simulate the reducing conditions that would be expected during normal steam generator operations. To simulate the hot functional test and operating cycle, sulfate or thiosulfate were added to the solution to simulate sulfur contamination.

Single tube/tubesheet mockups were also tested. These tests included duplication of the peroxide (H_2O_2) cleaning cycle, hot functionals and the first operating cycle.

The long-term corrosion lead test program provides an adequate simulation of operating conditions and a means for making a comprehensive assessment of tube performance in the TMI-1 steam

generators prior to actual operation. Adverse results from the corrosion lead test program can therefore be factored into plant operations in advance of anticipated problems.

Q.13 In summary, what is your professional opinion of the adequacy of license conditions proposed by the staff for TMI-1?

A.13 The overall license conditions proposed in NUREG-1019 and as modified in Supplement No. 1 to NUREG-1019 are more conservative than are typically applied subsequent to steam generator repairs. Implementation of these license conditions will provide reasonable assurance that the public health and safety is protected.

Q.14 The Board in its June 1 Order (p. 23, paragraph 2) asked that the parties address "[t]he effect of inadvertent initiation of emergency feedwater flow at high power or following rapid cooldown after a LOCA ... with attention to calculation of maximum transient stresses in steam generator tubes." In that regard, what is the most severe accident, in terms of loading, on the OTSG tubes?

A.14 The most severe loads on the OTSG tubes would occur as a result of a break in the main steam lines (MSLB). An MSLB will result in a maximum tube load of 3140 pounds as discussed in Section 3.4 of NUREG-1019.

Q.15 What makes the main steam line break limiting, in relation to tube tension?

A.15 During a main steam line break, very rapid boiling of the entire OTSG secondary water volume occurs as steam is released through the

break. This boiling rapidly removes heat from the entire reactor coolant system resulting in a rapid decrease in temperature of the entire length of the 56-foot steam generator tubes. The 3140 pound tube load is caused by the tendency of Inconel-600 tubes to shrink when cold, while the steam generator shell remains hot and expanded. The comparative lower tube temperature and hotter shell temperature produce a tensile load on the tubes. The main steam line break is limiting because it is the design basis accident which results in the most rapid cooldown and largest average temperature decrease of the Inconel-600 tubes.

Q.16 Is the effect of inadvertent initiation of emergency feedwater flow at high power or following rapid cooldown after a LOCA bounded by the MSLB 3140 pound load?

A.16 Yes. In the event of emergency feedwater initiation at high power, reactor coolant temperature remains relatively high and therefore the average OTSG tube temperature remains high even though some localized cooling of the tubes would occur due to the direct impingement of emergency feedwater flow. However, because this cooling affects only localized sections of the tubes on the secondary side of the steam generators while the primary side of the tubes remain hot, the average tube temperature will only be slightly reduced and the resultant tube shrinkage and tension will be small. Emergency feedwater flow initiation following rapid cooldown after a LOCA would simply result in the addition of some cold water to a

volume of already hot water which would be bottled up on the secondary side of the OTSG. Again, the average tube temperature decrease would be less than that caused by a MSLB.

Q.17 The Board in its June 1 Order (p. 23, paragraph 3) asked the parties to address the "reasons for not including hardness tests on repaired tubes in the post repair testing program...." In that regard, what is the definition of hardness, and how is it measured?

A.17 Hardness is a metallurgical term which defines the resistance of metals or alloys to plastic deformation usually by indentation. Sometimes it is also refers to resistance to scratching, abrasion or cutting. Hardness of metals or alloys can be measured by standard hardness testers such as Brinell, Rockwell, and Vickers. The measurements are usually made on the same or similar specimens taken from tubes, pipes, or components for metallographic analysis.

Q.18 What information is required in fracture mechanics analysis of structure integrity?

A.18 Basically, material properties, stresses, and defect sizes are required in the expression of stress intensity factor (K_I) which is the main parameter in fracture mechanics analysis.

Q.19 Is hardness a material property required in stress intensity factor derivation? Is hardness considered in fracture mechanics analysis?

A.19 Hardness is not needed in stress intensity factor (K_I) derivation, and it is not considered in fracture mechanics analysis. Toughness

is the material property generally considered in fracture mechanics analysis.

Q.20 Is hardness a parameter considered in stress corrosion cracking?

A.20 Hardness is not needed in the stress corrosion cracking evaluation of materials.

Q.21 Are hardness tests on repaired tubes necessary in the qualification of TMI-1 steam generator tube/tube joint repairs?

A.21 No, there is no need for hardness measurement on repaired tubes, because hardness is not a parameter required in the evaluation or analysis of stress corrosion cracking and/or crack propagation.

Q.22 Were hardness measurements used for any purpose as part of the kinetic expansion repair evaluation? If so, what was their use?

A.22 As indicated on pg. 11 of Supplement No. 1 to NUREG-1019, the licensee's kinetic expansion repair process increased the transition zone length between the expanded and unexpanded tube sections by approximately a factor of 2 to 4 from the original as-fabricated zones. The increased transition zone length results in a corresponding decrease in strain and residual stress. Verification of this relationship by test is not necessary because it is easily predicted mathematically. When strain and residual stresses are reduced, a comparable reduction in hardness occurs in Inconel-600. Therefore, reduced hardness measurements can be used to infer a reduction in strain and residual stress. However, a hardness measurement is not necessary.

The relationship between hardness and residual stress was mentioned on pg. 19 of NUREG-1019, based on a measurement by the licensee which showed reduced hardness in the longer kinetically expanded transition zone when compared to the original as-fabricated transition length. The only conclusion inferred is that due to reduced hardness, the residual stresses will be less and therefore the tubes at the tranistion zone may be less susceptible to stress corrosion cracking than the original as-fabricated tubes. The fact that the transition zone of the kinetically repaired tubes may be less susceptible to stress corrosion cracking was predicted mathematically as stated in the preceeding paragraph. Therefore, the hardness measurements conducted by the licensee on test specimens simply confirmed what was already known.

Q.23 Can hardness of the transition zone be readily measured in the repaired steam generators?

A.23 No. The transition zone is located a minimum of 17 inches deep in a 3/8-inch tube, and hardness measuring devices do not exist which are capable of measuring under those conditions. Therefore, to measure hardness, tubes would have to be severed, sectioned and removed from the repaired steam generators. This is an extensive effort which would result in radiation exposure to the workers. Since information which could be obtained on the hardness of removed tube transition zones is not necessary for acceptance of the repair process, as discussed in the preceeding responses, tube removal for hardness measurements is not consistent with ALARA.

Q.24 In the June 1 Order (p. 23, paragraph 4) the Board asked the parties to provide "information ... about whether tube integrity during subsequent operation depends on whether the process is a repair, or a manufacturing process using new materials." Recalling Licensee's statement that the use of kinetic expansions to seal heat exchanger tubes within tubesheets has a broad base of successful experience, is tube integrity during subsequent operation dependent on whether the process is a repair, or a manufacturing process using new materials?

A.24 As discussed in the Staff's Testimony in response to Contention 1b, the steam generator tubing alloy, Inconel-600, maintains its mechanical strength and ductility even after prolonged service in a steam generator. Therefore, as long as the repair process is qualified by producing the tube/tubesheet joints which meet the original licensing basis of a pullout strength of greater than 3140 lbs, the structural integrity of the tubes during subsequent operation does not depend on whether the process is a repair, or a manufacturing process using new materials.

Q.25 In your professional opinion, does the kinetic expansion repair technique provide reasonable assurance that operation of TMI-1 can be conducted without endangering public health and safety?

A.25 Yes; as discussed in NUREG-1019, NUREG-1019 Supplement No. 1, Staff Motions for Summary Disposition, and in testimony in response to TMIA Contentions 1a and 1b, reasonable assurance has been provided that the kinetic expansion repair process has returned the OTSGs to

their original license basis and that there is an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture, consistent with the requirements of GDC-14.

Conrad E. McCracken

Professional Qualifications

I am Section Chief of the Chemical Technology Section in the Chemical Engineering Branch of the Division of Engineering, Office of Nuclear Reactor Regulation. My responsibilities in this position include supervision of the evaluation of all PWR's for compliance with chemistry and corrosion requirements of the Commission. Specifically, this includes evaluating the chemistry and corrosion control measures that are instituted to minimize corrosion of steam generator materials. I have served in this capacity since April 1982. Between February 1981 and April 1982 I served as a senior chemical engineer with the same branch, where my duties included the evaluation of steam generator chemistry and corrosion programs at both operating plants and plants in the licensing process.

From 1966 to 1981 I was employed by Combustion Engineering Corporation in a variety of management and engineering positions, the last of which was Manager of Chemistry Development from 1977 to 1981. During this 15-year period, my prime technical responsibility was support to operating nuclear power plants and nuclear plants in construction in the area of chemical and radiochemical sampling, analysis, data interpretation, establishing chemistry specifications and conducting laboratory experiments to verify or support nuclear plant requirements. In this capacity I made frequent visits to nuclear power plants where I physically conducted sample and analysis programs or audited the utilities' capabilities in the chemistry and radiochemistry area. During the last twelve years at Combustion Engineering, approximately fifty percent of my time was expended in areas associated with understanding and resolving steam generator corrosion problems.

From 1958 to 1966 I served in the United States Navy where I was Qualified in submarines for all nuclear duties. For three years of this period I was an instructor, responsible for teaching officer and enlisted personnel in the area of chemistry, corrosion and mechanical systems operations and control. My final duty station in the Navy was on the USS Nautilus, where I was responsible for all chemistry and corrosion control and personnel radiation exposure.

Education

I attended the University of Hartford School of Engineering and completed course work in 1970. I am a Registered Professional Corrosion Engineer.

Paul C. S. Wu
Chemical Engineering Branch
Division of Engineering

Professional Qualifications

FIELD: Corrosion and Water Chemistry

TOTAL EXPERIENCE: 19 years

NUCLEAR: 16 years

KEY RELEVANT EXPERIENCE

- Principal Engineer, Materials and Corrosion Programs at Westinghouse ARD
- Supervisor, Mechanical Properties Laboratory
- Lead Engineer, Advance Nuclear Control Material Development
- Lead Engineer, Materials and Corrosion Evaluation for Power Generating Equipments
- Lead Engineer, High Temperature Design Criteria and Method
- Lead Engineer, Low Friction and High Wear Resistant Materials Development
- Lead Engineer, Liquid Metal Corrosion and Sodium Technology

RELATED PROFESSIONAL BACKGROUND

Before joining the Metallurgy and Materials Research Branch at NRC, I was employed as a Principal Materials Engineer at the Westinghouse Advanced Reactors Division. I was responsible for many materials and corrosion programs at ARD. From 1976 to 1979, I was in charge of all materials and corrosion programs concerning aqueous corrosion and pertinent to nuclear fuel reprocessing and waste management. I was responsible for proposal preparation, research execution, and program coordination among various Westinghouse divisions and national laboratories. Prior to 1976, I was in charge of the Mechanical Properties Laboratory at ARD, and was responsible for characterizing the creep, fatigue, and stress-rupture of stainless steels and nickel-base alloys for the national program on high temperature design criteria and methods. Before joining Westinghouse, I was a research scientist at the Ames Laboratory of USAEC engaging in sodium technology and nuclear materials research.

EDUCATIONAL BACKGROUND

B.S. (Metallurgical Engineering, 1964), National Cheng-Kung University, Taiwan

M.S. (Metallurgical Engineering, 1967), University of Missouri at Rolla, Rolla, MO

Ph.D. (Materials Science and Inorganic Chemistry, 1972), Iowa State University, Ames, Iowa

MANAGEMENT TRAINING

- Management Techniques, Westinghouse Learning Corporation
- Decision Making, Westinghouse Learning Corporation
- Communication Skills, Westinghouse Learning Corporation
- Fracture Mechanics, Westinghouse Headquarters Engineering

HONORS AND ACHIEVEMENTS

- Who's Who in Technology
- Member of the American Honorary Chemical Society
- Member of the Review Board of TMS and ASM Publications
- Member of the NACE Committee on Stress Corrosion Cracking
- Member of the NACE International Relations Committee
- Westinghouse Advanced Reactors Division Cost Saving Award (1975)
- Technical Program Chairman, Pittsburgh Diffraction Conference (1976)

PUBLICATIONS AND PRESENTATIONS

I have published more than 30 technical papers and reports on subjects covering corrosion, materials evaluation and selection, mechanical properties of engineering alloys, sodium technology, friction and wear of materials, nuclear control material development, fuel reprocessing technology, and waste management. In addition, 8 invited presentations at Stanford Research Institute, ANL, ORNL, Sandia Laboratory and other research institutions have also been accredited to me.

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JUDGE WOLFE: Ms. Bradford, cross-examination?

CROSS-EXAMINATION

MS. BRADFORD: On page 2 of your testimony, regarding your assertion that cracks less than 70 percent through-wall won't rupture, what degree of confidence do you have in that statement?

WITNESS McCRACKEN: I have absolute confidence in that statement. I have performed calculations; additionally, I have run tests on tubing doing exactly those types of tube rupture tests.

MS. BRADFORD: To your knowledge, have leaks or ruptures ever been found in any reactor with tubes with less than 70 percent through-wall cracks?

WITNESS McCRACKEN: By definition, if it leaks or ruptures, it has to be 100 percent through-wall.

MS. BRADFORD: However, reported from a last inspection as being less than 70 percent through-wall.

WITNESS McCRACKEN: You can have a report of a depth of degradation on a tube in one inspection, and that degradation in some instances can increase prior to another inspection, or it can increase during an operating period and subsequently leak.

MS. BRADFORD: What is the rate of degradation?

WITNESS McCRACKEN: The rate of degradation in relation to what?

MS. BRADFORD: In the steam generator tubes.

WITNESS McCRACKEN: The rate of localized degradation, which I assume is what you must be asking about, is totally dependent on the chemical environment that you are operating in the specific steam generators. So there is no one given rate of degradation that you can state. You would have to assess the individual conditions on a case-by-case basis.

MS. BRADFORD: On page 3 of your testimony, the first paragraph, starting with "The 40 percent plugging criteria includes an uncertainty allowance for determination of the depth of degradation and a corrosion allowance for continued degradation during the next operating period," that operating period, is that generally a 12-month period?

WITNESS McCRACKEN: No. As referred to here, that operating period can be a 12-month period; it can also be a shorter period if we have determined that the rate of degradation is such that you would reach the 70 percent through-wall degradation in that time frame.

In other words, if we looked at the rate of corrosion as a non-entity and said that in six months we would anticipate approaching the 70 percent through-wall, then we would say: shut down and reexamine in six months. That way you insure that you have maintained the margin of failure that you need to maintain through that operating period.

MS. BRADFORD: The next paragraph, about half-way

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through the paragraph, you state, "This is accomplished by assuring ourselves that either the steam generator has been returned to its original licensing basis..." "Original licensing basis" as you use it in this sentence here, does that mean as manufactured?

WITNESS McCRACKEN: The original licensing basis, if I'm interpreting your question correctly, includes a consideration of how it is manufactured. This specific area we are talking about tube integrity only, and the tube that is used, the material that is used, is reviewed in the licensing basis to insure that it will meet the ASME Boiler and Pressure Vessel Codes.

MS. BRADFORD: Let me state that to you another way. When a plant is licensed everything is just built, and that is when the original licensing basis is set; that's when it is determined?

WITNESS McCRACKEN: The licensing basis is a series of documents or general design criteria that we use to review and insure that plants meet the safety goals we have.

MS. BRADFORD: When a plant is first licensed to operate a new plant, are the original licensing bases designed at that time for a new plant, and does that include the steam generators?

WITNESS McCRACKEN: The licensing bases which we have are basically that a plant meet our general design criteria,

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which insures that it is manufactured in a way such that the public health and safety may be protected.

To meet that licensing basis, we refer to several standard codes, ASME Boiler and Pressure Vessel Codes. When a product is manufactured, it is up to the manufacturer and the licensee to verify that that product is manufactured to be consistent with that code. They typically design it to exceed the code so that there are margins in excess of the code involved in the actual design of the component.

MS. BRADFORD: When you set that original design basis, that is when the leak rate is established on that design basis?

WITNESS McCRACKEN: That's the original licensing basis. The licensing basis permits a leakage, by technical specifications, of up to one gallon per minute for this particular plant.

MS. BRADFORD: Does that anticipate a 60 gallon per hour leakage from a new steam generator?

WITNESS McCRACKEN: No, that's one gallon per minute.

MS. BRADFORD: That's 60 gallons per hour; that's what I thought I said.

WITNESS McCRACKEN: I'm sorry.

MS. BRADFORD: Is the answer to that yes?

WITNESS McCRACKEN: The answer to that is yes.

MS. BRADFORD: And the source of this leakage is either one or multiple tubes?

WITNESS McCRACKEN: Yes.

MS. BRADFORD: One of the conditions that you had set up on the Licensee was -- just a moment; let me check that.

(Pause.)

MS. BRADFORD: License Condition 3 in NUREG-1019 states the conditions and the times for eddy current examinations; that those periods are either 90 days after reaching full power or 120 calendar days after exceeding 50 percent power, whichever should come first; is that correct?

(Witness McCracken nodding affirmatively.)

MS. BRADFORD: With the 90 or 120-day shutdown determination factors and the precise rate of degradation, is it possible that the rate will increase over time?

WITNESS McCRACKEN: As I stated in this particular testimony, the 90 to 120 days is not based upon a predicted rate of degradation. The degradation, based on all the testing and analysis that has been done so far, shows that it is not progressing. Therefore, this is simply a conservatism by the staff where we have elected to have the Licensee shut down an eddy current test after a nominal operating period; but it is not based on the known rate of degradation.

If we went simply on the known rate of degradation, then, by technical specifications, the Licensee could have

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operated until the next normal refueling shutdown in 12 to 24 months.

MS. BRADFORD: To your knowledge, is there any other nuclear reactor plant similar steam generator that has had degradation detected during an outage greater than that which had been anticipated?

WITNESS McCRACKEN: When you say "detected during an outage" are you referring to shutting down eddy current testing and then you find that it corroded faster than you expected it would? I'm not sure exactly what you're asking.

MS. BRADFORD: They have various ways of measuring leak rate, and from there they can determine approximately what kind of degradation there might be. They can anticipate -- I'm sure there are limited amounts of degradation that would cause leakage.

What I'm saying is, to your knowledge, has degradation ever been detected once they shut down which was greater than that which they expected?

WITNESS McCRACKEN: I guess I still have problems with -- I'm sure that there are some people who have seen degradation in excess of what they expected. I'm not sure that those are people who technically had evaluated what was going on and made a determination based on facts.

MS. BRADFORD: Has a crack proceeded through-wall in any other steam generator more quickly than that which had

been estimated?

WITNESS McCRACKEN: I think I still have the same problem, which is: who is estimating?

MS. BRADFORD: Either the NRC or the owner of the plant.

WITNESS McCRACKEN: When you do an evaluation of a plant to determine whether you have reasonable assurances that it can continue to operate, you are looking for reasonable assurances that you will not get a tube rupture.

If a tube has a small indication on it and that indication grows and you get minor leakage from it, that does not constitute a tube rupture. Therefore, that is anticipated, and you have reasonable assurances that you will, in fact, get that leak, which is one of the things that tell you that it is then time to shut down and reexamine. So that leak occurs prior to the tube rupturing.

JUDGE WOLFE: I think now might be a good time for our luncheon recess. We will recess until a quarter of 2:00.

In the meantime, Ms. Wagner, I have had casion to wonder -- and I am particularly interested in your reasoning behind it, for only introducing into evidence excerpts from the SER and Supplement 1 thereto.

What gives me some concern is that when the Board writes its decision, it is going to have to have something on the record with regard to the kinetic process itself, how it

works, to give the reader some background on what this process is, undisputed facts, background.

I leave this up to you. You know what's in the record. But I am thinking, you have offered pages 2 and 4 of the SER, and at page 2 there appears to be the beginning of the description of the repair method. I don't think anybody would quarrel with that. Then you excepted page 3, which is a continuation of the description of the method, and I don't know what you're going to rely on to propose facts to the Board on this process; but I can tell you now, if it's not in the record, the Board is not going to make a finding, and somebody is going to read this and is going to say: what is the Board talking about and why didn't the Board make better findings?

That is up to you; I'll drop it there.

MR. CHURCHILL: Could I comment briefly on that?

JUDGE WOLFE: Yes.

MR. CHURCHILL: Two points; I think probably that the Board is free to take administrative notice of background material like that as is contained in the SER and the SER supplement. It is background that is needed for the reader; I understand that.

Secondly, there is a lot of material that goes into the description of the repair in our Statements of Facts, and the Staff's, and the Motions for Summary Disposition which have been granted by the Board. Those have now become undisputed

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facts which are, in fact, on the record and are available to the parties to use in their proposed findings, as well as to the Board.

We, for example, when we submit our proposed findings, would -- which would be in the form of a proposed initial decision, which is the practice before the boards in hearings of this type -- rely on the information in both ours and the Staff's Motions for Summary Disposition, the factual information which has been found by the Board to be undisputed and, therefore, not in dispute, and our facts that are on the record.

Under 2749 those facts which were not contested --

JUDGE WOLFE: Once again, Mr. Churchill, you're a better judge of what is on the record than the Board is at this point.

If Staff is satisfied with its documents, written testimony, whatever presentation, fine. What I am saying is, if there are holes, now is the time to make a proper adjustment. I don't know; we worked hard on the motions, but that was a month ago. I've forgotten what's in the memorandum already.

If you think that there is a good summary and statement of facts somewhere in the Memorandum and Order, fine; but don't come back to me and say: gee, we forgot to set out a nice little summary in summary form what this process is all about.

I would drop it there. We will now recess for lunch.

(Whereupon, at 12:47 p.m., the hearing was adjourned, to be reconvened at 1:47 p.m., this same day.)

AFTERNOON SESSION

(1:45 p.m.)

JUDGE WOLFE: All right, Ms. Bradford.

Whereupon,

CONRAD E. McCRACKEN
and
PAUL C. WU

were called for examination and, having been first duly sworn, were examined and testified as follows:

CROSS-EXAMINATION (Continued)

MS. BRADFORD: At the top of page 4 you state that the license conditions for the repaired steam generators will provide adequate assurance that the probability of tube rupture remains extremely low.

To the best of your knowledge, has the Staff ever proposed license conditions which were assumed to provide adequate assurance which later proved inadequate?

MS. WAGNER: A point of clarification; is this any license conditions or license conditions for repaired steam generators?

MS. BRADFORD: For the steam generators.

WITNESS McCRACKEN: I guess I'm really not sure what question you're trying to ask me. In the area of steam generators, when there has been a corrosion concern, we have proposed license conditions.

To my recollection, in none of the cases where a

steam generator has been operating after review by the Staff, under these types of guidelines, have we ever had a tube rupture.

MS. BRADFORD: At the bottom of the page under License Condition No. 4 you state that "If the leakage exceeds the baseline leakage rate by more than 0.1 gpm, the plant shall be shut down and leak tested."

During the incidents that were the subject of the recent PNOs, was the leakage rate exceeded?

WITNESS McCRACKEN: Could the leakage rate be what, please?

MS. BRADFORD: Exceeded; was that 0.1 gallon per minute exceeded during any of those most recent events, to your knowledge?

WITNESS McCRACKEN: I'm not sure which most recent events you are talking about.

MS. BRADFORD: One moment, please.

(Pause.)

MS. BRADFORD: Since the Licensee recently did their hot functional testing there have been three incidents of leakage. I am asking you: to your knowledge, do you know if, during any of those incidents, this 0.1 gallon per minute limit has been exceeded?

WITNESS McCRACKEN: We're speaking purely now of the TMI-1 once-through steam generators?

MS. BRADFORD: Correct.

WITNESS McCRACKEN: Since the repairs?

MS. BRADFORD: Correct.

WITNESS McCRACKEN: To my knowledge, they have not been exceeded.

MS. BRADFORD: On page 5, answer 5, you state that "Bowing, if it occurs, will limit the compressive forces which exist."

Does the tube then stay in that bowed position?

WITNESS McCRACKEN: Only during the heatup. The bowing is something that occurs due to a differential in average tube temperature versus average shell temperature in the steam generator. Because the average shell temperature is very cold or relatively cold during the heatup, the tube is getting hot more quickly because those inner walls tend to expand more rapidly.

So, during the heatup process, there is a time period when the tubes actually go into more compression or the maximum compression they see. As soon as the plant is fully heated, which would take a period of maybe eight or ten hours, then they equalize and they go to normal operating pressures; and at that point that compressive load is reduced to whatever the normal operating load would be.

MS. BRADFORD: Then the tube will straighten?

WITNESS McCRACKEN: Yes.

MS. BRADFORD: How much do you anticipate the tube

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would bow under those conditions?

WITNESS McCRACKEN: The maximum, based on the Licensee's calculations, which we independently looked at through one of our contractors, was a deflection of less than a quarter of an inch, because that's a deflection that would have it contact the tube most adjacent to it.

MS. BRADFORD: So there is a space of a quarter-inch between the tubes?

WITNESS McCRACKEN: Yes.

MS. BRADFORD: If such a bowing condition would exist and there were a less than 40 percent crack, would that be sufficient bowing on the tube, if it should bow in the area of the crack to less than 40 percent, would that open that crack?

WITNESS McCRACKEN: No.

MS. BRADFORD: On page 6, in reaching the decision of a 90 to 120-day inspection, can you tell me how you arrived at that decision?

WITNESS McCRACKEN: Yes. The original 90 days I selected because I felt that provided sufficient operational time to get the system running and to establish normalized chemistry control conditions and a sufficient period of time, if any unanticipated corrosion was progressing, that we would be able to find or detect it if it were there. So I felt it was long enough to give me that kind of assurance.

The 120 days I put in later on when I realized that the Licensee was not, in fact, going up to full power in a normal manner, which typically would take two weeks to 30 days, which is what I had originally assumed. When I found they were not going up that fast in power, they chose to go up at a slower rate of power, I put in the 120 days to put an additional limitation in to make sure we looked at it in the event they held at low power for a longer period of time.

MS. BRADFORD: Are you familiar with a memorandum of May 19, 1982, from William Johnston to Thomas Novak, Assistant Director for Operating Reactors; and the title of that document is "Staff Evaluation of TMI No. 1 Steam Generator Corrosion Problem."

Are you familiar with that?

WITNESS McCRACKEN: Yes, I'm familiar with that.

MS. WAGNER: Excuse me, Judge Wolfe. If there is going to be examination on this document, I don't have a copy myself, but Mr. McCracken does.

Do you mind if I look over his shoulder?

JUDGE WOLFE: Not at all; go ahead.

MS. BRADFORD: Mr. McCracken, did you have any input into this document?

WITNESS McCRACKEN: Yes, I did. I wrote it. If you notice, on the left-hand corner here at the bottom of the front page it says, "Contact C.E. McCracken." In NRC language

that means that's the originator.

JUDGE WOLFE: Who is Mr. Johnston and who was the receiver?

WITNESS McCRACKEN: Mr. Johnston is the Assistant Director of the Materials and Qualifications Engineering Branch in the Division of Engineering, who is my superior.

My Novak was the Assistant Director of Operating Reactors at that time who had responsibility for the group that had Three Mile Island under its control.

MS. BRADFORD: In this document you express a number of reservations concerning the proposed repair; is that correct?

WITNESS McCRACKEN: That is correct.

MS. BRADFORD: What caused you to change your opinion?

WITNESS McCRACKEN: I didn't change my opinion. The reservations I had, as I stated there on May 19, 1982, was that the repair process which was going to be conducted could have been conducted by the Licensee under some interpretations under what is called 10 CFR 5059, which means there would have been no NRC involvement or review; the Licensee could have done it under their own license.

I felt that the corrosion was of a sufficient magnitude, and the type of repair they were using was, at that time, not clearly defined yet as to what they were going to do --

there were questions about the corrosion process -- that we, the Staff, should definitely review that whether we were involved in a technicality of whether we were legally entitled to or not. That memo is to express the opinion that we should review it.

MS. BRADFORD: On page 3 of the document, item d, it states: "Operate for 30 to 60 days, then shut down and eddy current test to assess progression of degradation."

WITNESS McCRACKEN: Yes.

MS. BRADFORD: That is a different time schedule from the 90 to 120 days.

WITNESS McCRACKEN: Yes, it is.

MS. BRADFORD: What caused you to change your mind?

WITNESS McCRACKEN: In May of '82 we did not know the exact corrosion mechanism, we did not have the information available on what any rate of progression would be. Since that time we have received a large amount of information on the rate of progression, the type of attacks, the corrosive species, et cetera. Most of that was discussed, I think, in quite a bit of detail in the Summary Disposition Motions.

MS. BRADFORD: On the estimated rate of degradation for these tubes, what is the rate of degradation?

WITNESS McCRACKEN: We do not estimate that there will be a rate of degradation. Everything we have right now

shows that the corrosion mechanism which was active has now ceased at TMI-1.

MS. BRADFORD: Is the corrosion from the primary side the only method of degradation? I mean, are there not other factors?

WITNESS McCRACKEN: That's the only method that we evaluated in this particular case. There are other means of having degradation, secondary side or so on; any plant can have them. But certainly that was not a consideration in this particular instance.

MS. BRADFORD: Can you tell me why not?

WITNESS McCRACKEN: Because the instances prior to this degradation at Three Mile Island Unit 1 had shown that they really did not have any significant problem with secondary side corrosion compared to what other plants in the industry had, and their eddy current examinations that they conducted as part of this test verified that there were no new or unique or novel situations that occurred on the secondary side.

MS. BRADFORD: Are there other means by which a tube would become degraded other than chemical degradation?

WITNESS McCRACKEN: Tubes can become mechnically degraded; they can rub or wear.

MS. BRADFORD: Is one of the problems with steam generator tube degradation throughout the industry that the NRC has been examining a problem with loose parts?

MS. WAGNER: I object to that question on the grounds that I don't see its relevance to the contention that we're litigating right now, which is the method of determining frequency of eddy current tests.

MS. BRADFORD: It seems to me, Judge Wolfe, that all of these things that could impact on the degradation of the steam generator tubes should be --

JUDGE WOLFE: What does it have to do with eddy current testing?

MS. BRADFORD: Because all of those elements are present in -- or at least I haven't heard any discussion that they have been eliminated. So that that would be in addition to the primary contamination --

JUDGE WOLFE: Are you saying that eddy current testing tests for loose parts?

MS. BRADFORD: No; no. That the possibility of degradation caused by loose parts should also be factored into a decision on how frequently the steam generators should be eddy current tested.

JUDGE WOLFE: The question is eddy current testing and the adequacy behind it; does it pick up deterioration or does it not? That's the only question before us.

Sustained. Next question.

MS. BRADFORD: Did the secondary side environment at TMI-1 steam generator in any way impact on your decision as

to the frequency of eddy current testing?

WITNESS McCRACKEN: No.

MS. BRADFORD: You did not consider that?

WITNESS McCRACKEN: The secondary side of the steam generator was not part of this corrosion process or the repair process.

MS. BRADFORD: So it did not factor into your --

WITNESS McCRACKEN: No.

MS. BRADFORD: On page 7 --

WITNESS McCRACKEN: Are we back to my testimony, or are we still on the May memo?

MS. BRADFORD: Page 7, I'm sorry, of your testimony. At the middle of the page, the last paragraph of question 6, you say "If continued degradation is detected, an additional midcycle inspection may be required."

When will this degradation be detected? Are you referring to a 90 or 120-day --

WITNESS McCRACKEN: Yes, I'm referring to the 90 to 120-day inspection.

MS. BRADFORD: And you will then make some estimate of the rate of degradation?

WITNESS McCRACKEN: We will then be able to make a very accurate estimate on the rate of degradation, because we would have two data points showing what it was before it operated and what it was after that operating time period.

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MS. BRADFORD: When you use the term "midcycle," would you please just elaborate on that a little bit for me?

WITNESS McCRACKEN: Midcycle simply means any time between the beginning and end of the fuel cycle. It doesn't refer to any specific time frame, but just to the midcycle. It is somewhere in the operating cycle before you have to refuel.

MS. BRADFORD: I see. So this could be a period of many months?

WITNESS McCRACKEN: I believe the fuel cycle at Three Mile Island Unit 1 is 12 months. That is speculation. I could be wrong; it could be 18. I think it's 12. But any decision to go back in and re-eddy current test based on the results of the 90 to 120-day inspections would not be based on how long the fuel cycle is, but would be based on any evidence of continued corrosion that was found.

MS. BRADFORD: In answer 7 on that same page, about half-way through that last paragraph, you say that the leak rate limits for TMI are as restrictive or more restrictive than those which are typically implemented after steam generator repairs.

WITNESS McCRACKEN: That's correct.

MS. BRADFORD: In your May 19 memo, you have said -- I'll find it for you in just a minute.

(Pause.)

MS. BRADFORD: Mr. McCracken, my copy is an exceedingly poor copy, but I'm going to ask you: did you make the statement in this May 19 memo that the leak rate limit for TMI was the most liberal?

WITNESS McCRACKEN: That's correct.

MS. BRADFORD: And do you still feel that to be true?

WITNESS McCRACKEN: The leakage rate limit for Three Mile Island Unit 1 is the same leakage rate limit for Tech Specs, 1 gallon per minute, that the majority of operating reactors have, pressurized water reactors. That is the most liberal limit that any plant has.

There are very few that have lower limits than that for total leakage.

The tenth of a gallon per minute which we are proposing here as a license condition is one-tenth of that number, and that is the most restrictive limit that we have ever put on a plant.

MS. BRADFORD: Were either of you involved in the testing of the process, the kinetic expansion process, and its suitability to the TMI steam generators?

WITNESS McCRACKEN: Yes.

MS. BRADFORD: In what capacity were you involved in that process?

WITNESS McCRACKEN: The responsibility had included

the overall evaluation of the corrosion problem, the repairs, the return to service.

Part of that was the evaluation of the kinetic expansion repair process. So I was intimately aware of what was going on with the qualification test programs, how they were formulated, the basis for them.

MS. BRADFORD: Did you do any testing yourself as the NRC to evaluate the repair process?

WITNESS McCRACKEN: Yes. We had Franklin Research Center review many of the things that the Licensee did at the Licensee's facilities, plus the test blocks which were discussed this morning by Mr. Slear; we also had one of those that we independently tested to verify the results that they were getting.

MS. BRADFORD: That was the -- I've forgotten the laboratory name.

WITNESS McCRACKEN: Franklin Research Center.

MS. BRADFORD: What sample size -- of the tests that the Franklin Research Center did, what was their sample size -- let me withdraw that question and pose another.

The tests that you did, did they involve using steam generator tubing materials and expanding them?

WITNESS McCRACKEN: They did a series of tests in addition to evaluating and watching and observing what the Licensee did. We did two separate things. We, one, went to

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watch the Licensee and observe what they did, reviewed their calculations, methodology, the procedures whereby they did things, to assure ourselves that they were using proper procedures and methods.

We then independently, using those same procedures and methods, took test blocks and had tubes expanded and verified ourselves that we could achieve the same results that the Licensee did independently.

MS. BRADFORD: How large was the sample size that the NRC used?

WITNESS McCRACKEN: We had one of the ten-tube test blocks, and I forget how many single-tube specimens we used.

MS. BRADFORD: And these were tubes from the actual steam generator?

WITNESS McCRACKEN: No, these were archive tubing that had been heat treated along with the test blocks to simulate the same condition that they would have seen after operation.

MS. BRADFORD: Has the NRC conducted its own independent long-term corrosion test?

WITNESS McCRACKEN: We have not tried to duplicate the long-term corrosion tests under anticipated operating conditions that the Licensee has been conducting. We have reviewed those tests thoroughly to assure ourselves that we believe they

are applicable.

MS. BRADFORD: Are you aware of any other nuclear power plant which has conducted repairs as extensive as were conducted at TMI?

MS. WAGNER: For clarification, what kind of repairs are you talking about?

MS. BRADFORD: I'm sorry; repairs on their steam generator tubes.

WITNESS McCRACKEN: That would be a hard question to accurately quantify. A number of steam generators have had to go through extensive repairs. A lot of them have installed something called sleeves, which is another alternative to plugging.

I certainly think the magnitude of the repair process itself in some of those generators was probably equal to the magnitude of the repair process at Three Mile Island Unit 1.

MS. BRADFORD: Do you know the age of those plants?

WITNESS McCRACKEN: The oldest one, I believe, started in 1968.

MS. BRADFORD: Were any of those plants kinetically expanded, repaired by the kinetic expansion repair method?

WITNESS McCRACKEN: There have been some non-U.S. plants that have used the kinetic expansion method to expand tubes after going into service. I am not --

MS. BRADFORD: Does the NRC typically inspect those plants?

WITNESS McCRACKEN: We don't inspect those plants. We do have access to that type of information, usually on a proprietary basis, from the country which they exist in.

MS. BRADFORD: On page 16 of your testimony you state that there is no need for hardness measurements on repaired tubes.

What is the basis for that statement?

WITNESS McCRACKEN: I think I would like to defer to Dr. Wu and have him answer that.

WITNESS WU: Based on our review of the Licensee's failure analysis and the results it provided to us in the corrosion examination of the failed tubes and the contaminant that they identified which caused the failure in the first place, and based on our staff review and also the consultant independent tests conducted at the Brookhaven National Laboratory, we have established and agreed with the Licensee that the causative agent for the corrosive process has been determined.

Also, we have verified independently that the corrosive contaminant has been eliminated from the source.

In addition to that, the Licensee has conducted 100 percent eddy current inspection. Based on their eddy current inspection results, they have taken out of service any tube that shows degradation in the free span. Also, for all the

tubes which have degradation in the tubesheet that were repaired, then the test has been done that they withstand the maximum anticipated design accident load of 3,140 pounds. Therefore, --

MS. BRADFORD: Excuse me, Dr. Wu; my question went to the hardness measurement.

WITNESS WU: I'll get to that after I describe the basis for our rationale for why a hardness test is not -- so, we have determined clearly that the corrosion mechanism has been well-established by the Licensee, and we verified independently that sulfur-induced stress corrosion cracking was, indeed, the mechanism which caused the failure.

Now, in a stress corrosion analysis for stainless steel, nickel-based alloy, for any alloy, hardness is not a parameter that enters into the consideration or analysis of stress corrosion cracking.

For stress corrosion cracking normally we evaluate on the basis of material properties, such as the microstructure sensitization, as you know, and the stress and the contaminant. Hardness is not a material property that entered into the evaluation of stress corrosion cracking.

MS. BRADFORD: Is hardness a factor in the ductility of metal?

WITNESS WU: Yes. For a given alloy, increasing the hardness increases the ductility.

MS. BRADFORD: And we have heard earlier testimony that the kinetic expansion process will increase the hardness factor and thereby decrease the ductility of the metal.

WITNESS WU: As I recall, in our evaluation and also the Licensee's testimony previously, the kinetic expansion process -- the amount of hardness increase, they testified and our review of the results indicated, is less than the hot roll condition, which is consistent. The less increase in hardness allows more ductility remaining than the hot roll process.

MS. BRADFORD: But the NRC did no tests to discover what the actual condition and the measurements of hardness were.

WITNESS WU: We did --

MS. WAGNER: Excuse me; I'm not sure I heard a question. Is that a question?

MS. BRADFORD: Yes.

WITNESS WU: We did analysis, although the NRC did not do testing in this particular case. But in the technical community and open literature there is plenty of test results available. Based on those results and our own analysis, we find the Licensee's results were consistent. In other words, the hardness -- the increase in hardness was less than the hot roll condition, therefore, the amount of ductility will be remaining in the kinetic expanded tubes.

MS. BRADFORD: Dr. Wu, will you just give me a yes

or no answer, and then if you wish to expand on it, that's fine.

WITNESS WU: Okay.

MS. BRADFORD: What I'm asking is: did the NRC independently do their own hardness tests after the repair program?

WITNESS WU: We did not do it. The reason why? It is not necessary.

MS. BRADFORD: On page 17, answer number 23, you have stated that "The transition zone is located a minimum of 17 inches deep" into the tubesheet; is that correct?

WITNESS McCRACKEN: That is correct.

MS. BRADFORD: Is this a measurement from the lower face of the upper tubesheet?

WITNESS McCRACKEN: No, it's a measurement from the top face to the upper tubesheet, which is where you would have to go down through if you were going to try to do something.

MS. BRADFORD: I see. That was just a clarification question.

At any time were the samples of the tubes pulled from the steam generator at TMI-1, were they available to NRC -- or any portion of those tubes -- for testing?

WITNESS McCRACKEN: Yes, they were.

MS. BRADFORD: Was it possible or would it not have been possible for the NRC to have conducted an out-of-generator tube expansion on those samples?

WITNESS McCRACKEN: It may have been physically possible to do so. We chose instead to have our consultants and our staff people go to the places where the Licensee was doing this and look over their shoulders as they were doing the work and doing the evaluations.

We felt that was a better way to handle the number of radioactive tube samples that were available.

MS. BRADFORD: And you did not suggest that hardness tests should be done?

WITNESS McCRACKEN: Absolutely not.

MS. BRADFORD: For the reasons you stated.

WITNESS McCRACKEN: Yes.

MS. BRADFORD: Can you tell me, what is a probabilistic risk assessment study? How do you go about determining a probabilistic risk of a simultaneous tube rupture, for instance, in both steam generators?

MS. WAGNER: Excuse me; I'm not sure what issue you're questioning on now.

MS. BRADFORD: I withdraw the question.

In your opinion, are the steam generators -- if no license conditions were imposed, would the steam generators be safe to operate at TMI?

WITNESS McCRACKEN: Yes, they would.

MS. BRADFORD: For how long; a two-year period?

WITNESS McCRACKEN: They would be safe to go within

their normal Tech Specs and their normal operating cycles, which means, my belief is, they would be capable of running until the next refueling outage, which is when they would then be scheduled to do another eddy current test.

The current Tech Spec limits which they have of 1 gallon per minute total, plus the requirement that they would have to reinspect at the end of the fuel cycle, I think would be sufficient to assure that the plant would operate safely.

MS. BRADFORD: The past few days we have heard testimony from Licensee witnesses who have testified to how you have done a review of the industry for successful application of this method.

In your knowledge, do you know of any plants where there were unsuccessful experiences, similar?

WITNESS McCRACKEN: In my experience -- and I have extensive experience in my past with kinetic expansion processes and repair processes -- I have found that a kinetic expansion process is a more reliable, more easily controlled process than is the rolling process.

In the case of Combustion Engineering -- I forget the total number of plants operating now; I think it's somewhere around 13 or 14 -- all steam generators have received a full-depth expansion of the tubes using the kinetic expansion process. That process has expanded the tubes to the very surface of the tubesheet. In other words, the expanded surface, rather than

being indented two inches minimum, as it is here at Three Mile Island, is actually right at the surface of the tubesheet.

There have been no instances of corrosion, cracking or any other types of failure mechanisms in those tubes at that transition joint in those generators.

MS. BRADFORD: Were those once-through generators?

WITNESS McCRACKEN: No; those are U-tube steam generators.

MS. BRADFORD: Does that make a difference in the pressures experienced by the tubes?

WITNESS McCRACKEN: I guess I'm not sure what you mean by "pressures." The operating pressures of the two systems are similar; their pressures and temperatures are similar.

MS. BRADFORD: Do those tubes experience loads similar to a once-through steam generator?

WITNESS McCRACKEN: Those tubes did not, by original design, experience loads similar to once-through steam generators. Unfortunately, due to corrosion mechanisms in some of the U-tube steam generators, some of the tubes have become fixed, as they are now in once-through steam generators, and they do experience loads on heatup and cooldown.

MS. BRADFORD: I have no further questions.

JUDGE WOLFE: Mr. Au?

CROSS-EXAMINATION

MR. DORNSIFE: Is it your understanding that RM-A5L

is the primary monitor for detecting increased leakage from the primary system to the generator?

WITNESS McCRACKEN: RM-A5L is the low-range monitor and it is the monitor which provides the most rapid indication of any increase. Whether you would say that is the primary monitor, I don't think I would call it the primary monitor because they also use grab samples as a monitor.

So I think they use both simultaneously. I would say there are two primary monitors; one, grab samples, and one, continuous.

MR. DORNSIFE: But RM-A5L is the on-line monitor, primary on-line monitor?

WITNESS McCRACKEN: It is the one on-line monitor coming off the condenser off-gas system which would give you the most rapid response time in the event of a primary/secondary leak.

MR. DORNSIFE: NRC Staff has proposed now no license conditions for operating without that monitor available; correct?

MS. WAGNER: Objection. I'm not sure what issue this relates to.

MR. DORNSIFE: Leak rate measurements, the reliability of leak rate measurements.

MS. WAGNER: Could I hear the question again? Would that be all right?

MR. DORNSIFE: The NRC Staff has not proposed any

license conditions for operating without this monitor, --

JUDGE WOLFE: Without what?

MR. DORNSIFE: RM-A5L -- is that correct?

JUDGE WOLFE: Do you have an objection?

MS. WAGNER: I will withdraw the objection.

WITNESS McCRACKEN: We have not imposed or proposed a license condition on operability of that monitor, nor do we do that at any plant.

MR. DORNSIFE: What would you consider to be an acceptable period of time with a leak rate above the administrative leak rate limit, not having an on-line monitor available that may alarm at that administrative leak limit?

WITNESS McCRACKEN: I think when you say "administrative leak limit" you're talking about the .1 gallon per minute leakage rate which we also have as a proposed license condition.

MR. DORNSIFE: That's correct.

WITNESS McCRACKEN: If they exceed the proposed license condition, I anticipate that they would take the action that Mr. Slear discussed earlier, which is, they will start an orderly plant shutdown. Whether that monitor is available or not, I think, really affects you little if you're in the process of an orderly plant shutdown.

MR. DORNSIFE: My point is that if that monitor is not available, the alarm function of that monitor is not

available, wnich I understand is set at the administrative leak limit, how long would the Staff consider to be an acceptable time period operating above that administrative leak limit before a grab sample or some other device might be noticed by the operator?

WITNESS McCRACKEN: The current procedures, as we understand them, are that they take samples by grab sample every eight-hour shift. That means the longest period of time you could run between a prior no-alarm reading and an alarm occurring would be one shift, assuming it was a small leak; it would have to be a small leak. If you had any kind of a large leak, there are many other indications that would tell you that.

So the longest period of time they could run with a small leak exceeding the .1 gpm would be about eight hours.

MR. DORNSIFE: And Staff has reviewed and found that acceptable?

WITNESS McCRACKEN: Yes.

MR. DORNSIFE: I have no further questions -- wait; one more question.

CROSS-EXAMINATION

MR. AU: Turning to your prepared testimony at page 6, you state a proposed License Condition No. 3. You prepared that license condition; is that correct?

WITNESS McCRACKEN: That's correct.

MR. AU: Do you construe that to mean that the

Licensee shall conduct eddy current examinations 90 days after first reaching full power even though the Licensee may not maintain full power after the first instance?

WITNESS McCRACKEN: Yes. I consider that to be after first reaching full power or the 120 days after first reaching 50 percent power, regardless of what he does subsequently.

MR. AU: Thank you.

JUDGE WOLFE: Mr. Churchill?

MR. CHURCHILL: Your Honor, I don't think I have any cross-examination. There is one possible question, but I have to find some information in a document. I wonder if we could just go on, and if I have that later, perhaps I could reserve my right to ask that one question. I may not have it, but it might turn up.

MS. WAGNER: Do you think it would take you long to find it?

MR. CHURCHILL: If I don't find it pretty soon, we'll abandon it. I know he'll be here and I don't want to hold up the proceedings.

MS. WAGNER: I have a couple questions.

JUDGE WOLFE: Fine.

REDIRECT EXAMINATION

MS. WAGNER: Mr. McCracken, do you anticipate that tube leaks will occur in the TMI once-through steam generators

during subsequent operations?

WITNESS McCRACKEN: I anticipate that any plant, when operating with corrosion processes that are available, will, at some time or another, have primary/secondary leakage rates.

I believe that the Technical Specifications that are imposed provide adequate assurances that, if those types of leaks occur, they are, one, detected, and two, responded to prior to the potential for tube rupture.

Therefore, although I do anticipate that leaks would occur here as any other steam generator, the quantity or significance of those leaks will be quite small in any effect on public health and safety.

MS. WAGNER: That concludes my questions.

JUDGE WOLFE: Board questions?

JUDGE LAMB: Mr. McCracken, on page 3 of your testimony, the second paragraph just below the middle of the page, you mention two conditions, one of which is "the steam generator has been returned to its original licensing basis."

Would you explain what you mean by that? I want to make certain there is no misunderstanding on the record as to what you mean by "original licensing basis."

WITNESS McCRACKEN: I think I went on to discuss that a little more in the remainder of this prepared testimony, but, basically, the original licensing basis looks at two

conditions, the normal operating condition that a tube would have to see and the accident or transient conditions that the tube would have to see. It compares the structural integrity of that tube to the ASME Code and verifies that, in fact, that tube with that amount of wall thickness remaining will withstand what it is supposed to withstand.

In this particular case, the licensing basis was that the tube be capable of withstanding the most limiting accident condition, which was main steam line break, and that wound up being a 3,140-pound tensile load on the tube.

The other licensing basis was the thickness of the tube for rupture or leakage; normal leakage through the tube wall, not just pull-out load. The limiting condition for that is actually -- there are two pressures you look at, the maximum pressure you could see during an accident and, by the Code, three times normal operating pressure.

In this case three times the normal operating pressure is the limiting load, and the tube has to be shown that it will withstand three times the normal operating pressure.

The 70 percent through-wall that I refer to in here, in my testimony, refers to the three times the normal operating pressure, which, in the case of these tubes, comes out to be around 7,000 pounds of pressure that they have to be capable of holding, which they are capable of holding, at 70 percent through-wall degradation.

JUDGE LAMB: When you mention in this context the original licensing basis and the return of the repaired unit to that basis, am I correct in assuming that that basis represents the minimum qualifications for the facility? In other words, the facility must be that good or better?

WITNESS McCRACKEN: Yes. What it says is that if somebody brings in a brand new steam generator which has never operated, performs an eddy current test and finds some tubes which show flaws that are less than 40 percent through-wall, it will be acceptable for that brand new unit to start in that condition.

JUDGE LAMB: So saying that the steam generator has been returned to the original licensing basis does not mean that it has been returned to its as-new basis; is that correct?

WITNESS McCRACKEN: No, it doesn't.

JUDGE LAMB: In other words, it is returned to the original minimum qualification that was the basis for licensing the plant, not the condition of the generator at the time of license, if you understand the distinction that I'm drawing.

WITNESS McCRACKEN: I understand the distinction. There are some cases when both of those could be the same thing.

JUDGE LAMB: That's right.

WITNESS McCRACKEN: But that's right, it's referring to the licensing basis, that which was found acceptable to protect the public health and safety.

JUDGE LAMB: But not necessarily the same condition that the new generator was in when installed and started.

WITNESS McCRACKEN: Not necessarily a design basis, which a manufacturer would sometimes add excess design margin over what the licensing basis is.

JUDGE LAMB: At page 11, under the rationale for proposed License Condition No. 6, you talk about the long-term corrosion lead test program, and down about the sixth or seventh line in that discussion you say, "Because this test program leads actual plant operation by more than a year" -- the present tense in that suggests a continuing type of an operation.

Do you picture that to be a continuing kind of an operation or not?

WITNESS McCRACKEN: No. When I wrote this it was still in progress.

JUDGE LAMB: Okay.

WITNESS McCRACKEN: It had not yet completed the full operating cycle. The operating cycle which they have recently completed is what we anticipated they would run; and when we wrote NUREG-1019, we assumed that the plant was going to be operational prior to completion of those tests.

Now that those tests have been completed prior to that, we will see all the results of those when they finish their examination prior to operation of the plant.

JUDGE LAMB: So these tests are -- as I understand

Licensee's testimony, these are now concluded and are actually being analyzed; is that correct?

WITNESS McCRACKEN: Yes.

JUDGE LAMB: You mentioned, if I understood you correctly, experience with the kinetic expansion process in non-U.S. plants.

WITNESS McCRACKEN: Yes, sir.

JUDGE LAMB: Can you expand on that a little bit from the point of view of the type of experience that has occurred and its value to you and to the Licensee in deciding to use the process here?

WITNESS McCRACKEN: I am not sure that I can comment on the value to the Licensee. I can comment as to the value to me in evaluating what the Licensee did.

JUDGE LAMB: Fine.

WITNESS McCRACKEN: I spent 15 years working for Combustion Engineering prior to going to the NRC. Combustion Engineering has used the kinetic expansion process in all of their steam generators' initial manufacture.

I was familiar with it as a repair process on feed-water heat exchangers, which are like a once-through steam generator lying in a horizontal position. It is a very similar application.

During a trip to Japan last year, I discussed some of the crevices that they were eliminating in Japanese plants

by the use of the kinetic expansion process and the types of controls they had on it, what they were doing, and how successful they thought it was. In the comparisons between the results using kinetic expansion and using roll expansion, the kinetic expansion process is more easy to QA and to insure a uniform result. When you get into rolling you sometimes have a lot of trouble with mechanical devices that are involved in the rolling process. You appear to get a much tighter joint, in addition to the metallurgical advantages that you gain from using the kinetic expansion process, because it doesn't give you as much cold working material.

So, in my opinion, the kinetic expansion process is a superior means of closing a crevice.

JUDGE LAMB: Is this foreign experience that you referred to in the context of manufacturing new facilities or repairing existing facilities?

WITNESS McCRACKEN: It is both. They are using it in some cases to close crevices in units which have gone into service, and also to close crevices in units in the manufacturing process.

JUDGE LAMB: This is in steam generators?

WITNESS McCRACKEN: Yes.

JUDGE LAMB: Do you know how long this process has -- first, am I correct in interpreting your statements as meaning that the utilization of the kinetic expansion process in facilities

you referred to would be very similar to the utilization on this job?

WITNESS McCRACKEN: Yes, very similar. They are steam generators of another manufacturer, but they are still steam generators. They are a 20-inch crevice instead of a 22-inch crevice. But the application is very similar.

JUDGE LAMB: Can you give us some information about the extent to which this has been used; how many and how long it has been in use?

WITNESS McCRACKEN: They were just in the process of having done this on a couple of plants when I was there over a year ago; they were starting to do it as a routine process. I can't tell you right now where they are in status.

JUDGE LAMB: Is this on a large scale in those plants; a few tubes or a great number of tubes?

WITNESS McCRACKEN: No; this was large scale. They were talking about doing entire tubesheets, not just one or two tubes.

JUDGE LAMB: Do you have any follow-up information on the results that they have observed from those, any problems they have incurred?

WITNESS McCRACKEN: To my knowledge, they have incurred no problems at all with the ones that they have repaired that way.

JUDGE LAMB: Do you know if any of these repairs involve corroded tubes similar to the situation that was present at TMI-1?

WITNESS McCRACKEN: I don't know that. I can't tell you. I didn't ask that question.

JUDGE LAMB: Are you aware of the experience using the kinetic expansion process in that fashion, that is for repair work, in countries other than Japan?

WITNESS McCRACKEN: I am not personally aware that other countries have used it. I understand that a couple may have, but I do not have firsthand knowledge of that.

JUDGE LAMB: This information was available to you, I gather, at the time you made the decision on the approvals of the repair job here?

WITNESS McCRACKEN: That's correct.

JUDGE LAMB: I am wondering the extent to which that experience that you have observed and discussed with other people entered into your decision.

WITNESS McCRACKEN: Very little. The reason that I was satisfied with this particular process is, I have had a lot of experience with it, myself, at Combustion Engineering prior to going to the NRC.

We had run a number of model boilers where we had done full depth expansion of tubes and operated them for two or three years under very extreme chemistry conditions, and then

sectioned the tubesheets.

At the end of those operating periods, you would see a tube which was still in an as-new condition. It would still be bright and shiny because it was obvious that it had never seen water or any other products near it. It just sat there the whole time because you had a relatively tight seal that had not leaked.

We had done metallurgical examinations comparing that process with the roll process, and knew that we got less work hardening of the material.

So therefore it was a process which gave a good, tight seal, plus it did less metallurgical harm to the material. So we felt it was a superior process.

JUDGE LAMB: That's new or repair jobs?

WITNESS McCRACKEN: That's new, but as we discussed in our testimony the Inconel 600 is selected specifically because it does maintain its ductility.

There was one comment I believe the first day of this hearing, and I forget who you had asked, how long Inconel 600 would last, and he said, "Well, at least the 40-year design lifetime."

If you look purely at general corrosion rates for Inconel 600, it would last significantly longer than the 40 year design lifetime. There is really nothing that is going to affect its ductility.

k3

You can have localized corrosion phenomenon as we have had at TMI-1 and other plants have. As long as you repair that localized area of defective tubing, the remainder of the tubing still maintains ductility for an indefinite period of time.

JUDGE LAMB: A lot of concern has been expressed in the past about the number of tubes, the massive size of this repair job, the number of tubes that have been repaired and the probabilities or statistical possibilities of failures of some of those tubes.

Can you address that from the point of view of the Staff with respect to safety and reliability of the repair job considering the massive number of tubes?

WITNESS McCRACKEN: Yes. Although there was a great deal of corrosion at Three Mile Island, Unit 1 steam generators, the Licensee was fortunate in that it occurred primarily in the upper tubesheet which was an area where you could restrain the tubes or repair the tubes and not be concerned about having tube ruptures in the sense that we are talking about or are worried about.

The amount of corrosion that occurred outside the tubesheet was of much more concern to the Staff than the corrosion within the tubesheet.

The corrosion within the tubesheet, the kinetic expansion repair was a relatively simple engineering process.

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I am sure they don't want to hear that, because they went through a lot of qualification, but it took a lot of qualification to make it acceptable and to reduce leakages so that they wouldn't have operational problems.

But from the point of view of tube rupture, the problem up in the tubesheet was not a very significant issue. The amount of corrosion outside the tubesheet, which is what Staff would be concerned about primarily in worrying about tube ruptures or things that could affect public health and safety, was actually significantly lower than a lot of plants that are running.

So the repairs at Three Mile Island, Unit 1 were extensive, but they were in an area that was not an area of prime worry where you'd have a tube rupture.

And I think we discussed that quite a bit in the Motions for Summary Disposition, NUREGs and so on. The only reason for leaving a two-inch unexpanded area in the bottom was simply so that you could demonstrate clearly that you would not get tube pull-out in the event the tube ever did separate.

So I think that the amount of degradation outside the tubesheet was the real concern to the Staff, and that they find everything outside the tubesheet and repair it, take care of that part of it.

And the rest of it was a long, complicated process that took a lot of work, but it was something that became

obvious rather early on that there was an engineering solution available which would be acceptable.

WITNESS WU: Your Honor, I would also like to add on this issue here, we do have concern about the great number of tubes being repaired.

However, the most important thing that we considered is whether the causative agent has been identified and the mechanism has been understood, and also the repair mechanism is qualified, and will it return the steam generator back to its original design basis.

And we have found indeed that the repair method has been satisfactory as indicated by the test results in our analysis.

Therefore, it is not a matter of how many tubes they repaired, how many tubes they find degraded; rather, we find the repair method has been well understood and qualified and the joint has been repaired, has been tested and otherwise meet all the requirements in the standards.

JUDGE LAMB: Dr. Wu, are you and other Staff members thoroughly satisfied with respect to identification of the corrosive agent as described by the Licensee in documents we received?

WITNESS WU: Yes.

JUDGE LAMB: You have no reservations on that?

WITNESS WU: I have no reservations on that.

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JUDGE LAMB: For both of you: with respect to this repair job, just looking at all the facets viewed from the point of view of health and safety, do you have any reservations about any aspect of this repair job?

WITNESS McCRACKEN: No, sir, I don't.

WITNESS WU: I don't.

WITNESS McCRACKEN: I would add to that, that that specific question I asked each of the other Staff members and our consultants as we were doing this job, as we got through every phase of it.

That question got asked of each of those people prior to putting in our final documentation accepting it.

JUDGE LAMB: Thank you. That's very helpful.

JUDGE WOLFE: You say you asked that question of each member of your Staff and the consultants at each stage?

WITNESS McCRACKEN: Yes, sir.

JUDGE WOLFE: And the answer?

WITNESS McCRACKEN: If I inadvertently left that out, I am glad to see that at least one of us are aware. The answer was that everybody was satisfied, and nobody felt there was anything wrong or any issue unaddressed which would affect public health and safety.

JUDGE HETRICK: Gentlemen, on page 10 of your testimony, answer number 10, you begin by saying that, "Proposed license conditions 1 and 2 are not intended to limit power

ascension." And then further down, you say limitations were formulated by the Licensee. "Because the Licensee elected to perform a slow, step-by-step power ascension, the staff, conservatively, proposed a license condition," et cetera.

I want to ask you why you felt you had to do anything other than simply acknowledge what the Licensee elected to do. I want to ask, is this a typical procedure to codify as a regulation or licensing issue a voluntary conservatism?

WITNESS McCRACKEN: What we elected to do here was, when we originally started proposing our license conditions, as I said in the beginning, we had assumed that they would start up and go to power and reach full power within roughly a month, as most plants typically do.

When we found out that was not going to be the case, that they were electing to go through a much more gradual process of increase in power, we felt that it would be prudent to have available to ourselves the results of each of the examinations they did as they went up in power.

That does not mean that we're going to limit anything they're doing; we're simply saying, have available to us the results of those.

And we thought the way that you had worded the discussion in your Memorandum and Order of June 1 that you were interpreting it that we were trying to limit power specifically

for this process, and we were trying to make sure that we clarified in our testimony that we're not doing that.

JUDGE PETRICK: A short while ago there were some questions from the representatives of the Commonwealth of Pennsylvania, and I'd like to clarify a point there for my own benefit.

I think you said in response to a question, there is no license condition for operation without the leak rate monitor or something related to that. Could you go over that again, please?

WITNESS McCRACKEN: Yes. The representative for the State of Pennsylvania was discussing the leakage rate monitor which is located at the exhaust of the condenser off-gas system.

What occurs when you have a primary-secondary leak is the gaseous activity comes very rapidly from the tube through the steam generator and it is then removed in the condenser off-gas system.

And you have an instrument which, as Mr. Slear said, gives you a response on an order of minutes that you know you have any kind of an increase in leakage.

That particular monitor has both a high and low range on it. The low range monitor is the one that the State of Pennsylvania was questioning us on, and the low range monitor is the one that would pick up leakage that would be at

less than a tenth of a gallon per minute. It would tell you very quickly of any increase in leakages.

And he was asking whether we had proposed any license conditions that would require some sort of operational limitation on the plant if that were not in service.

We elected not to do that, because there are other means that they use for sampling. For instance, they do have the grab sample which is taken every eight hours, which means that at most you would be without the capability to detect a small leak for a period of eight hours. And I want to point out that I am saying small leak.

The backup to the instrument they were talking about is a higher range monitor, and that would pick up leakage if you got to a leakage rate that would be around the one gallon per minute tech spec leakage limit which is currently there.

So you could only get an increase in leakage of a relatively small magnitude without picking it up by a secondary monitor which is there as a backup.

JUDGE HETRICK: Normally, are both ranges operable all the time?

WITNESS McCRACKEN: Normally, both ranges are operable all the time, and those are standard equipment for other plants. As I said earlier, this is not an instrument that we have tech spec'd on other plants.

JUDGE HETRICK: Either one of the ranges?

WITNESS McCRACKEN: Either one of the ranges, yes. They have other limits on -- I am getting outside my area of expertise, so if you could bear with me a little bit -- but they do have off-gas monitors and stack monitors where, as you're discharging this, if you had any significant activity coming out, there are other instruments there to indicate significant plant problems that would get you back into the plant to find out what's wrong.

These are to detect small leaks which would be primarily operational problems, not public health and safety issues.

JUDGE HETRICK: Do I understand correctly, though, that the plant could conceivably operate at full power for as much as eight hours without knowledge of a small leak? I am not sure how we define "small;" I guess by that I mean a leak that would be observable in one or the other of those two ranges.

WITNESS McCRACKEN: Yes. They can operate for a period of up to eight hours with a leak of less than a gallon a minute.

JUDGE HETRICK: Suppose a leak on the order of several gallons per minute or 10 or 20 should occur with both of those monitor ranges inoperable. Would it be detected by some other plant condition?

WITNESS McCRACKEN: Yes, there are other plant conditions that would tell you if you saw any significant leakage in a hurry.

JUDGE HETRICK: Do you think there would be any point in a license condition which would require the operability of either or both ranges of this monitoring system?

WITNESS McCRACKEN: No. I considered that at the time we were going through the license conditions which we had proposed, and it does provide an operational convenience to the Licensee to be able to monitor that closely.

But looking at issues that would affect public health and safety and looking at the potential difficulties with having them try to maintain that instrument on line all the time, I could conceive of them having to shut down because that instrument for some reason wouldn't be operational, they couldn't get a part for it; yet the lack of that instrument being available would really not impact public health and safety because there are other means available of knowing if they have leakage.

A leak of less than a gallon a minute for eight hours would be an extremely small leak, and certainly far below any of the allowable limits for release. They have committed to meet Appendix I, which is the tightest limits that any plant in the country has on off-site releases, so their integrated dose over the year will still be extremely small even if that

occurred for some eight-hour period.

JUDGE HETRICK: Do you think NRC Staff and perhaps you personally would be dismayed if such a license condition were proposed?

WITNESS McCRACKEN: I am sure that no matter what happens in life, people get dismayed. I don't believe personally that it's necessary. I would not like to see the plant in a position where, because that monitor isn't available, they would wind up having to shut down for any significant time.

I certainly am not going to try to preclude the Board from reviewing this case, as is your job, and deciding whether you think we have done an adequate job.

JUDGE HETRICK: Maybe I should ask a better question: do you think such a condition would be more trouble than it's worth?

WITNESS McCRACKEN: Yes.

JUDGE HETRICK: Thank you.

JUDGE WOLFE: Cross on Board questions, Ms. Bradford?

MS. BRADFORD: I have no further questions.

JUDGE WOLFE: Mr. Au?

MR. AU: No questions.

JUDGE WOLFE: Mr. Churchill, did you find that question you wanted to ask? Why don't we finish here with the cross on Board questions, and then we can come back to your

question that you wanted to ask.

MR. CHURCHILL: Actually, that one question is germane to the question that Judge Hetrick just asked. Is it my turn for cross?

JUDGE WOLFE: Cross on Board questions.

MR. CHURCHILL: That's what I will do, and that will be that question.

(Pause.)

JUDGE WOLFE: Do you have any cross whatsoever?

MR. CHURCHILL: Yes, I do.

CROSS-EXAMINATION

MR. CHURCHILL: Mr. McCracken, do you happen to have a copy of the tech specs with you for the TMI-1 plant?

WITNESS McCRACKEN: No.

MR. CHURCHILL: Would you allow that they are very, very thick?

WITNESS McCRACKEN: That's why I don't have a copy with me.

MR. CHURCHILL: I am going to ask if you think you might be slightly mistaken about whether we have a requirement to operate with the RM-A5. That's not a question, that's just a lead-in.

I think the best way to go about this is to show you a copy of my tech specs.

(Document handed to Witness McCracken.)

MR. CHURCHILL: Mr. McCracken, I have just shown you a copy of the tech specs for TMI Unit 1, and I think I have shown you one related to the question that Judge Hetrick was asking.

Does that in any way change your last answer about that?

WITNESS McCRACKEN: No, it doesn't change my last answer.

MR. CHURCHILL: It looked awfully close to what you said, so I am not even sure whether it's changing anything or not. How about a different answer other than the last answer?

WITNESS McCRACKEN: Okay. The particular incident does have in the tech spec a limiting condition for operation which I was not aware of, which basically allows that it can be out of service for 28 days providing they are taking grab samples. I was not aware they had that particular condition in this license.

JUDGE HETRICK: Excuse me. It can be out of service for 28 days; that means both ranges, or are we talking of one of the two ranges?

WITNESS McCRACKEN: The condition simply says, "Noble gas activity monitor, RM-A5," and there is an "L" and a "Hi" on it, and it doesn't differentiate between low or high.

And it simply says, "Out of action, slightly out,

under condition 27 for 28 days." And that's provided they take grab samples, which is what they do anyway.

MR. CHURCHILL: Mr. McCracken, are you aware also that GPU has a self-imposed administrative limitation such that if RM-A5 is determined to be out of service, an off-gas grab sample will be taken immediately to verify leak rate and repeated every four hours? Were you aware of that administrative limitation?

WITNESS McCRACKEN: Yes, I am aware of that.

MR. CHURCHILL: And it is correct that that is not a tech spec requirement?

WITNESS McCRACKEN: That is correct.

MR. CHURCHILL: Thank you. I have no other questions.

JUDGE WOLFE: Redirect, Ms. Wagner?

MS. WAGNER: I have no redirect.

JUDGE WOLFE: It is now 3:20. How do things look for completion this afternoon? Just an estimate; your cross-examination will be approximately how long on this last portion?

MS. BRADFORD: Not very long. I would anticipate that we will be done today.

JUDGE WOLFE: Mr. Churchill?

MR. CHURCHILL: At this point, I don't think I have any cross-examination on the last issue.

JUDGE WOLFE: Mr. Au?

MR. AU: We have very few questions, if any.

JUDGE WOLFE: Do you think we can conclude by today, or shall I make some sort of arrangement to anticipate continuing tomorrow?

MS. BRADFORD: I do not have a great deal of cross-examination.

JUDGE WOLFE: All right. We will have a ten-minute recess.

(Recess.)

JUDGE WOLFE: All right, Ms. Wagner.

MS. WAGNER: At this time, upon consideration of the Board's comments directly before lunch that it might be helpful to introduce additional pages of the SER, I would like to present certain additional pages into evidence at this time.

JUDGE WOLFE: These will be added to Exhibits Nos. 1 and 2?

MS. WAGNER: Precisely; that is, I would propose to add page three from the SER to Exhibit No. 1, and to Exhibit No. 2 I would propose to add the first page which is unnumbered entitled "Introduction" and the second page.

DIRECT EXAMINATION

MS. WAGNER: Mr. McCracken, are you familiar with page three of NUREG 1019?

WITNESS McCRACKEN: Yes, I am.

MS. WAGNER: Did you prepare it or was it prepared under your supervision?

WITNESS McCRACKEN: Yes, I prepared it.

MS. WAGNER: And would you state briefly for the record what it concerns?

WITNESS McCRACKEN: It includes a summary discussion of the repair operation.

MS. WAGNER: I would ask at this time that it be accepted into evidence.

JUDGE WOLFE: I don't know whether your mike is working or not, Ms. Wagner.

MS. WAGNER: I would ask at this time that it be accepted into evidence, that page three be accepted into evidence as part of Staff Exhibit No. 1.

JUDGE WOLFE: Any objections?

MR. CHURCHILL: No objection.

MS. BRADFORD: No objection.

MR. AU: No objection.

JUDGE WOLFE: Page three will be admitted into evidence as part of Staff Exhibit No. 1.

(Whereupon, the document marked Staff Exhibit No. 1 was received in evidence as amended.)

MS. WAGNER: Mr. McCracken, are you familiar with pages one and two of Supplement No. 1 to NUREG 1019?

WITNESS McCRACKEN: Yes, I am.

MS. WAGNER: Did you prepare them?

WITNESS McCRACKEN: Yes, I did.

MS. WAGNER: Could you state generally for the record what the subject matter of those pages is?

WITNESS McCRACKEN: Pages one and two of the supplement incorporate a clarification which discusses in a little more detail the repair process that was discussed in page two and three of NUREG 1019.

MS. WAGNER: Judge Wolfe, I would ask at this time that pages one and two of Supplement No. 1 to NUREG 1019 be admitted into the record and incorporated as part of Staff Exhibit No. 2.

JUDGE WOLFE: Any objections?

(No response.)

JUDGE WOLFE: Absent any objection, pages one and two of Staff Exhibit No. 2 are admitted into evidence.

(Whereupon, the document marked Staff Exhibit No. 2 was received in evidence as amended.)

MS. WAGNER: Mr. McCracken, are you familiar with the document entitled, "Testimony of Conrad E. McCracken and Paul C. Wu on TMIA Contention 1.b"?

WITNESS McCRACKEN: Yes, I am.

MS. WAGNER: Was this testimony prepared by you or under your supervision?

WITNESS McCRACKEN: Yes, it was.

MS. WAGNER: Do you have any changes or corrections to that testimony at this time?

WITNESS McCRACKEN: I have one typo on page eight, the last line. The word "contaminants" was misspelled. It should be A-N-T-S at the end of the word.

MS. WAGNER: As corrected, is this document true and correct to the best of your knowledge?

WITNESS McCRACKEN: Yes, it is.

MS. WAGNER: And do you adopt this testimony as your testimony in this proceeding?

WITNESS McCRACKEN: Yes, I do.

MS. WAGNER: Dr. Wu, are you familiar with the document entitled, "Testimony of Conrad E. McCracken and Paul C. Wu on TMI Contention 1.b?"

WITNESS WU: Yes, I am.

MS. WAGNER: Was this testimony prepared by you or under your supervision?

WITNESS WU: Yes.

MS. WAGNER: Do you have any changes or corrections that you would like to make to that testimony?

WITNESS WU: No.

MS. WAGNER: Is this document true and correct to the best of your knowledge?

WITNESS WU: Yes.

MS. WAGNER: And do you adopt this testimony as

your testimony in this proceeding?

WITNESS WU: Yes, I do.

MS. WAGNER: Mr. Chairman, I request at this time that the document entitled, "Testimony of Conrad E. McCracken and Paul C. Wu on TMIA Contention 1.b" be bound into the record as if read.

JUDGE WOLFE: Objection?

MR. CHURCHILL: No objections.

MR. AU: No objection.

JUDGE WOLFE: Absent objections, the identified direct testimony is incorporated into the record as if read.

(Whereupon, the Staff's testimony of Conrad E. McCracken and Paul C. Wu on TMIA Contention 1.b follows:)

June 29, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)	
)	
METROPOLITAN EDISON COMPANY, ET AL.)	Docket No. 50-289
)	(Steam Generator Repair)
(Three Mile Island Nuclear Station,)	
Unit No. 1))	

TESTIMONY OF CONRAD E. McCRACKEN
AND PAUL C. WU ON TMIA CONTENTION 1.b

Q.1 Please state your names and positions with the NRC.

A.1 My name is Conrad E. McCracken. I am the Section Chief of the Chemical and Corrosion Technology Section, Chemical Engineering Branch, NRC Division of Engineering. A copy of my professional qualifications is attached.

My name is Paul C. Wu. I am a Chemical Engineer in the Chemical and Corrosion Technology Section, Chemical Engineering Branch, NRC Division of Engineering. A copy of my professional qualifications is attached.

Q.2 What is the purpose of this testimony?

A.2 The purpose of this testimony is to address that portion of TMIA Contention 1.b. dealing with the potential for the kinetic expansion repair process to increase the probability of simultaneous tube ruptures involving both TMI-1 steam generators.

Q.3 Why is the alloy Inconel-600 chosen as the steam generator tube material?

A.3 Inconel-600 is a nickel-base alloy. Like the austenitic stainless steels, Inconel-600 is a standard engineering material for applications which require resistance to corrosion and heat. The alloy has excellent mechanical strength, its room temperature yield strength is about 40,000 psi and, at 1,000°F, its yield strength still remains above 32,000 psi. The alloy does not embrittle after long exposure to high temperatures. Test results* indicate that the alloy maintains its room temperature ductility after 2159 hours of creep test at 1000°F under 10,000 psi. Inconel-600 is highly corrosion-resistant in water and particularly it is more resistant than stainless steels to chloride-induced stress corrosion cracking. Consequently, Inconel-600 has been chosen as the steam generator tube material for the commerical nuclear industry.

Q.4 Will the Inconel-600 tubing lose its strength or material properties after a certain period of service in an operating steam generator?

A.4 As pointed out in response to Q.3, mechanical strength and ductility of Inconel-600 does not change significantly even after prolonged exposure at 1000°F. At the normal nuclear power plant operating temperature of about 600°F, there will be no significant change in mechanical properties, microstructure or carbide precipitation of Inconel-600. Consequently, the alloy is expected to maintain its original strength and ductility even after prolonged service in operating steam generators under normal operating conditions.

* "Inconel-600", Huntington Alloys, Huntington, West Virginia, 1973, at 9.

Q.5 The TMI-1 steam generator tubes are sensitized. What does sensitized mean?

A.5 Inconel-600, like the austenitic stainless steels, containing more than approximately 0.025% carbon by weight will, when heat-treated in the temperature range between 800°F and 1600°F, form grain boundary networks of chromium (Cr) carbides. The precipitation of Cr carbides along grain boundaries results in a network of Cr-depleted zones adjacent to the grain boundaries in which the Cr concentrations fall below those in the bulk of the grains. This enables the formation of electrochemical cells between the grain boundaries and the grains. This phenomenon is commonly referred to as sensitization. Austenitic alloys, containing networks of Cr carbides along grain boundaries with adjacent Cr-depleted zones, are said to be sensitized.

Q.6 What caused the Inconel-600 tubes at TMI-1 to become sensitized?

A.6 When the manufacturing process is completed, the entire OTSG is placed in a furnace and heated to approximately 1100°F to relieve stresses in the structural welds. This heat treatment leads to precipitation of Cr carbides along gran boundaries with adjacent Cr depleted zones, thus causing the Inconel-600 to become sensitized.

Q.7 What effect does sensitization have on the structural integrity of the kinetically expanded repair joint?

A.7 Sensitization does not significantly alter the mechanical strength or ductility of Inconel-600. The microstructural changes which occur when Inconel-600 is sensitized affect primarily its

resistance to various types of localized corrosion. Because sensitization does not significantly alter the mechanical strength or ductility of Inconel-600, it does not adversely influence the structural integrity of the repaired joint.

Q.8 What is the safety margin for degraded steam generator tubes?

A.8 The TMI-1 steam generators, as fabricated and installed, have tube wall thickness which exceed the Section III requirements of the ASME Boiler and Pressure Vessel Code. At tube wall degradations of approximately 70% (30% tube wall remaining) it has been demonstrated both analytically and experimentally that the boiler and pressure vessel code requirements are met and that steam generator tube integrity will be maintained for design basis accident conditions. Because the code itself contains a built-in conservatism of approximately a factor of 2, additional margin to failure exists for design basis accidents even if a tube is degraded in excess of 70% through wall.

Q.9 In NUREG-1019, its supplement and affidavit accompanying Staff's Motion for summary disposition it is concluded, in part, that the kinetic expansion repair process is acceptable because the OTSG's are returned to their original licensing basis. Considering that the Inconel-600 tubes have been exposed to various service and shutdown conditions for a period of ten years, how is it possible to conclude that they have been returned to the original licensing basis?

A.9 As discussed in response to Q.3 through Q.7, Inconel-600 tubing maintains its mechanical strength and ductility even after extended service in the steam generators. Inconel-600 was specifically

selected for application in nuclear steam generators because its strength and ductility will not significantly change during the design life of the plant. In NUREG-1019 at Pg. 2 and 4 and Supplement No. 1 to NUREG-1019, at Pg. 1 and 2, the repair process is described. The repair process relies on a six-inch defect-free kinetic expansion joint plus a 2-inch or 7-inch defect-free unexpanded section. As discussed in Response to Q.8, the repaired joint plus the unexpanded sections could have met the ASME boiler and pressure vessel code requirements and therefore the original licensing basis even if degradation had been present. Because the licensee elected to remove from service all tubes which had defects within the kinetic expansion repair area and the defect-free unexpanded sections, the kinetic expansion repair process has returned the steam generators to the original licensing basis.

Q.10 Has the kinetic expansion repair increased the probability of simultaneous tube ruptures involving both TMI-1 steam generators?

A.10 No. The kinetic expansion repair has returned the TMI-1 steam generators to their original licensing basis. Because Inconel retains its strength and ductility despite previous operation and because the repair itself did not affect that strength and ductility, the tubes are as resistant to rupture now, after the repair, as they were when they were new and had not experienced operation. Therefore, the probability of simultaneous tube ruptures involving both steam generators is no greater now than it was at the time of the original licensing.

Q.11 Does the NRC consider the potential for tube ruptures in multiple steam generators to be any greater for TMI-1 than for any other plant?

A.11 The staff does not consider the potential for tube ruptures in multiple steam generators to be any greater for TMI-1 than for any other plant. A number of factors influence this conclusion.

1. The licensee has thoroughly quantified the corrosion condition of the steam generators by conducting 100% eddy current testing (ECT)* of both steam generators.

2. When considering steam generator tube ruptures, tubes in the free span (the 52 feet open area between upper and lower tubesheets) are the primary concern, because this is the only location where the classic guillotine break is possible. Tubes which have been repaired within the tubesheets are restrained from separating within the tubesheet crevice. Therefore, although leakage in the tubesheet is possible, "tube rupture" in the classic sense is not. Greater than 95% of all corrosion at TMI-1 took place within the upper tubesheet crevice, where separation is restrained. All tubes in the free span of both TMI-1 steam generators that were identified as defective have been removed from service. Therefore, both TMI-1 steam generators will be returned to service under the same criteria

* ECT is a means whereby the electrical conductivity of a tube is checked by passing a coil with an induced voltage along the tube. If some form of tube degradation has occurred (such as corrosion) which has separated the metal, an electrical discontinuity exists. The electrical discontinuity will be proportional to the amount of metal which is missing. If 40% or more of the tube wall is missing, the tube is classified as defective and has to be repaired or removed from service.

as other units which have experienced corrosion. These criteria have been demonstrated to be successful in reducing the potential for tube rupture.

3. The most limiting initiating event for a steam generator tube rupture is the main steam line break (MSLB) accident. Under MSLB, maximum differential pressure will exist on the tubes. For a tube to rupture during a MSLB, it would have to be uniformly degraded through by greater than 70% of its wall thickness. The tube plugging criteria of less than 40% includes a corrosion allowance for the next operating period and an uncertainty allowance. Because most corrosion mechanisms do not result in uniform degradation that would cause structural failure before an unacceptable leakage occurs, 40% plugging criterion is very conservative. This is evidenced by the fact that no steam generator tube ruptures due to corrosion have occurred since 1976, and only two occurred prior to that time.

4. In addition to the conservatism of the tube plugging criteria, a number of other factors contribute to making tube rupture in multiple steam generators at TMI-1 no more likely than before the corrosion problem.

   a. The vast majority of defects are within the upper tubesheet. The tubesheet structural restraint would act to prevent tube rupture, even if continued degradation occurs.

   b. All tubes with detected defects in the tube free span have been plugged.

c. The extent of ECT for the TMI-1 steam generators is greater than that performed at any other operating plant. The techniques used and extent of ECT provide reasonable assurance that defects which may be present have been detected. (NUREG-1019, Section 3.3).

d. A significant difference exists in the extent of corrosion between the two steam generators. Although both steam generators have been repaired to the same criteria, a statistical difference exists as to the potential for continued corrosion. This factor reduces the probability that ruptures would occur in multiple steam generators, even in the event of a MSLB.

e. The corrosion which has been found is circumferential, and in most cases involves less than one-third the tube circumference. This results in sufficient tube wall remaining to maintain structural strength, even for a MSLB, in the event a defective tube has not been identified.

f. Extensive pre-critical hot functional testing has been performed to verify reliability of the steam generators.

g. Subsequent to criticality, power escalation will be slow (approximately 8 weeks to reach 75% power). Once 50% power is reached, the plant will be shutdown within 90 to 120 days and the steam generators examined by ECT to monitor for continued corrosion.

h. Extensive efforts have been conducted to identify and remove the contaminents to mitigate the possibility of recontamination

of the reactor coolant system (NUREG-1019 and Supplement No. 1 to NUREG-1019).

In summary, the probability of steam generator tube ruptures in multiple steam generators is no greater for TMI-1 than for any other plant.

Conrad E. McCracken

Professional Qualifications

I am Section Chief of the Chemical Technology Section in the Chemical Engineering Branch of the Division of Engineering, Office of Nuclear Reactor Regulation. My responsibilities in this position include supervision of the evaluation of all PWR's for compliance with chemistry and corrosion requirements of the Commission. Specifically, this includes evaluating the chemistry and corrosion control measures that are instituted to minimize corrosion of steam generator materials. I have served in this capacity since April 1982. Between February 1981 and April 1982 I served as a senior chemical engineer with the same branch, where my duties included the evaluation of steam generator chemistry and corrosion programs at both operating plants and plants in the licensing process.

From 1966 to 1981 I was employed by Combustion Engineering Corporation in a variety of management and engineering positions, the last of which was Manager of Chemistry Development from 1977 to 1981. During this 15-year period, my prime technical responsibility was support to operating nuclear power plants and nuclear plants in construction in the area of chemical and radiochemical sampling, analysis, data interpretation, establishing chemistry specifications and conducting laboratory experiments to verify or support nuclear plant requirements. In this capacity I made frequent visits to nuclear power plants where I physically conducted sample and analysis programs or audited the utilities' capabilities in the chemistry and radiochemistry area. During the last twelve years at Combustion Engineering, approximately fifty percent of my time was expended in areas associated with understanding and resolving steam generator corrosion problems.

From 1958 to 1966 I served in the United States Navy where I was Qualified in submarines for all nuclear duties. For three years of this period I was an instructor, responsible for teaching officer and enlisted personnel in the area of chemistry, corrosion and mechanical systems operations and control. My final duty station in the Navy was on the USS Nautilus, where I was responsible for all chemistry and corrosion control and personnel radiation exposure.

Education

I attended the University of Hartford School of Engineering and completed course work in 1970. I am a Registered Professional Corrosion Engineer.

Paul C. S. Wu
Chemical Engineering Branch
Division of Engineering

Professional Qualifications

FIELD: Corrosion and Water Chemistry

TOTAL EXPERIENCE: 19 years

NUCLEAR: 16 years

KEY RELEVANT EXPERIENCE

- Principal Engineer, Materials and Corrosion Programs at Westinghouse ARD
- Supervisor, Mechanical Properties Laboratory
- Lead Engineer, Advance Nuclear Control Material Development
- Lead Engineer, Materials and Corrosion Evaluation for Power Generating Equipments
- Lead Engineer, High Temperature Design Criteria and Method
- Lead Engineer, Low Friction and High Wear Resistant Materials Development
- Lead Engineer, Liquid Metal Corrosion and Sodium Technology

RELATED PROFESSIONAL BACKGROUND

Before joining the Metallurgy and Materials Research Branch at NRC, I was employed as a Principal Materials Engineer at the Westinghouse Advanced Reactors Division. I was responsible for many materials and corrosion programs at ARD. From 1976 to 1979, I was in charge of all materials and corrosion programs concerning aqueous corrosion and pertinent to nuclear fuel reprocessing and waste management. I was responsible for proposal preparation, research execution, and program coordination among various Westinghouse divisions and national laboratories. Prior to 1976, I was in charge of the Mechanical Properties Laboratory at ARD, and was responsible for characterizing the creep, fatigue, and stress-rupture of stainless steels and nickel-base alloys for the national program on high temperature design criteria and methods. Before joining Westinghouse, I was a research scientist at the Ames Laboratory of USAEC engaging in sodium technology and nuclear materials research.

EDUCATIONAL BACKGROUND

B.S. (Metallurgical Engineering, 1964), National Cheng-Kung University, Taiwan

M.S. (Metallurgical Engineering, 1967), University of Missouri at Rolla, Rolla, MO

Ph.D. (Materials Science and Inorganic Chemistry, 1972), Iowa State University, Ames, Iowa

MANAGEMENT TRAINING

- Management Techniques, Westinghouse Learning Corporation
- Decision Making, Westinghouse Learning Corporation
- Communication Skills, Westinghouse Learning Corporation
- Fracture Mechanics, Westinghouse Headquarters Engineering

HONORS AND ACHIEVEMENTS

- Who's Who in Technology
- Member of the American Honorary Chemical Society
- Member of the Review Board of TMS and ASM Publications
- Member of the NACE Committee on Stress Corrosion Cracking
- Member of the NACE International Relations Committee
- Westinghouse Advanced Reactors Division Cost Saving Award (1975)
- Technical Program Chairman, Pittsburgh Diffraction Conference (1976)

PUBLICATIONS AND PRESENTATIONS

I have published more than 30 technical papers and reports on subjects covering corrosion, materials evaluation and selection, mechanical properties of engineering alloys, sodium technology, friction and wear of materials, nuclear control material development, fuel reprocessing technology, and waste management. In addition, 8 invited presentations at Stanford Research Institute, ANL, ORNL, Sandia Laboratory and other research institutions have also been accredited to me.

MS. WAGNER: That concludes the Staff's direct examination.

JUDGE WOLFE: Ms. Bradford, cross-examination?

CROSS-EXAMINATION

MS. BRADFORD: On page 3 of the testimony, answer seven, you indicate that sensitization does not significantly alter the mechanical strength.

Would you define "significantly" for me, please?

WITNESS WU: Under the severe sensitized condition, the micro-hardness measurements and also the characteristics of the tensile test -- by that I mean the stress and strain curve -- might be changed, when you compare heavily sensitized material with annealed material.

But with an alloy such as inconel 600 in the sensitized condition as we are referring to in the TMI-1 tube case, the degree of sensitization does not change its mechanical properties.

MS. BRADFORD: So you are saying that the word "significantly" there --

WITNESS WU: What I mean is, for any alloy, there is a range of its yield strength and ultimate tensile strength and ductility.

The range, when you test a specimen for instance, and even in the fully annealed condition, you would have different answers but they would fall within the range of STME

standards. The minimum yield strength has to be above that.

For the sensitized condition, heavily sensitized condition tested, the stress-strain curve for that particular alloy will show slight change microstructurally because of the strength hardening at the localized grain region between the carbides which are present in the sensitized alloy and the fully annealed condition without any precipitates.

So, it will show in the stress-strain curve a little bit. However, it does not change their nominal yield strength or ultimate tensile strength to any significant amount that would render them out of spec.

MS. BRADFORD: Does the sensitization process or the annealing process which causes sensitization and attacks the grain boundaries and precipitates -- I am just trying to understand what you mean by "significantly."

WITNESS WU: I think I tried to be here more specific technically. From a microscopic point of view for a material scientist when you look at an engineering alloy, it's a little bit different than say a design engineer or a mechanical engineer looking at engineering properties.

So here, "does not significantly change" -- in other words, for all practical speaking from an engineering point of view, it is the same when you test a sensitized alloy and an annealed alloy.

However, microstructurally, microscopically, there

are slight differences there. But that differences does not make this alloy inferior mechanically in terms of load-carrying capability with respect to annealed alloys.

MS. BRADFORD: On page four, question nine at the bottom of the page, it states that "Inconel 600 tubing maintains its mechanical strength and ductility even after extended service in the steam generators." Does that include a long down time?

WITNESS WU: Yes.

MS. BRADFORD: Does that have a different effect than service conditions?

WITNESS WU: No, it would not have a different effect than service conditions. As a matter of fact, a down time would have less, because the temperature is lower than operating temperature.

Even at operating temperature, about 600 degrees Fahrenheit, it does not change the mechanical property of Inconel 600.

MS. BRADFORD: On page five, answer ten, you say there that "...the repair itself did not affect" the strength and ductility of the tubes. Did NRC conduct some testing to determine that that statement is correct? Did you yourself do testing on samples that were kinetically expanded?

WITNESS WU: I have not carried out any tests on the TMI-1 steam generator tubing. However, I have conducted

many mechanical tests on Inconel 600 before when I was employed at Westinghouse. And at 600 degrees Fahrenheit, which is the normal operating temperature for a PWR, the mechanical property, namely the yield strengths, only slightly drop.

And it does not embrittle the material at all at the temperatures that we are interested in here.

WITNESS McCRACKEN: Additionally, we did review the Licensee's data on the three heats which they examined and determined that those were representative of the range of ductility of the 60 heats that are in the steam generator.

MS. BRADFORD: Does the NRC consider the potential for tube rupture to be greater at TMI than at any other plant?

WITNESS McCRACKEN: No.

MS. BRADFORD: On what do you base that response?

WITNESS McCRACKEN: On the whole evaluation process that we have gone through for two and a half years, as given in NUREG 1019, Supplement No. 1 to it, and our Summary Disposition Motions.

We have thoroughly reviewed the process that caused the corrosion. We are satisfied that the causative agent has been determined, has been removed; that adequate assurances have been provided that the repair in fact has returned the generator to the original licensing basis; and all other potential questions that we had had been answered.

MS. BRADFORD: The one gallon per minute limit

on the leak rate, is that for both steam generators?

WITNESS McCRACKEN: That's total leakage.

MS. BRADFORD: What is the safety impact of leaks in both steam generators--that is, up to the allowable limit -- if they were presumed to be evenly distributed?

MR. CHURCHILL: Your Honor, Licensee objects to that question. That's outside the scope of this issue, which as posed by the Board is: is the likelihood of a simultaneous rupture involving both steam generators any greater now because of the repair?

Safety consequences are clearly not within the scope of that, and none of these witnesses, either the Staff's or ours, in fact testified on that because it was clearly outside the scope of the issue as formulated by the Board.

MS. WAGNER: Staff joins in that objection.

MS. BRADFORD: I will withdraw the question.

Is it possible that there are cracks in the free span which went undetected?

WITNESS McCRACKEN: It is possible that there are small cracks below the threshold of detectability of the eddy current test probe that could exist in the free span.

MS. BRADFORD: On page seven, item three, you state here that "... most corrosion mechanisms do not result in uniform degradation that would cause structural failure before an unacceptable leakage occurs...." First let me ask you, the

individual tubes, are you able to calculate a load for an individual tube within the steam generator? Is that possible?

WITNESS McCRACKEN: If you're referring to the 3,140 pounds, that is the limiting load for the tube that has the most stress on it, and it is based on the conditions taking worst-case conditions in all parts.

MS. BRADFORD: But you are not able to actually predict a load for each individual tube?

WITNESS McCRACKEN: I don't believe there is any way to say that this specific tube is going to see 3,140 pounds and the one beside it will see 2,937.

MS. BRADFORD: Is there any relationship to that uncertainty and the action of the corrosion mechanism; that is, that some tubes might see a varying load, and for that reason the corrosion mechanism would react in a different way?

WITNESS McCRACKEN: I am not sure I understand what you are trying to ask me.

MS. BRADFORD: One of the identified means of the corrosion cracking or the scenario of the corrosion cracking is that there was an axial load placed on the tubes.

Now you just told me that there isn't a way to identify what that load might have been for each individual tube. And I am asking you if that is part of the reason that a corrosion mechanism does not result in uniform degradation.

WITNESS McCRACKEN: I think now I know where you

are at. My confusion was the 3,140 pounds. They are talking about a design basis load. If you are asking the question, when the original corrosion occurred, could a factor have been in the reason the distribution was different between the two steam generators that maybe there was a little more stress in one generator than the other during the cooldown where this particular corrosion initiated, the answer is yes, that's one of the possibilities that could have affected the magnitude of corrosion.

MS. BRADFORD: My question went to more than that. If the axial load is a factor in this corrosion mechanism and you are not able to accurately predict the load for each tube, then the distribution of the damage within each steam generator is in part dependent on that axial load, and therefore to some extent unpredictable as to its distribution.

MS. WAGNER: Is that a question?

MS. BRADFORD: That was my question.

WITNESS McCRACKEN: The distribution of the damage in the steam generators was not attributed to either the load or the chemistry conditions. When you opened those generators, they were both open to the atmosphere at slightly different times. The amount of level fluctuations would have varied. Therefore, the amount of chemical concentration and dry-out could vary across the tubesheet. We could not conclusively say that the reason for the differences was either the environment or the particular amount of stress in the material at the time. It could have been a combination of both.

MS. BRADFORD: In that same paragraph, you state that there have been no steam generator tube ruptures since 1976. How many reactor years were there prior to 1976?

WITNESS McCRACKEN: Prior to '76 -- and I'm giving you an estimate -- there were, I would guess, somewhere between 50 and 100 operating reactor years for pressurized water reactors. In that time frame, there were two ruptures.

Since that tir , there have been an additional perhaps 300 operating years for pressurized water reactors, and there have been no ruptures.

MS. BRADFORD: The 70 percent limit that you have set on degradation, was this determined for all steam generators no matter the tubing material, or was this determined specifically for once-through steam generators using inconel 600?

WITNESS McCRACKEN: All steam generators, with one exception, in the United States use inconel 600. That 70 percent number applies to TMI-1 specifically.

There are other plants that have numbers that are even higher than that. There are some plants that have numbers as high as 80 or 82 percent.

MS. BRADFORD: I have no further questions.

JUDGE WO[illegible]: Mr. Au?

CROSS-EXAMINATION

MR. DORNSIFE: On page 7 of your testimony, you list reasons or factors that you feel contribute to the fact

that multiple tube ruptures in separate steam generators are not a possibility or a low probability.

Focusing on the second reason -- "All tubes with detected defects in the tube free span have been plugged." -- focusing on that particular reason, would your conclusion about simultaneous tube rupture be different if there were missing plugs?

WITNESS McCRACKEN: I would have to know where the plugs are missing from and what tubes they had been in. If they are tubes that had been preventatively plugged, I would figure there was not any significant change.

For this particular plant, the majority of corrosion which they had went through-wall. There were very few of the tubes they found with corrosion on them that did not have through-wall defects.

Therefore, on this plant if they were to be minus a plug it would probably leak and give you a very rapid indication that you've got a problem.

An additional factor at this particular plant was that this particular corrosion that was detected in the free span was a very small circumferential length. In other words, if you look at the total circumference of the tube, it was not 360 degrees around the tube, which is what you would need to get a tube ruptured severance in the context of tube rupture which we discuss. It was more like -- I forget the number

exactly -- I think 70 degrees or to a maximum of one-third of the circumference. Under that kind of a condition, even if a plug was absent, you could get leakage. You would probably get leakage in excess of tech specs, but I would not anticipate a tube rupture.

MR. DORNSIFE: Are you aware of problems the Licensee has had recently with missing plugs?

MS. WAGNER: I object to that.

JUDGE WOLFE: I didn't even hear the question.

MR. DORNSIFE: I asked if the witness is aware of problems the Licensee has had recently with plugs that are missing.

JUDGE WOLFE: You object to that?

MS. WAGNER: Yes. I don't see the relationship between that and the issue, which is whether the repair process has increased the probability of an accident.

MR. CHURCHILL: I join the Staff in the objection, Your Honor.

JUDGE WOLFE: What do you have to say?

MR. DORNSIFE: The witness has indicated that that is one of his reasons for concluding that simultaneous ruptures are not possible. So he himself has made that an issue and considers it part of the repair process, apparently.

JUDGE WOLFE: Were there simultaneous tube ruptures recently?

MR. DORNSIFE: No. I am saying that all tubes have been plugged that have defects. He's making that a criteria for making that conclusion that it lowers the probability of simultaneous tube ruptures.

MS. WAGNER: And he already stated that if some of the plugs were missing it would not change his testimony.

I didn't object to your first question, but I think your second one is not related.

MR. DORNSIFE: I understood that depending upon how far through-wall the cracks were. That's how I understood the answer.

MR. CHURCHILL: Your Honor, a tube is plugged and taken out of service. Now, I suppose if the plug at each end of that tube were to be missing, it's back into service again. And if it's a leaking tube and both ends of the tubes are unplugged, maybe that would have an impact, but I know of no such situation that has occurred.

JUDGE WOLFE: That has occurred?

MR. CHURCHILL: That has occurred, yes.

JUDGE WOLFE: Isn't that your question, whether that has occurred? Is that your question, Mr. Dornsife?

MR. DORNSIFE: My question was: was the witness aware of any experience with plugs that are missing.

JUDGE WOLFE: I think that's a fair question. Objection overruled.

WITNESS McCRACKEN: Yes. I am aware of recent occurrences of plugs missing.

MR. DORNSIFE: What do you anticipate will be the Staff's response to that problem?

WITNESS McCRACKEN: The Staff's response will be to review thoroughly the installation of the plug, that they are in their proper location, to define why these plugs are missing if they were not installed in the first place, or if they were installed, why they weren't properly installed and didn't retain themselves in as they should have, and then ensure that they are properly installed according to Reg Guide 1.121.

MR. DORNSIFE: Would that be independent of this particular license amendment? Would you not approve the license amendment until that issue is resolved?

WITNESS McCRACKEN: No. That is a routine repair process within their current tech specs. The plugging and plugging themselves were not part of this particular license amendment.

MR. DORNSIFE: But you would not anticipate allowing operation until that process, through review and approval, was completed?

MS. WAGNER: I object to this. I think again he is getting outside of the contention and outside of the testimony of these witnesses.

JUDGE WOLFE: We've already ruled on that. I think

the witness has already answered that. Haven't you already answered that?

MR. DORNSIFE: I asked in the context of this license amendment, not in the context of the other review.

JUDGE WOLFE: We will allow the question. Can you answer the question?

WITNESS McCRACKEN: Do you allow the question?

JUDGE WOLFE: Yes.

WITNESS McCRACKEN: The NRC will certainly review what is going on with the plugging problem, and the question of plug retention will be resolved to our satisfaction prior to the restart.

MR. DORNSIFE: Thank you. I have no further questions.

JUDGE WOLFE: Mr. Churchill?

MR. CHURCHILL: No questions, Your Honor.

JUDGE WOLFE: Does that conclude the presentation of direct testimony by Staff?

MS. WAGNER: Yes, sir.

JUDGE WOLFE: I guess then we are nearing the completion of this hearing.

JUDGE WOLFE: We will go back to you then, Ms. Wagner, for any redirect.

MS. WAGNER: I have no redirect.

JUDGE WOLFE: Now we will go to Board questions.

JUDGE HETRICK: On page 8 of the testimony, the second paragraph, could you clarify a little bit the statement that "a statistical difference exists as to the potential for continued corrosion"?

WITNESS McCRACKEN: Yes. That is simply trying to state that in the event there are undetected defects present in either steam generator which are below the detectability of eddy current testing, that there will be more in one generator than the other.

As any corrosion process occurs, there is always one that proceeds most rapidly. Therefore, you would anticipate that corrosion in the generator that had the majority of corrosion, if it were to proceed, would proceed first, and that would leak before and give you an indication of a problem before you would get the same condition in the other generator.

That is borne out by an enormous amount of data on corrosion in all operating steam generators, where every time you shut down and examine a generator with a corrosion problem, there's always one that winds up having more corrosion than the other one, or other two or three do.

JUDGE HETRICK: I think earlier today I used the phrase -- or you used the phrase "leak before break". Could you put that into better words? What does the concept mean?

WITNESS McCRACKEN: I can put it into I think words maybe in relation to steam generator tube ruptures and

relate that to tech spec leakage limits.

The term "leak before break" when applied to a steam generator tube means that you would like to have reasonable assurances that a steam generator tube will in fact leak and leak at numbers below the tech spec limit so it can be shut down and repaired prior to the point that a defect could grow and cause you to have a tube rupture or break open.

The most limiting condition for that or the most limiting type of corrosion is a longitudinal corrosion going along the length of the tube.

It has been determined analytically that a half inch long defect in a tube would leak at approximately .3 gallons per minute; and the half inch long defect is the length of size that we would be concerned could propagate or open wide during an accident and create the same effect as a tube rupture.

So, therefore, if you saw a leakage of .33 gallons per minute from an individual tube which had a crack in it, which is a limiting type of failure mechanism, then if you shut down prior to that, that tube should not have been able to fail during an operating period where you have a design basis accident.

JUDGE HETRICK: Are you satisfied this will happen in this plant?

WITNESS McCRACKEN: Yes. I am very satisfied with the condition of these steam generators, the eddy current test

program and the qualification of the tubes that are now in service.

JUDGE HETRICK: Were you involved in reviewing the basis for the conclusion that was discussed this morning with the Licensee's two witnesses? In other words, are you satisfied that the properties of the archival tubes are representative of tubes that were actually removed from the steam generators and also that those tubes that were removed are representative of the tubes that remain?

WITNESS McCRACKEN: Yes. We had access to that information when it was first developed. The Licensee prepared rather extensive plots showing where the distribution of every heat was in their steam generators. They overlaid that with where they had indications of corrosion so they could look at which tubes were corroded by heat versus location in the steam generator.

Additionally, they took out all of the heats and they had the material certs on them so they could show that, in fact, all the materials did meet the ASTM specification B163 requirement. That gave them the range of ductility for all of the materials they had which were within the standard nuclear grade specification.

The three they pulled were representative of that specification. They went ahead and tested those.

We have in the past simply accepted verification of

heat numbers and not actual testing to prove that a tube has maintained ductility, because in all the examinations where we have had tubes removed from operating steam generators, we have not seen any indication of a change in ductility in an operating steam generator tube that would have put it outside the normal specification for a nuclear grade tube.

JUDGE HETRICK: Do I conclude that you are satisfied that the correct conclusion was reached with regard to using these archival tubes?

WITNESS McCRACKEN: Yes. We think that was a proper decision.

JUDGE HETRICK: Even though there were no pull-out tests involving tubes removed from the steam generators and subsequently expanded, you conclude that the system has been returned to its original design basis?

WITNESS McCRACKEN: It has been returned to its original licensing basis.

JUDGE HETRICK: I beg your pardon; licensing basis?

WITNESS McCRACKEN: Yes.

JUDGE HETRICK: Are you aware of any probabilistic risk assessments involving steam generator tube ruptures?

WITNESS McCRACKEN: Yes, I am.

JUDGE HETRICK: Was any performed for this plant?

WITNESS McCRACKEN: We didn't perform any specific probabilistic study for this plant.

JUDGE HETRICK: Was any such study performed for a typical or some other once-through steam generator?

WITNESS McCRACKEN: In the past two years, we have been doing work to resolve unresolved safety issues A-3, A-4 and A-5, which are associated with steam generator tube integrity.

As part of that, we have looked generically at multiple ruptures or ruptures in more than one steam generator. We have not done that on a mechanistic basis by manufacturer. We have simply put all generators into the same lump, simply saying if you can have a steam generator tube rupture by any mechanism, it applies to all plants. So it's a very conservative one when you look at it from that point of view.

JUDGE HETRICK: Is this then an ongoing study in connection with the end result safety issues?

WITNESS McCRACKEN: It's a study which we have now completed and is before the Commissioners for their approval for issue.

JUDGE HETRICK: You don't happen to carry any numerical results in your head, do you?

WITNESS McCRACKEN: I guess the only one I carry in my head is the probability of significant core damage from any steam generator tube rupture is about 4 times 10 to the minus 6, and the probability of multiple is obviously a lower probability than a single tube rupture.

JUDGE HETRICK: Is that probability per reactor year?

WITNESS McCRACKEN: Yes.

JUDGE HETRICK: In our Board's Memorandum and Order of June 1st, we stated at that time that we reject the concept that the design basis for a new plant constructed using new materials is necessarily relevant to restart after extensive and uncommon repairs. I don't think your testimony addressed that point precisely. I wonder if you would like to make a comment on that at this point.

WITNESS McCRACKEN: I believe that our interpretation of the statement you had made was that you were questioning whether inconel 600 could still be as ductile and have the same yield strength as it had when you started.

Our interpretation was you were trying to ask: how can you say that a material that has been in service through 10 years of whatever kind of experience is still as good as it was in the beginning and therefore you can draw a conclusion that you can use it and repair it to the same condition you started with. So, therefore, I thought we had addressed that, at least our interpretation of what you were asking.

JUDGE HETRICK: In addition, we observed in the same Memorandum and Order that there had been other arguments concerned with the adequacy of emergency procedures and the possibility of attaining uncoolable conditions and that we

accept the Staff's position on these issues.

Are you satisifed that the Staff's position on these issues is correct?

WITNESS McCRACKEN: That is an area where the review was conducted by some other people. I am not an expert in that area. I can tell you that I personally feel comfortable with what they have told me, but I am not an expert, and I don't feel I should try to testify in that area.

JUDGE HETRICK: I have one final question. Are there any additional license conditions that you would like to see the Board impose?

WITNESS McCRACKEN: In reviewing the license conditions which I have, I only have seen one potential plant condition which I think I did not anticipate, and that is that they would run for an extended period of time even up to a full fuel cycle without ever going above 50 percent of power.

I would assume if that were to occur that I would like to see another eddy current examination sometime in the middle of the cycle.

In other words, the license condition, as I've read it, said "90 days after reaching 100 percent power or 120 days after reaching 50 percent power." I did not believe the plant would run for an extended or protracted period of less than 50 percent power. If that were to occur, my

inclination would be after 180 to 200 days or something like that, that we would talk to the Licensee and tell them that we would like them to shut down eddy current tests, which I assume they would be willing to do.

I would have no serious objections if that were added on to the license condition to make it clear that that's the intent.

JUDGE HETRICK: Thank you.

JUDGE WOLFE: I don't think this question has been posed before. On page 8 of your direct testimony, I don't quite understand Paragraph E. Whoever wrote that, would they please explain particularly the second sentence of the paragraph.

WITNESS McCRACKEN: The reference to that I sort of touched on a little bit in the past when I talked about the extent of circumferential defects. The punch line on it is that the majority of corrosion that has been found within the free span has been small in circumferential length, which means it has not affected the majority up to two-thirds of the actual tube. Therefore, up to two-thirds of the actual tube is in its original structural condition.

Two-thirds of that tube, even if you had 100 percent through-wall defect on the other third, is capable of holding its normal structural loads. That's all that is trying to say.

JUDGE WOLFE: Ms. Bradford, cross on Board questions?

MS. BRADFORD: I have no questions.

JUDGE WOLFE: Mr. Au?

MR. AU: No questions.

JUDGE WOLFE: Mr. Churchill?

MR. CHURCHILL: No questions.

JUDGE WOLFE: Any redirect, Ms. Wagner?

MS. WAGNER: No, sir.

JUDGE WOLFE: Now I think we are coming into the conclusion of the hearing. There is one housekeeping matter with respect to TMIA Exhibit 1, which was marked for identification.

Your tender of that was rejected, but we gave you leave -- I think you said you were going to offer it through a witness or something that first day. Do you wish to retender that exhibit, or just have it accompany the record for identification?

MS. BRADFORD: I have no witness who will be able to sponsor it.

JUDGE WOLFE: I'm sorry; I didn't hear you.

MS. BRADFORD: I have no witness who will be able to sponsor that exhibit. Therefore, I would like for it to accompany the record.

JUDGE WOLFE: It will follow the record; it won't be part of the record.

All right; TMIA Exhibit 1 remains marked for identification, as well as its Exhibit 2 remains marked for identification.

In light of what has transpired during the course of the hearing, the Board must make a ruling. We were aware, and Ms. Bradford has affirmed, that TMIA has refused to accept the delivery of the 35 unexpurgated documents which the licensee

originally tendered I believe on March 1, 1984.

We are also aware, and Ms. Bradford has affirmed, that TMIA refuses to recognize and/or abide by the ruling of the Board's Protective Order, and Ms. Bradford also affirms that TMIA refuses to participate in any in camera hearings with respect to the alleged proprietary data.

The Board rules that since TMIA has refused to accept delivery of these 35 documents asserted to be proprietary and has refused to abide by the Protective Order, and has not agreed and would not agree to proceed to an in camera hearing, if portions that were deemed to be proprietary were to be offered into evidence, in light of those circumstances there is no need for the Board to determine whether this information is privileged commercial or financial information, and we need not determine whether this information should be withheld from public disclosure.

There is no need because it is now a non-issue. Moreover, I would add that we have reviewed the 35 unexpurgated documents and concluded that none of the asserted privileged portions of these documents evoke any concern on our part with respect to the health and safety of TMI-1.

Under these circumstances, we rescind our Protective Order. There is no need for it anymore, and there is no need for our motion and order which granted the licensee's Motion for a Protective Order. As I say, all this is moot; it is a

non-issue now.

I would have all the parties recognize the status of these alleged proprietary documents.

MS. BRADFORD: Judge Wolfe?

JUDGE WOLFE: Yes.

MS. BRADFORD: I'm going to need some direction. Yesterday there was a motion allowed, an objection by the licensee to a question which the Board ruled involved proprietary information, and which TMIA argued was freely available in the documents.

Earlier at a bench conference you had -- at some point you told me that if I could make a showing that this information was available, that that would affect your ruling on that issue. I have not been able to do that because I have simply not had the time. The information that I refer to is so prevalent throughout the documents that I really have not ever bothered to cite it, so I have no cites to give you.

JUDGE WOLFE: The fact of the matter is that you would refuse, as I understand your position as of yesterday; regardless of anything else, when push came to shove, the policy of TMIA would be to refuse to proceed and agree to an in camera hearing even if we were to agree that you could get this information on the record. Isn't that so?

MS. BRADFORD: I did, indeed, refuse to be party to an in camera session, and the reason I refused is I still

feel that that is not proprietary information. I am not interested in any information that the licensee has deemed proprietary and to which that proprietary privilege attaches.

I have objected to the licensee six months later attempting to bring in more information under the umbrella of a proprietary privilege. That was my objection at the bench conference yesterday.

And to that objection, you wanted to know where it was cited, and I have not been able to provide that information because I simply have not had time.

JUDGE WOLFE: Yes, and we are at the last day of hearings, and I don't know what we can do about it, because I do intend to close the proceedings this afternoon.

MS. BRADFORD: I understand that, but it is my contention that TMIA has been harmed by the ruling that was made yesterday. I was not permitted to continue a line of questioning because there were proprietary claims.

JUDGE WOLFE: That has always been so.

MS. BRADFORD: What I am saying to you now is that I thought the proprietary claim at the time was improper, and now I am asking guidance on how I should proceed.

JUDGE WOLFE: Does anybody recall that particular question? I think it had to do with -- I think you said: if I can show you in the documents that this particular matter has been disclosed in various portions of these 35 documents

and was not deleted therefrom as being allegedly proprietary, would you allow me -- you -- to ask the question?

Isn't that the way it went?

Then I said that if you could show me that, then I would permit you to ask the question.

It is late in the day and late in the proceedings. If you knew of something, it should have been brought to the Board's attention before the completion of this hearing. That's all I'm saying at this point.

Absent any such showing to this Board -- and we are going to close the record -- that's it. Our ruling remains the same because we don't know yet; we have had nothing from you as to where this does appear, apparently, as a non-privileged piece of information.

All right, one final matter. Does the State of Pennsylvania, Mr. Au, intend to file proposed findings of fact and conclusions of law and a recommended form of Order?

You are not required to do so; I'm just trying to find out whether you intend to.

MR. AU: We are not certain at this point, but we will abide by any Board Order concerning that.

JUDGE WOLFE: Will the parties in a short five-minute recess propose to the Board when the applicant shall file its proposed findings of fact and conclusions of law, brief and proposal on the order and decision, when TMIA will file

their submissions, when Staff will file its submissions; and I would indicate in this final ruling or order that the parties are directed to file these submissions, and if they don't they will be held in default.

So let me hear those filing dates and I will incorporate that into an order, and then I will close the record.

MS. WAGNER: Judge Wolfe, may our witnesses be excused?

JUDGE WOLFE: Certainly. The witnesses are excused.

(Witnesses excused.)

JUDGE WOLFE: We will recess now.

(Recess.)

JUDGE WOLFE: Has there been some agreement on findings?

MR. CHURCHILL: Yes, Your Honor. The parties got together and agreed on the following dates and the following conditions. Licensee will file its proposed findings of fact and conclusions of law on August 3. We will hand-deliver on that date our filing to both the Staff and TMIA.

TMIA's date for filing is August 10.

JUDGE WOLFE: When was that again?

MR. CHURCHILL: August 10th.

JUDGE WOLFE: Intervenor?

MR. CHURCHILL: The intervenor will be August 10th,

and the Commonwealth would also be that date if it chose to file.

With respect to intervenor, Licensee will make available a messenger to physically pick it up that day and delivery it to the Staff.

JUDGE WOLFE: Who will do that?

MR. CHURCHILL: The Licensee.

JUDGE WOLFE: That won't have to be in the order.

MR. CHURCHILL: That won't have to be in the order, but that is what we plan to do.

The Staff's filing then would be due on August 20th.

JUDGE WOLFE: And then a reply brief by Licensee?

MR. CHURCHILL: If that were required, I think that would just be according to the rules, which would be in five days.

JUDGE WOLFE: Before we get into that, the Board had conferred. We just wondered if we understood what your problem was, Ms. Bradford, when you asked for guidance. When someone asks for guidance, we try to give the best guidance we have. I thought I understood what your problem was. Perhaps in giving you the answer I did. I really didn't understand what guidance you were seeking. Would you please explain that once again?

Go ahead.

MS. BRADFORD: During yesterday's bench conference I expressed the opinion that Licensee could not bring in this issue as a proprietary right because --

JUDGE WOLFE: On a particular question?

MS. BRADFORD: On a particular question. The rest we would agree and have abided by, all of those conditions.

My point is that six months later you cannot extend that proprietary umbrella without a justification.

JUDGE WOLFE: I don't understand that.

MS. BRADFORD: We have documents that were available and have been available since January or February, and six months later the Licensee suddenly says, "Oh, we forgot something, and we would like to cover that also." And I am saying that that is not possible without a justification argument. I mean showing justification for doing that and including it in the initial proprietary grouping, if you will.

The Board then told me that if I could make a showing that this was freely available and documents were available to both TMIA and to the public that you would reconsider your ruling.

I don't even know that we got to the word, "reconsider." You wanted me to make a showing. My statement is there really hasn't been time to locate that.

As I said before, it is so prevalant throughout the documents that I had assumed that it was common knowledge.

JUDGE WOLFE: So what precise guidance are you seeking?

MS. BRADFORD: My question to you is: must I produce cites to show to you -- you wanted some showing that this, indeed, was not covered by the proprietary order.

JUDGE WOLFE: I wanted some showing?

You now want guidance from us as to what we meant in the sidebar conference by suggesting that you make some showing that this information has been in the public domain, for example, for some six months?

MS. BRADFORD: That's correct.

JUDGE WOLFE: All right. In conferring with my colleagues, they refreshed my recollection now. I do recollect that this, indeed, was brought up, and saying that if you could make such a showing we would hear the testimony or allow you to ask the questions.

My colleagues refreshed my recollection, and my recollection, as refreshed, is now that I suggested that if you could make such a showing that this alleged proprietary data had been in the public domain for some six months, that you could ask the questions, but that we upon objection would then have to rule upon whether an adequate showing had been made. I believe -- that is my recollection on how we ruled.

Your request for guidance now is how you should go about making that showing?

MS. BRADFORD: Yes.

JUDGE WOLFE: But as I indicated earlier in our initial ruling -- well, in our ruling today, as I indicated, it is too late to make such a showing.

If certain data, as you assert, was for whatever reason made a part of or became a part of the public domain, and, as you indicated, appeared in several documents, between yesterday and today, which is the day the proof is being closed, such a showing should have been made.

Therefore, it is too late; it is now moot. Therefore, I see no point, even if I were so disposed to advise a party on how they could make a showing to shore up their argument in the case, even if I were so disposed time has run out. You have no more time. The request for guidance is in a vacuum.

All right. The final oral ruling is: pursuant to 10 CFR, Section 2.754, the parties are directed to file, and will be deemed in default if they do not file, proposed findings of fact and conclusions of law, briefs and a proposed form of order or decision.

The Licensee shall file by August 3, 1984 proposed findings of fact and conclusions of law and brief and a proposed form of order or decision.

The intervenor shall file by August 10, 1984 its proposed findings of fact and conclusions of law and brief.

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The State of Pennsylvania may if it so desires file by August 10 its similar submissions.

The Staff shall file by August 20th.

To the above-described submissions, the Licensee shall have the regular time to reply, within five days, to the filings of proposed findings of fact, conclusions of law and briefs by the parties.

The proposed findings of fact and proposed conclusions of law shall follow the format in Section 2.754(c).

Further:

(1) Proposed findings should not summarize pleadings and filing dates.

(2) They should not summarize testimony.

(3) They should not summarize prior rulings in the case except when necessary.

(4) They should set forth in declarative sentences and use the active voice.

(5) Uncontroverted findings shall be set forth first.

(6) Ultimate findings of fact should be supported by subsidiary findings.

(7) Those parties filing after the Licensee should, wherever possible, incorporate by reference Licensee's proposed findings with which they really do not disagree.

The parties should file a brief discussing the important issues and how they should be resolved. The brief

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should set forth in captions its contentions and discuss the reasons why the contentions should be resolved in favor of the submitting parties, and it should cite controlling statutes and case law, and should cite the supporting findings by number.

Is there anything else to be discussed before we close the record?

(No response.)

JUDGE WOLFE: All right; the record is formally closed. Thank you.

(Whereupon, at 5:10 p.m. the hearing was closed.)

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CERTIFICATE OF PROCEEDINGS

This is to certify that the attached proceedings before the

NRC COMMISSION

In the matter of: Evidentiary Hearing before the Atomic Safety and Licensing Board Panel

Date of Proceeding: Wednesday, July, 18, 1984

Place of Proceeding: Capital Campus, Middletown, Pennsylvania

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

John A. Kelly
Official Reporter - Typed

John A. Kelly
Official Reporter - Signature

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