UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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IN THE MATTER OF:	)	Docket Nos.
	)	50-329-OM
CONSUMERS POWER COMPANY	)	50-330-OM
(Midland Plant, Units 1	)	50-329-OL
and 2)	)	50-330-OL

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The deposition of ALBERT SAVAGE, a witness herein, taken before Deborah A. Parent, RPR, CSR-2364, and Notary Public, on Monday, March 28, 1983, at or about 6:20 o'clock P.M., at the Holiday Inn, Midland, Michigan.

APPEARANCES:

ISHAM, LINCOLN & BEALE,
BY: PHILIP P. STEPTOE, III, Esq.,

Appearing on behalf of Consumers Power Company.

MICHAEL WILCOVE, Esq.,

Appearing on behalf of the Nuclear Regulatory Commission Staff.

INDEX

EXHIBITS

NUMBER	DESCRIPTION	PAGE
Savage Deposition Exhibit No. 1	Document	5
Savage Deposition Exhibit No. 2	Sketch	85

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ALBERT SAVAGE,

was thereupon called as a witness, and having been first duly sworn, testified on his oath as follows:

MR. STEPTOE: This deposition is being held

pursuant to the Rules of Practice of the Nuclear Regulatory Commission and pursuant to agreement of the parties in the matter of Consumers Power Company application for operating licenses for the Midland Plant, Units 1 and 2.

This application is presently pending before the Atomic Safety and Licensing Board.

EXAMINATION

BY MR. STEPTOE:

Q Would you please state your name and your address, for the record?

A My name is Albert B. Savage, S-a-v-a-g-e, and I live at 122 Varner Court in Midland.

Q And I spoke, Mr. Savage, to Ms. Sinclair who said that she had an errand to run but that she would be here later. Do you have any objection to going forward at this time?

A No.

Q And am I correct that you're not going to be represented by a lawyer here?

A No.

Q Okay. When we spoke last week, you told me that you understood what a deposition is, but would you mind if I just go over it again?

A Okay.

Q As you know, you're under oath and I will ask you questions and your answers are transcribed by this lady so that we'll

have a written record of my questions and your answers.

In general, I will be asking you questions about your background and your work experience, about what you have done to prepare to give this testimony, and then about the substance of your testimony.

If at any time you feel the need to take a break, just tell me and we'll take a break. If you would like to call Ms. Sinclair's husband or anybody else, we can arrange for a private phone for you to do that.

At the end of the deposition, we'll get you a copy of your deposition. You'll have the opportunity to read through it and correct any mistakes which might occur either in transcription or any other errors that you would like to correct.

If you don't understand a question, please let me know because the assumption is, when I ask the question and you give an answer, that you have heard it.

A Okay.

Q Mr. Savage, it's my understanding that you have agreed to testify on behalf of Ms. Sinclair with respect to Sinclair Contention No. 4. Is that understanding correct?

A Essentially. She gave me some papers to read about this and I wrote her a seven-page thing which included her specific contention and other things about the possibilities of corrosion of the steam generators and so forth. In other

words, what I would have to say perhaps is more general or more broad than her specific contention, if that's all right.

Q In general, the evidence in a Nuclear Regulatory Commision proceeding is directed towards an individual contention and the Board will be deciding to what extent your testimony will be allowed if it exceeds the actual bounds of contention and that is certainly one of the things that --

A She said she had given what I wrote to somebody. I don't know if she did or not.

Q Yes. Mr. Savage, I'll hand you a copy of a nine-page document. The front page is a cover letter from Mary Sinclair to the administrative judges and the remaining eight pages appear to be your testimony.

Would you take a look at that document and tell me if that is the --

A I rewrote my first page slightly. I have it there and there are on that also some notes in my own writing that were just incidental things that might come up in a course of a question or something like that, because I did this in a hurry and there were places where things weren't always completely defined.

Q I see.

A This is it essentially, yes. This is it, yes.

Q Well --

A The front page is very little different from what I have there.

Q Well, is this an extra copy?

A Yes.

MR. STEPTOE: Okay. I would like to have the -- yes, I would like to have this document that you gave me which is an eight-page document entitled Statement of A.B. Savage as to Sinclair Contention No. 4 marked as Savage Deposition Exhibit No. 1.

(Whereupon Savage Deposition Exhibit No. 1 was marked for identification by the Court Reporter.)

Q Now, Mr. Savage, do you intend to give any further testimony, whether written or oral or other documents, in this proceeding other than this Savage Deposition Exhibit No. 1?

A No.

Q Let's start with the last page, Mr. Savage, which appears to me to be your resume.

Is this resume accurate?

A Well, I have some papers here if you wish to see them.

Q Are those your diplomas, sir?

A Yes. I have three of them actually. I also have a Bachelor of Arts Cumlaude because I was supposed to be the first person to take a course in business administration and engineering, but my advisor died so that was dropped. But here are these three diplomas. The Engineering with distinction

corresponds to Cumlaude in Arts. There's also my Masters there.

Q I'm not going to mark these diplomas but I note that they're all from the University of Minnesota.

A Yes. Here's my membership in the American Institute of Chemical Engineers which is elective which is saying you have to have certain qualifications. I was an active member of that organization. This is just my diploma from the National Honorary Research Society. I'm a research engineer, by the way, rather than a production and design engineer. The Scientific Research Society of America is the same essentially as Sigma Xi and I was elected to that while at Dow and to the Beta Phi Honorary Engineering Fraternity and the Phi Lambda Upsilon Honorary Chemical Fraternity. My Bachelor of Arts was a major in chemistry and a minor in mathematics so I guess you've seen them all.

Q I take it that this resume on Page 8 is accurate?

A Yes.

Q Okay.

A Do you want information about what I did while at Cascade or --

Q I will ask you specific questions and go through this.

A All right.

Q In the second paragraph, you stated when you attened the University of Minnosota and received a Bachelor of Chemical

Engineering with distinction in 1934 or in 1935, excuse me, courses of special relevance included resistance of materials.

Could you tell me what resistance of materials is?

A There were two courses. The course amounts to mechanical design, pressures, columns, beams, all that sort of thing. There was another course which had to do with specific use of chemicals in industry. This was before there was a hand booklet that had those things in it. So essentially I had one course in chemical properties and another course on mechanical design.

Q Would either one of those courses have included the corrosion resistance of materials?

A Some of that was in the course of chemical resistance and also the electro chemistry course had corrosion in it.

Q Could you tell me what --

A I've worked, of course, with regard to corrosion since then.

Q Could you tell me how much corrosion was involved in the second course you mentioned on specific use of chemicals in industry?

A Well, materials you would choose say if you had a reaction with sulphuric acid as the medium, for example, or hydrochloric acid or chlorine or caustic, that sort of thing.

Q What materials you would use to confine such acid solutions?

A Yes.

Q Was there any discussion in that course of corrosion of

materials due to the presence of contaminants in water?
A In general in that course it was in larger amounts. Later on while working out at Dow I did work that had to do with the corrosion of paint cans, for example, by materials in the paint, in making a polytex paint or something like that. So this was -- the small amount of things came later, in other words.
Q Okay. So that it didn't -- it wasn't involved in your courses on resistance of materials?
A Only indirectly, yes.
Q Now, could you explain to me what your course on industrial electro chemistry involved?
A Well, that was -- at that time I was thinking of going into electro chemistry which has to do with things like chlorine cells, magnifying aluminum, magnesium, that sort of thing. It had to do with batteries, choosing metals to prevent corrosion, things like that, if you had metals in contact, what kind of voltage you would have between them, for example.
Q Again, did that course involve the corrosion resistance of materials subjected to water with small amounts of contaminants?
A Well, not as much as small amounts, no.
Q What relevance did your course on electric power add to the testimony as you've written it?
A Oh, it's relatively of little relevance other than I

understand how powerhouses and turbans and generators and so forth work.

Q Since this was 1935, am I correct in assuming that this course on electric power did not include any aspects of nuclear engineering?

A No, it didn't.

Q Do you have any affiliation with the National Association of Corrosion Engineers?

A No. Since I retired, I'm no longer a member of it. I was also a member of the American Chemical Society, by the way. They don't give you any diploma or anything. They give you a card every year and I was a member of that, the American Chemical Society.

Q Were you ever affiliated with the National Association of Corrosion Engineers?

A No.

Q Have you ever attended any specific courses sponsored by the National Association of Corrosion Engineers or the American Institute of Chemical Engineers pertaining to corrosion?

A I have, I think, of the American Institute of Chemical Engineers, yes.

Q Can you remember what that course was about or those courses?

A I don't remember.

Q Have you ever had any courses in nuclear energy?

A No.

Q Have you ever had any courses in nuclear reactor physics?
A No.
Q Have you ever had any courses in nuclear criticality?
A No.
Q Have you had any courses in thermodynamics?
A Yes.
Q When was this?
A I had -- that was when I was in college and also I had some at Dow where I worked in conjunction with the thermal laboratory on some problems.
Q Have you ever had any courses in the design or the fabrication or the maintenance or the operation of steam generators?
A Not steam generators, no.
Q You state in the third paragraph that you worked as a research chemical engineer under various titles with Dow Chemical for thirty-nine and a half years?
A Yes.
Q And then you go on to talk about various aspects of your work.

You state that your experience included reactions involving corrosive acids under pressure, PH control and the observation of an evaporator, observation and maintenance.
A That was when I was still at the paper company.
Q I'm sorry. I'm misreading your testimony.

Can you describe what the evaporators were that you were working with?

A Yes. There are essentially two ways of making chemical pulp that were used. One was the so-called craft process which uses a mixture of sodium barbonate, sodium sulfides and caustic and that's the material which was being evaporated It's washed out of the pulp in what are called diffusers or at least a spraying effect and then it's put through a multiple effect evaporator. At that time they had tubes. The tubes in the evaporators were admiralty metal which is a kind of a bronze that was developed for use with sea water.

Q Were these evaporators similar either to steam generators or condensors such as you described?

A They were horizontal tube evaporators.

Q Were these evaporators similar to either steam generators or condensors of the kind that you're discussing at the Midland Plant?

A They are similar to condensors.

Q Similar in what way, sir?

A Well, they were a horizontal tube.

Q Were they similar in --

A There was steam in the tubes and the liquid, I believe, was -- I think the liquid was on the outside.

Q But the liquid and the steam, were they water?

A Water with the sulfides and things, carbonates and so forth.

Q Is it true that the fluids that you're talking about at the paper company were much more corrosive than you would expect the pond water to be?

A Yes. I was about to say that -- the corrosive acids had to do with sulphuric acid and they react to sulphuric acid and calcium bi-sulfide and there was very severe corrosion there. The bronze valve might only last five days and when we were able to obtain a valve of eighteen stainless steel, they would last over a month which was a big improvement. The principal thing was wire drawing through the valve when you vented it.

Q But to summarize, these evaporators were subject to much more corrosive conditions than the condensors at the Midland Plant or the steam generators at the Midland Plant?

A Yes, but they had the same sort of structurial deficiencies that were shown in the pictures than on these papers.

Q Okay. I'll come back to that later.

A All right.

Q When did you join Dow Chemical?

A 1937, in July.

Q And when did you retire, sir?

A 1976, the end of December.

Q And were you working at Midland the whole time?

A Yes.

Q Was this retirement due to reaching the normal retirement

age?

A It was a year early but I had become sort of worn down and tired from what I was doing and I found I was working for a very small difference from what the retirement pension would be.

Q But was it voluntary?

A Yes.

Q Okay. Now, you say you were a research chemical engineer and not a design and production engineer.

Could you please describe what the difference is?

A Well, the larger scale things I did were pilot plant work in general. That is where you're developing a new process and working out the bugs in it and finding out what materials and temperatures and pressures and all that sort of thing to use. Then from what the experience is there, you build a production plant which is run by production people and it involves some design but it wasn't working day by day in the Design Engineering Department. I also did quite a lot of laboratory work.

Q How large would these pilot plant operations be?

A Well, some up to say 100,000 pounds of material a month or something like that.

Q That's the production that's going through?

A That's the production, yes, and some smaller, depending on what stage you are on development. You start on a very small

scale making a pound a product and maybe scale on up to 20 or 25 pounds and then you go up to maybe 100 or 1500 and then you go up to a bigger scale.

Q In the third paragraph of your resume, you state that your experience included operation of reactors at about 200 psig.

Were these chemical reactors or nuclear reactors?

A They were chemical reactors.

Q Similarly, you state that you had to do with prevention of runaway reactions. Again this refers to chemical reactions?

A Yes.

Q Finally, the course in continuous reactor design from the University of Michigan instructor, is that --

A That again was chemical reactors.

Q Are you stating in this third paragraph that you had experience in the design and operation of condensors and heat exchangers when you were at Dow?

A Yes.

Q And was that in connection with these pilot plants?

A Yes.

Q Is there any other experience with condensors and heat exchangers while you were at Dow?

A You mean -- well, we worked with the production plants that had these things, too. Like, for instance, we changed a batch steel system to a continuous steel system, for example.

Q Were these condensors of the same size and type as those

which are at Midland, to the best of your knowledge?
A This was in Midland, yes.
Q I'm sorry. At the Midland Nuclear Power Plant?
A They were, of course, smaller, I think.
Q Can you give me an idea of how much smaller?
A Well, probably the largest was maybe 400 square feet or something like that and generally Dow doesn't have very big operations in Midland.
Q Is that just the gross size of the --
A That's the heat exchange area.
Q I see.
A The area of the tubes, for example.
Q Okay. And with respect to the heat exchangers, can you give me an idea of whether these were comparable to those that one would find at a nuclear power plant?
A They were, of course, smaller because they don't have as big of ones in those.
Q Were they both -- were both the condensors and heat exchangers using water as the fluid?
A Yes.
Q On both sides?
A Well, sometimes you'd have some water on both sides. Sometimes you'd have water on one side and solvent on another side. Like if you were condensing an organic vapor, you'd have water condensing the vapor.

Q Do you have any experience in the design or the fabrication or the maintenance or the operation of steam generators?
A Well, no.
Q Do any of your patents have application to nuclear power plant design or operation?
A No.
Q Did any of the technical book chapters or encyclopedia articles relate to nuclear power plant design or operation?
A No. What I'm specifically talking about is corrosion of the steam part of the thing.
Q I see. Can you explain what a frangible safety is?
A Yes.
Q Would you, please?
A Yes. Say you have a pipe that's connected to a reactor that develops pressure. You make a thin nickel, for example, a sheet of definite thickness and it can be -- if there's to be vacuum on one side, you pump it a little bit and this is held between flanges that are bolted together, usually fairly high pressure flanges.

You place this in the line and, if the pressure gets to a certain amount, then this nickel thing will burst. Sometimes they have little pieces inside with points on it which would be sure to make it burst more easily.
Q Are these sometimes called rupture discs?
A Yes.

Q And you referred in your previous answer to a reactor. Are you talking about chemical reactors there?
A Yes.
Q What did you have to do with frangible safeties?
A Well, on all our reactors and storage tanks we have frangible safety. It's very rare to have a pop valve.
Q And by all of our reactors and storage tanks, you're talking about all of them at Dow?
A Yes, in general.
Q Okay. What did you have to do with relief valves?
A Well, they were on steam. For example, I had to deal with a Dow boiler which had Dowtherm. The Dowtherm system had relief valves on it and storage of certain kind of chemicals. They sometimes in more recent years began to use relief valves rather than frangible safeties. If there was a hazard for having -- by the way, you generally have two of these frangibles, one of another and, if one is likely to blow, you have a divided pipe, two sets of two so that -- when you connect the stems of the valves together, you can turn one on while the other is off. So if you have to change one, you can do that.
Q I think you talk about that later on in your testimony.
A Yes.
Q And I'll ask you about that later.

You said you had to do with frangible safeties and

relief valves. What precisely was it that you personally had to do with these things?

A Well, you had to choose what size they should be in order to give -- be able to give sufficient escape to relieve whatever was going on inside the reactor. You had to select the materials. Sometimes it was nickel and in some cases they were aluminum and in some cases you'd use a plastic film between the tank and the metal so as to protect it from corrosion. The way they fail is usually by a pin hole through a leak at first. You have a pressure gauge or whatever so you can tell if it's leaking and you can change it.

Q Am I correct in assuming that you were using both frangible safeties and relief valves in desiging these pilot plants?

A Yes.

Q Did you ever work with pilot operated relief valves?

A Air operated.

Q Well, I don't -- I'm not familiar enough with the terms to answer that question.

A Well, you can have an automatic valve that's operated by air that gets say to a certain pressure.

Q Did you ever design one of thoese?

A Design the valve?

Q Yes.

A I designed the installation but the valve itself was something you buy.

Q Did you ever design the installation of such a valve?
A Yes.
Q Did you ever work with target rock valves?
A Pardon?
Q Did you ever work with target rock valves?
A I don't know what that is.
Q Have you ever designed anything for a nuclear power plant?
A No.
Q Have you ever worked in a nuclear power plant?
A No.
Q Am I also correct in assuming that you have no experience in the manufacture of steam generators?
A No.
Q I'm not correct or I am correct?
A Yes, you are correct.

MR. STEPTOE: I will note, for the record, that Ms. Sinclair is now present in the room.

Q Are you familiar with the techniques of stress relief used by Babcock and Wilcox as part of its manufacturing process for steam generators?
A I presume there would be something like an aneeling of them.
Q Do you know what they do?
A I don't know, no.
Q Have you ever toured a nuclear power plant, the site?
A No.

Q You've never toured the Midland site?

A No.

Q Mr. Savage, what documents did you review in the course of preparing this testimony?

A There were some that Ms. Sinclair loaned to me.

Q Do you recall what they were, sir?

A There was one that was testimony by Mr. Hillman. There's one about the Ginna Power Plant. There was one about the Babcock and Wilcox type steam generator and there was one about steam generators in general. There was also an environmental study and some answers to environmental questions.

Q Do you recall anything else, sir?

A There was some miscellaneous letters and things but some of them were marked copies and I'm not sure which were duplicates and which weren't.

Q Referring to the document about Ginnea, I hand you a copy of NUREG-0916 which is entitled Safety Evaluation Report relating to the restart of RE-Ginna Nuclear Power Plant. Is that the document you reviewed, sir?

A Yes, and there were two small ones about so thick, ones on steam generators and --

Q We'll see if we can find those.

Is this the -- I'll hand you a copy of NUREG-0537, Final Environmental Statement. Is that the document you

reviewed?

A Yes, sir, I reviewed that. This is one of the ones I did review.

Q Would you identify that or let me identify it.

A This was the other one.

Q You reviewed NUREG-0571, Summary of Tube Integrity Operating Experience with Once-Through Steam Generators, is that correct?

A Yes.

Q And you also reviewed a document entitled NUREG-0886 entitled Steam Generators Tube Experience?

A Yes.

Q I think the Court Reporter would have an easier time if you would let me finish asking my question before you answer, sir.

A Okay.

Q Do you -- can you identify anymore clearly the miscellaneous documents and answers to environmental questions that you reviewed?

A Besides this yellow one, there was an earlier one.

Q You mean the Draft Environmental Statement?

A Yes.

Q And that was green?

A Green, yes.

Q And was there anything else that you can recall that you

reviewed?

A I can't recall what the other things were.

Q Did you review the document called the Final Safety Analysis Report for the Midland Plant? It's a multi-volume document.

A No.

Q Did you review this document which is called the Safety Evaluation Report for the Midland Plant? It's NUREG-0793.

A No.

Q Did you ever review any of the supplements to NUREG-0793 which are thinner documents?

A No.

Q Your answer is no?

A Right.

Q Did you ever review a document entitled the Environmental Report for the Midland Plant? It's another multi-volume document in big binders.

A Bigger than the green one?

Q Yes, it's like a three-ring binder.

A No.

Q In the Final Environmental Statement, are you aware that your letter commenting on the Draft Environmental Statement is included in this document?

A Yes.

Q And did you read the staff responses?

A Yes.

Q To your letter?
A Yes.
Q Have you reviewed Consumers Power Company's Proposed Secondary Water Chemistry Limits?
A I guess I don't -- I'm not clear what you mean. Do you mean the analysis or --
Q No. I'll ask you -- I'll simply tell you that there are specific limits on levels of contaminants in the secondary water system which have been proposed by Consumers Power Company, for instance, so much for chloride and so forth. Have you reviewed that list?
A I think I've seen it but I can't remember what it was in.
Q Do you recall what any of those limits were?
A No.
Q Did you rely on those limits in preparing your testimony?
A I guess I had forgotten them.
Q You said you -- I wasn't clear when you had forgotten them, sir.
Did you forget them before you wrote your testimony?
A Yes.
Q Have you reviewed the Midland Plant operating procedures as they relate to secondary system chemistry monitoring control?
A There were notes on the testimony of Mr. Hillman.
Q But apart from Mr. Hillman's testimony, did you ever review

the Midland Plant operating procedures?
A No.
Q Have you ever read any Midland Plant operating procedures dealing with the blowdown of the steam generators or blowdown requirements or procedures for the steam generators?
A No.
Q Have you ever reviewed any procedures relating to the proposed maintenance of the systems for controlling secondary water chemistry?
A No.
Q Have you ever reviewed any nuclear power plant operating procedures governing emergency procedures in the event of a steam generator to rupture?
A I read the Ginna Report.
Q Apart from the Ginna Report, have you ever read any other procedures governing that situation?
A No.
Q Turning to your testimony and Savage Deposition Exhibit No. 1, turning to the third paragraph of Page 1, can you explain why the causes described in this paragraph are a more serious cause of steam generator corrosion than leakage through the condensor into the secondary system?
A Well, the combination of the materials of construction and of the chemistry and of pressure tend to make the -- that is the amount of material leaking in from the pond water system

would be relatively low in a variable composition. If the high pressure leaks to the low pressure, that is if the 2,000 pound pressure leaks into the shell side of the steam generator, then it's a much more serious matter and the steam generator, according to the materials that are used, is very likely to be corroided.

For instance, if it has copper in it, the amonia will attack the copper to form a complex and this will create pitting of round crystals and every time the ion exchangers run out, you'll tend to have corrosive materials come through from the ion exchangers.

Q Is there anything else you would like to add, sir?

A You do have these dissimilar metals which will set up corrosive couples which will have a voltage difference between -- say if there's a piece of copper there and a piece of nickel there, there would be a voltage difference between the copper and the nickel and that will cause corrosion also. In addition, you have all these stresses and strains.

Q I think you are referring to the 2,000 pounds per square inch pressure. Are you talking about the pressure in the primary system at the steam generators?

A Yes, pressure in the primary system would be about 2,000 pounds and in the secondary system it would be about 1,000 pounds. So if there's a leak through the driving pressure

there would be about a 1,000 pounds per square inch so it would tend to leak more rapidly.

Q Than a leak in the condensor?

A Yes.

Q Let me ask you to assume that there will be no careless operation of the cation and anion exchangers in the secondary system and assume further that the controls for when to blow-down to be performed will be adequate.

Would you have a serious concern about the resistance of the steam generators to corrosion due to the possibility of leaking of pond water through the condensor tubes into the secondary system?

A Well, I think your first assumption is not very probable. The thing is you don't know when these exchangers are going to run out. They're usually delegated to some operator who just looks at them once a day or something like that. It's difficult to measure when the material is going through and you'd have a very good analytical system to tell what's in the bottom of the generator, that is if ions collect in there.

Q Well, I understand that you object to my hypothesis but let me ask you again, sir, if the only problem with the secondary water chemistry was due to leakage of pond water through the condensor tubes, would you be seriously concerned about the corrosion potential for the steam generator?

A You would still have the matter of dissimilar metals and

vibrations and mechanical stress. All of those things can set corrosion.

Q All right. Let me ask you to weigh those problems so that the only problem is the possible introduction of pond water into the secondary system through the condensor tubes. Would that represent a serious corrosion problem to the steam generators?

A Over a period of time, you can build up ions even from the pond and the steam generator and have them cause corrosion.

Q If the condensor were allowed to continue leaking for a long period of time, is that correct?

A Yes, and also you will have ions picked up from the pipes and the pump and so forth. You have cavitation in the pump which corrodes it.

Q Can you estimate how long it would take if your only problem was due to a leakage in the condensor before you would have a corrosion problem in the steam generators?

A It depends a lot on the kind of water that's being put through the condensor, how much carbon dioxide is in the system, how much air is in the system, various things like that. It's very hard to estimate it.

Q So at this point you can't, as you sit here today, you can't make that estimate, is that correct?

A Not at this time, no.

Q Why is the concern expressed in the third paragraph on this

page, more particularly serious for that unit which supplies steam to the Dow Chemical Company?

A Because there's so much more make up water, you create a chance of bringing in ions.

Q Can you tell me --

A You have to have a great deal -- you use relatively make up in the other unit but a great deal of make up so -- there's a considerable amount of make up even if only about -- well, say 20 percent of that were make up and the rest were condensate returned, we don't return all of the condensates. Some of it's used for other purposes, like if you're thawing pipes in the wintertime and things like that. Also there's some processes where the steam condensate can get contaminated and they don't return that either.

Q Is it your understanding that the steam from the secondary cycle goes to the Dow Chemical Company and is returned as condensates together with make up from the Dow Chemical Company and reintroduced into the secondary system?

A That part that Dow uses would be circulated.

Q And reintroduced into the secondary system?

A Yes. It will have to probably go through ion exchangers or something and filters and so forth first.

Q Is your statement that there will be careless operation of the cation and anion exchangers, very common in the chemical industry, is that related to the operation of such exchangers

at the Dow Chemical Company or at the Midland Plant?

A It probably would be at both places.

Q In your experience at Dow, have you observed the careless operation of the cation and the anion exchangers?

A Well, the ph, they just -- the powerhouse, they just had a cation exchanger on the sodium cycle. In the plants I had to deal with, we had both cation and anion exchangers. In both of these places you can get considerable ph variation.

Q So your experience was that the ph --

A My experience in the plant was -- in fact, it happened that they had some piping that was Monel at the time which they had to get rid of. Monel has a considerable amount of copper and every time the ion exchanger would start to run out, you'd pick up that copper and have it come through into the product and with Inconel, you still have copper. You can also have trouble if your glass electrode fails. You measure ph -- if you're controlling by ph, you have a glass electrode and a calomel electrode. The calomel electrode is a glass one with a little fiber up through it and it carries mecuric oxide in it and that little fiber has to be cleaned off once in awhile or the electrode will no longer be at the proper potential, the same way as the glass electrode which has a little glass bulb that has a certain ph or concentration of acid on the inside. Gradually material will make its way through from the outside to the inside and that electrode

will also change so that you have to change your electrodes every -- probably in continuous operation, you might have to change them at least every month if not oftener. Not only that, but the glass electrode can crack and let material pass through.

Q Sc your statement here is based on your experience at Dow that there often is careless operation?

A It isn't always careless. Sometimes it can just be the fault of the measuring devices. Another thing, if you take conductivity, a conductivity cell has little pieces of platinum that have had a black sponge generated on their surface and that can pick up ions and things out of water and no longer give you the same conductivity as you had before.

Q Okay. And what kind of processes are these ion exchangers used at Dow Chemical?

A They are used -- well, in the powerhouse they are used to move the hard ions in the powerhouse, feed the calcium and that's an ion exchanger that removes those and puts in sodium. You've got a so-called soft water which tends to foam somewhat but it doesn't give you precipitate, if you have something like soap present and it works all right in a powerhouse.

In some of the plants it's required to have water very free of ions and they could have both the cation and anion

exchanger and, in order to do that, you've got to run the cation on one hydrogen cycle that is regenerating with acid rather than with salt and then, when you do that, an anion exchanger will absorb the acids as such. You can't do that with CO^2, by the way. CO^2 has to be boiled out with water.

Q Can you explain what the powerhouse is at Dow?

A That's where they have the steam boilers. There's a south powerhouse and a north powerhouse. The south powerhouse used to be where the ion exchanger unit was.

Q And they're supplying processed steam for Dow?

A Yes. In the early days it used to generate electricity also.

Q What is your basis for your statement about careless operation of the ion exchangers as it applies to the Midland Plant?

A Well, it's a matter -- you don't always notice when the ion exchanger runs out because you're dealing with relatively low concentrations and it may be quite awhile before it attracts the attention of the operator who's running it. You may have other duties to do.

Q You are -- is it correct that you are simply applying your experience at Dow Chemical to the Midland situation, the Midland Nuclear Plant situation and assuming that Midland Nuclear's Plant experience will be no better than Dow's?

A Well, it's experience with more than one set of ion

exchangers and there are these measuring problems.

Q Are you familiar with a specific measuring instrument that they have in place at the Midland Plant or will have in place on the secondary system?

A Not the specific ones. Instruments have changed quite a bit over the years.

Q Are you familiar with what alarms there are on the ion exchangers for other demineralizing equipment that will be in use at the Midland Plant?

A You could have conductivity operated once or ph operated once. They probably could have both.

Q But do you know what they have, sir?

A No.

Q Okay. Do you know what training the Consumers Power Company personnel have who are going to be responsible for this demineralizing equipment?

A No.

Q When was your last experience with Dow ion exchangers?

A Oh, about 1974 or so.

Q All right. Thank you.

Can you tell me what is wrong with using ammonia for neutralization?

A Because if there's any copper, it will form a complex with copper and have intergranular corrosion. Also, Inconel is not resistant to a number of things. Inconel has only

partial resistance to ammonia chloride, for example, so any chloride ion that comes through from any source, then you'll have some ammonia chloride. If any chlorine comes through the water from any source, you'll have corrosion from that. HCL or Inconel isn't even too resistant to calcium hydroxide, if you should have calcium coming through. All these things can build up.

Q I understand, but the only one that comes from using ammonia for neutralization would be the ammonium chloride, is that correct?

A Ammonium chloride and the complex copper, ammonium complex, if you have bits of free copper anywhere in any of your metal, fabricated metal.

Q Do you know whether there's any copper in the secondary system?

A Well, Inconel contains copper.

Q Aside from the copper contained in Inconel, do you know of any copper that is in the secondary system at Midland?

A I don't know completely what the types of pipe and so forth used are. Most nickel-type alloys are chromium-type alloys and have copper in them, a little copper in them also.

Q But at the present time, apart from the copper in the Inconel, you're not aware of any other copper in the secondary system, is that correct?

A Yes.

Q Would you expect the copper in the Inconel --
A Copper can come in the water, too.
Q Would you expect the copper in the Inconel to leak out of the Inconel due to the presence of ammonium in the secondary system water?
A I think it would give corrosion around the edges of crystals. You have granuals that are exposed rather than actually leaking out. You'd have to have something like chloride or acid which probably would actually leak it out.
Q So that the copper that would be subject to combining with ammonium would be the copper at the surface of the Inconel, is that correct?
A Yes.
Q Can you explain what is wrong with using hydrazine for oxygen scavenging?
A The hydrazine chemical is a similar material to ammonia so it would have similar properties to ammonia probably.
Q Above and beyond the properties that we've already discussed with respect to ammonia, is there anything else wrong about using hydrazine as an oxygen scavenger in the secondary system?
A Well, as an oxygen scavenger, it probably works pretty well. It is, of course, an explosive material under certain circumstances.
Q Isn't it true that it's explosive when it's in the anhydrous

condition?

A In general, yes, but I don't think you really know when you're at high temperatures. That is, things can decompose just because of temperature.

Q Do you know what concentrations the hydrazine will be used in the secondary system?

A It's probably low parts per million.

Q Do you have any experimental evidence or data which indicates that at those concentrations hydrazine can be explosive?

A Well, the data given on hydrazine gives it according to temperature generally, the data I've seen.

Q Do you know what temperatures the secondary system will operate at?

A Probably around 550 Fahrenheit or so which is much the same temperature, I think, at which I've read that hydrazine can decompose. Hydrazine sulfate in particular can decompose.

Q At those temperatures, sir?

A At a temperature like that. The other conditions weren't given.

Q Do you have any evidence or experimental data which suggests that those temperatures of hydrazine and the concentrations that will be used that's explosive?

A No.

Q Do you believe that the applicant who's going to use

ammonium chloride as a neutralization agent in the --

A Ammonium chloride isn't a neutralization agent. If you're using ammonia to neutralize something, it's going to neutralize chloride or sulfate or whatever happens to be there.

Q So the only way that ammonium chloride would come to be present in secondary system water would be if chlorides were present from another source and then ammonium was added as a neutralization agent, is that correct?

A Yes.

Q Similarly, the --

A The water has -- comes before it's -- as I say, if the exchanger runs out, some of that will come through and similarly chlorides are in the pond and, if some of those were to leak through, you'd have chlorides from that source, too.

Q You mentioned another compound chemical, hydrazine something else.

Can you refresh my recollection of what you said?

A I think I said hydrazine sulfate. Hydrazine is a base that forms salt with whatever acid ions are present just like a cation exchanger.

Q Do you believe that the applicant would be adding hydrazine sulfate to the secondary system?

A Not hydrazine sulfate. I understand that they're going to add hydrazine but I understand, if there's some chloride,

the the hydrazine will react with it.

Q Again, the chloride or the sulfate would have to come as impurities either from the pond or some other source to enter the secondary system, is that correct?

A The pond or from passing through the ion exchangers or from some straight piece of metal.

Q Okay. Now, you also stated --

A Or if there were chlorine present. I read that city water was to be used the first year. City water is chlorinated. If that was an error and they intended to use Huron water, then it wouldn't have chlorine in it.

Q With respect to the last statement in this paragraph, you refer to the failure to establish adequate controls when blowdown should be performed. Do you know what controls there are for blowdown for --

A You're going to have to --

Q Excuse me, sir.

A You're going to have ions that accumulate in there. The places of analysis show them on the way to the generator rather than right in the generator.

Q Mr. Savage, I'm afraid we're giving the Court Reporter a hard time here. Please let me finish. I know that I pause sometimes in my questions but, if we work together, we can probably make her life a little easier.

Have you reviewed what the controls are for blowdown

of the Babcock and Wilcox steam generators at the Midland Plant?

A No.

Q And what is your basis for stating that there will be a failure to establish adequate controls?

A I would say it was the difficulty in controlling such a situation because I was estimating from other plants that have all these problems that there is a general lack of such control.

Q Are you basing that on your study of these NUREG documents?

A Yes.

Q Do you know what the controls on blowdown are for the ones through steam generators?

A No.

Q Can you tell me in the next paragraph what dissimilar metals you are referring to?

A Well, for instance, you have these spacers or baffles at various places in the height of the generator which are in contact with the tubes and those spacers, I believe, are of iron whereas the tubes are of Inconel.

Q Do you believe that Inconel and stainless steel are dissimilar metals?

A Yes, although some stainless steels have the same, much the same properties as Inconel for most purposes but your whole variety of stainless steels have various materials and the

more resistant ones have say chromium and things like that in them and the less resistant ones could even have things like aluminum in them.

Q Do you know which kind of stainless steel is used in the Midland steam generators?

A No.

Q Are there any other dissimilar metals in the Midland steam generators other than the ones we just mentioned?

A Well, there's also the matter of the tube sheets.

Q What material are they made of?

A It doesn't specify.

Q Do you know of any other metals or materials that are used in the steam generators which you are referring to in this paragraph as being dissimilar?

A Well, constituants of the Inconel.

Q Are you stating that the constituants of the Inconel will act independently for purposes of galvanic corrosion?

A They could under certain conditions, yes, depending on how they've been fabricated, how they have been heat treated and so forth.

Q Are you prepared to testify under what conditions could occur?

A Well, for example, if the separaters in the steam generator broached, it makes a difference when you're broaching, whether you have to push a tool through or whether you turn

and burnish the thing. That's one example.

Q If Inconel and carbon steel are in contact, which will corrode, sir?

A I have at someplace here some voltages here. At the bottom of Page 5 there's some electrode potentials and the iron, that would be about a minus 0.44 volt and the nickel would be about minus 0.23 volt and the copper, it would be a plus 0.34 volt. So between the iron and the nickel there would be only about two-tenths of a volt. If the copper happened to be in contact with the iron, you'd have seven-tenths of a volt. Those are just approximate measurements of what kind of effect you'd have.

To illustrate that, between the metal and contact, there's a thin layer of salt and you will have different voltages with different metals. So that if these metals come in contact, there would be a different voltage between them.

Q Is the potential for Inconel shown at the bottom of Page 5?

A It's a picture. I've never seen the potential for Inconel. These are relevant to a hydrogen electrode.

Q Well, can you tell me if Inconel and carbon steel are in contact, which will corrode?

A I think the carbon steel would corrode.

Q You believe the carbon steel would corrode?

A Yes.

Q Are the corrosive couples that you are discussing on Page 1 affected by water chemistry?
A It could be to some extent, yes.
Q Can you explain why, sir?
A Well, it depends on the ph of the water and it depends on whether any of these ions are there. That is, you need ions both to be in contact with the place where the metal is and to make a bridge across between one piece of metal, one kind of metal and another kind of metal.
Q I see.
A And it would undoubtedly depend some upon the ph also and whether -- now, for example, if you have oxygen present, that will tend to make stainless and Incondel types more corrosion resistant even though the corrosion that would finally occur would be helped by oxygen. That's kind of a peculiar balance that's difficult to explain.
Q If the secondary water chemistry is adequate and the electrolyte present in the secondary water chemistry is minimized, won't that also reduce or minimize the corrosion due to these couples that you're talking about?
A It could tend to. One thing they do sometimes is put in anodes that would corrode more easily, for instance, a piece of -- for awhile, they were putting pieces of magnesium in the water heaters and the magnesium anode would corrode and the other wouldn't and sometimes in long lines they apply a

potential to these anodes.

Q Are you aware of any experience of galvanic corrosion in B & W steam generators?

A Well, what I've read in the report there doesn't distinguish whether it's galvanic or otherwise if I remember rightly.

Q Sir, would you please look at NUREG-0571 and indicate whether there's anything in there which you relied on to support the proposition that such corrosion may occur in B & W steam generators?

A Here they say they add ~~hydrazine~~ to dissolve oxygen rather than --

Q I think we've been assuming, sir, that that's a typographical error.

A I don't see where it would be considering any such corrosion in writing their report.

Q Is it correct that they have not reported any galvanic corrosion?

A Or have not differentiated from mechanical. This report is essentially on mechanical problems.

Q Okay. Moving on --

A One other thing they plan to do in the future is to study corrosion.

Q What page are you referring to there?

A A3, 4, 5/3.

Q Do they specifically refer to studies of galvanic corrosion

there?

A Corrosion and other materials related to tube failure phenomenon.

Q But they don't mention galvanic corrosion here, is that correct?

A No, they don't mention materials or the composition of most of the parts of the thing. It's almost purely mechanical.

Q They're going to do what?

A They indicate in their photomicrographs towards the end of it for Brookhaven and Franklin that there could have been galvanic corrosion.

Q My understanding of NUREG-0916, and correct me if I'm wrong, was that they attributed the tube failure to foreign objects.

A Yes, that was foreign objects, but some of the pictures in back of the thing, there seems to be some intergranular corrosion.

Q So that you derive from NUREG-0916 the conclusion that the tube failure was caused by foreign objects but there may have been some intergranular stress corrosion?

A Yes.

Q As well?

A Yes.

Q The next paragraph, you state that -- I'm sorry. In the next sentence you state that chemical components will aid in the initiation of intergranular corrosion cracking.

Are you referring to the hydrazine and the ammonium?
A Particularly the ammonium, yes, and any chlorides or whatnot that could leak in.
Q What mechanical stresses are you referring to in that sentence?
A Well, this has the tubes fixed at both ends as compared to the loop type one that some of the other companies use. So there's a tendency to have a column affect on the tubes, that's one stress.

Another stress is the expansion of the tubes to fit into the tube sheet. Another stress is vibration, particularly at the point at and above the surface of the liquid. There will tend to be more vibration above that. There will be vibration between the spacers and the tubes.
Q Is intergranular corrosion the same as galvanic corrosion, sir?
A Not necessarily, no. If you had -- galvanic corrosion would be where there were metals of a different kind. Some stainless steels consist of rather large granules and those will corrode around the outside of those granules. So some stainless steels are a solid solution and others are more austenitic type which you can have fairly good sized granules in them and eventually you'll have a little shallow eating out around each granule.

There was some mention there that some of them had

eaten down to 20 percent of the thickness, I think it said. Maybe I'm wrong. Maybe it was 20 percent in, but there was something like that said.

Q Is the intergranular corrosion -- I'm sorry.

Is the corrosion described in the Ginna NUREG-0916 intergranular corrosion or galvanic corrosion?

A There were some pictures that showed intergranular corrosion.

Q So that there's nothing --

A There's nothing in there of galvanic corrosion as such probably.

Q Okay. Moving on, you state that the chemicals chosen are not well suited to the materials of construction.

A Well, that really was the ammonia was not suited to the presence of possible copper is what I should have said.

Q I see. What is your basis for the statement two paragraphs down that the shutdown procedure in the Ginna system was haphazard and erratic?

A Well, they didn't seem to have any procedures to what to do when the computer failed.

Q The computer failed, sir?

A I believe it says the computer failed so they operated by hand.

Q You refer to NUREG-0537. Do you mean NUREG-0916, the Ginna Report, in that sentence?

A I guess I have the number wrong.

Q Okay. And is there any other -- and are you basing your statement about the shutdown procedure being haphazard and erratic on your reading of the Ginna NUREG?
A Yes.
Q You don't have any independent knowledge of Ginna even other that what you've read in this NUREG?
A No.
Q That's correct?
A Yes.
Q Is there any other aspect of the shutdown procedure at the Ginna system that struck you as haphazard and erratic?
A Well, there were opening valves and there were closing valves and so forth.
Q I'll hand you NUREG-0916 and ask you to read the last two paragraphs in Section 2.2.3 entitled Procedures and, after you've read that, would you please comment on whether you agree or disagree with the statements, conclusions presented there?
A Well, essentially it says there were significant deviations by plant personnel that were consciously made following a study of their consequences before execution. That's sort of double talk. How can they know the consequences before they execute it.
Q So you believe that the statements that are made in that NUREG concerning operator action are double talk?

A No. I say that the statement, the significant deviations from the procedure by plant personnel were consciously made following a study of their consequences before execution, I say that's a difficult sentence to follow. They made significant deviations from the procedure they had outlined, that's clear. They did it consciously. But how they could know what was going to happen before it had happened is the question. This statement is perhaps of not such great importance.

One thing you have to realize is that you're very near the critical point of water. Are you familiar with the critical point?

Q I was going to ask you about that later, sir.

A You're within 100 degrees Fahrenheit roughly of that.

Q I will ask you about that later, sir.

I assume that's what you are referring to when you say that there was a narrow margin of safety as potential pressure and temperature?

A Yes. There was a report in the paper that there was a 90 second margin of the Salem event where that was reported recently. In other words, if they didn't act within 90 seconds, their water would probably be past the critical point and you would have no cooling.

Q Do you know what kind of reactor Ginna is?

A Do you mean the reactor itself?

Q The vendor, is it Babcock and Wilcox or is it Westinghouse or --
A I've forgotten. It was in there but I've forgotten. I think it was Babcock and Wilcox but I'm not sure.
Q If it were Westinghouse, would that change in your mind the relevance of your statements about the shutdown procedures followed by the plant operators?
A I guess I'm not that aware of the difference in reactors.
Q Or in the shutdown procedures for those reactors?
A Yes.
Q That's correct?
A Yes.
Q You state that the incidence of tube failures in steam generators is increasing with time.
What do you mean by incidence of tube failures, do you mean the absolute numbers or the --
A Well, you go through these reports and the number of tubes, for instance, that have to be blocked off in the areas where these spacers come in from the outside increases with time and that, by the way, is galvanic corrosion there.
Q So are you referring to other steam generators or Babcock and Wilcox steam generators?
A I think it was in both reports, at least in the one that had all of them in them.
Q That's NUREG-0886 Steam Generator Tube Experience?

A There were places where they had a series of illustrations in one of these. There's one of these that with time showed how many tubes had to be plugged, how many tubes had to be plugged off.

Q I see.

A So you would have say one or two tubes near one of these places first and then maybe you'd have five tubes in that area and maybe in another area you'd have 10 tubes.

Q Tubes that are blocked you mean?

A Would have had to be blocked off because they leak.

Q You state that improved materials of construction and improved design and fabrication and compatible water chemistry are needed before permission is given for any more units to start up.

What do you mean by compatible water chemistry?

A Well, I guess I'm referring specifically to the use of ammonia for one thing and the fact they haven't studied perhaps enough the effects of corrosion and couples yet on the water chemistry. You already have a lot of reactors going where they're getting these effects and having plugged tubes and things and they need to get to the bottom of that.

Q Well, what improvements in design and fabrication would you suggest?

A Well, they've got to avoid having excessive vibration in the looped type. You've got to avoid having too much column

effect in the Babcock and Wilcox type and I think they ought to look further into what the materials of construction for the thing are to be and test under -- well, they are getting tests but they ought to go on with their tests further before they have more units that repeat the same problem.
Q Can you suggest any improvements in water chemistry, something other than ammonium that you would like to use?
A Ammonium is supposed to scavange acids and to neutralize any -- well, to neutralize any acids that might be there. I would think that a trace of caustic perhaps would be as good or better than ammonium.
Q A trace of caustic. What is caustic, sir?
A Sodium hydroxide, potassium hydroxide. See, these stainless type things are made passive initially by forming a very, very thin layer of oxide on the outside. If that layer of oxide is lost, they can't restore it again and it would be less likely to be lost where it's say you had a little caustic or something like that than if you had something like ammonia which can assist in eating into any copper or whatnot that might be present in the alloy.
Q Mr. Savage, I would suggest that we take a break now and come back to this and I'll try to move faster as we go through the rest of your testimony, if that's all right, and let's take a 10 minute break.

(Whereupon a short recess was had.)

MR. STEPTOE: Let's go back on the record. Let the record reflect that Ms. Sinclair had to leave and I have informed her that we would provide her with a copy of the deposition transcript.

Q (By Mr. Steptoe, continuing): Mr. Savage, turning to Page 2 of Savage Deposition Exhibit No. 1, Paragraph 1, the last sentence, it says that any gases will tend to accumulate above the upper tube sheet in the generator. What gases are you referring to?

A Well, any dissolved air or CO^2 that comes in and dissolves in the water or perhaps infinite tesamil. There are essential gases that would be dissolved in the water.

Q If they are dissolved in --

A Well, when you boil the water, then gases will separate.

Q Is the water in the primary coolant boiling?

A No, excuse me, it isn't. Any gases would come probably either from being dissolved in the water or come off from the nuclear core is what I should have said.

Q Do you know what kind of gases come off the nuclear core?

A I think like radon and possibly a little deuterium.

Q Are these gases dissolved in the primary coolant?

A I don't know.

Q Do you know whether radon and deuterium gases are formed in the reactor during normal operating conditions?

A Oh, they are vented, I believe.

Q From the primary system, sir?
A There's been much argument about them as a matter of atmospheric contamination. I believe that very small amounts are formed during normal operation.
Q If any gases are dissolved in the primary coolant, why will they accumulate above the upper tube sheet in the generator rather than passing through the generator with the coolant?
A Well, they tend to go through a high point.
Q If they're dissolved in the coolant, will they tend to go to a high point?
A Not if they're dissolved but, if there's free bubbles of gas, any bubbles of gas would tend to accumulate in a high point.
Q Do you know whether there are free bubbles of gas in the primary coolant of a pressurized water reactor during normal operation?
A This I don't know.
Q Moving on to Paragraph No. 3, the second sentence, you refer to cooling water (service water) from the pond.
Are you referring there to circulating water?
A The water that circulates through the condensor, yes. It's like the water that's used in the condensors at Dow that's put through coarse screens which take out the fish and weeds and things.
Q Paragraph No. 4 is a description of the steam sold to Dow

Chemical Company.

A Yes.

Q The sentence that begins, that one may suppose that the steam is withdrawn interstage between the turbogenerator stages, and then you go on to describe that, do you know for a fact that that is the way that the steam is withdrawn?

A No. Well, that's a logical way to do it.

Q But you have not reviewed the design of the turbogenerators to confirm this?

A Well, you would want to bring it to -- this would bring it to the proper measures at which it would be withdrawn. You certainly wouldn't want to waste the electricity that might be made by expanding it to that extent.

Q But is it correct -- am I correct in stating that this description is based on your supposition rather than your actual review of the design?

A Yes. The Stage 3 steam, high pressure steam or, excuse me, the low pressure steam specified is 25 pounds higher than what Dow generates at the present, 150 pounds of steam at the plant.

Q Referring to Paragraph No. 5, you state that perhaps 80 percent of the steam sold to Dow would be returned as condensate and then reused.

First of all, is the 80 percent figure again a supposition on your part?

A That is withing perhaps a plus or minus five percent of what the experience used to be when I was working. There would be so much loss of steam either because it was used directly like to thaw frozen lime or it got some kind of contaminant in it or it was used directly and went out the sewer or something like that.
Q So you're basing this estimate on the experience at Dow using the powerhouse and Dow's own process steam system, is that correct?
A Yes.
Q Okay. Again, could you explain how this steam would be re-used?
A Well, the condensate would come back and be put probably through the demineralizers and be circulated around just as it is in the powerhouse.
Q Circulated around the secondary system?
A Yes, to make steam.
Q Now, the last sentence on this page begins with the word it. Are you referring there to condensates or to make up water?
A Probably the combination of the two.
Q I'm sorry.
A Probably a combination of the two. However it was handled, you could run them all together in a tank or at times you could run condensate entirely perhaps for awhile, depending

on how much you had on hand.

Q Do you know that this condensate and/or the fresh water from Dow will be used for make up to the primary cooling system?

A Well, it's just condensed steam. It would be perfectly good.

Q But do you know whether it is going to be used for that purpose, sir?

A I guess not.

Q Okay. Turning to the next page, Paragraph 6, what are you referring to when you in the second line refer to the Dow Chemical Company's upstream operation?

A As I say a little farther down, most of the river gets circulated through the plants several times before it comes on downstream.

Q So you're referring to the discharge structure of Dow Chemical?

A Some of the water discharged from Dow will make its way into the pond.

Q How many discharge structures does Dow have, do you know?

A I don't know now. They've changed it since I retired.

Q Do you know -- well, are you saying that the Dow discharge is upstream of the Midland pond intake?

A Yes.

Q Is this based on your personal observation?

A They had a discharge way up by their west side powerhouse at one time. They had one near the end of Main Street at one

time.

Q Do you know where the discharge structure is located now with respect to the intake structure for the nuclear power plant pond?

A I think now there's probably more than one because one would discharge from things that they put through water treatment, taking stuff out for incineration whereas the other one would be just really the discharge of water that had been through condensors and things like that.

Q Well, you're speculating, are you not, about where the discharge structures are at the present time?

A Well, there's only one about 300 yards or so above, I think, where this intake for the pond is, but I think also there's a discharge farther upstream.

Q How do you know that, sir, is that based on your personal observation or your memory or what?

A Personal observation.

Q When was the last time that you observed the relative -- well, the location of the discharge structure for the Midland Plant or, I'm sorry, for the Dow Plant?

A Oh, it was a few years ago.

Q Have you seen it since they changed the location?

A No.

Q If the discharge structure --

A Well, I'm not making this issue a primary contaminant. I'm

just saying it's one of the points.

Q So if the discharge structure were downstream of the intake structure for the Midland Nuclear Plant cooling pond, that would not substantially effect your testimony, is that correct?

A Yes. One time long ago there was discharge from the chemical plant at St. Louis and from the Pure Oil Refinery that used to be across the river from Dow into the river where Dow got its water, too.

Q Is that on the Titabawassee?

A Yes.

Q And is that upstream?

A St. Louis is on the Chippewa which comes into the Titabawassee in the middle of town but then the Pure Oil Plant was below that, right opposite Dow. They had a refinery there at one time that discharged into the river.

Q In Paragraph (b), you state that it is intended initially to use Midland City water (Huron water would serve as well) as make up, and after the first year to use ion exchange water from the Dow Chemical Company.

What is your basis for that statement?

A Mr. Hillman said that.

Q Do you have a copy of that testimony in front of you, sir?

A Yes.

Q Can you show me where he says that? I guess I can refer you

to Page 6 of his testimony, the middle paragraph.

A Well, the plant make up demineralized its system, takes its normal suction from the City of Midland Water System but can use Dow as a back up source.

Q Is that what you were recalling from Mr. Hillman's testimony?

A Yes.

Q Does that say anything about after the first year using the water from the Dow Chemical Company?

A I saw that someplace in one of the things I read. It was in a place where they were discussing, and I think it was one of those ones, where they were discussing the fact that because Dow was using the steam and was supplying make up water, that they wouldn't further discuss it in that report, wherever it was, one of these environmental things.

Q Okay. If it were the case that, as Mr. Hillman's testimony states, that the plant make up demineralizer system takes its normal suction from the city water of Midland Water System but can use Dow Chemical Company's demineralized water as a backup source and, further the case, that in either event the source of water is processed through the plant make up demineralizers to assure proper quality, if that's true?

A Right here it says -- that was the condensate storage you're asking about?

Q Well, if that's true, isn't your discussion on Page 3 and 4

of the Dow demineralizing system, their cation exchange water, their water cycle and their anion exchange water, irrelevant?

A No, the reason being city water has been limed and chlorinated and contains flouride ions which are put into prevent tooth decay. Chlorine, when they have a leak around the city, is so strong that it comes up and bothers your e, s when you're in the bathtub. Normally it isn't that much but the chlorine -- hydrochloride is something that both stainless steel and Inconel are not resistant to.

The effect of flouride is relatively unknown. There hasn't been much study done of that but the lime has been used to remove calcium and magnesium. In order to see what happens when the ion exchanger runs out, you have to start with a composition that would normally be fed into it to see what the possibilities are, so it isn't irrelevant.

Q If they were not using Dow water in the secondary primary system at the nuclear power plant, then would your discussions of the Dow demineralizing processes in Paragraph 6 (b), (c), (d) and (e) be irrelevant?

A Well, there's an explanation of how our demineralizers work. Some of this I had to put in so that Mrs. Sinclair would understand it and so that perhaps you would understand it. It's a fairly complicated business.

Q But if the Dow water is not used in the secondary primary system, then the discussion of the Dow demineralization

process is not relevant to your testimony, is that correct?
A Unless they put the condensate through it before sending it back. It's much the same thing whether it's demineralized by Dow or by Consumers Power. You have the same possibilities.
Q You state that it is the commonest thing in the world for operators to permit this to occur. That's at the top of Page 4.
You're referring to exhaustion of the cation exchanger and that's based on your experience at Dow?
A Yes.
Q And it applies to -- well, strike that.
In Paragraph (f), you state that if city water is used, it will contain chlorine, which is not removed by an exchanger.
Does chlorine break down into chloride ions when it is put in water?
A It could give you chloride plus hydrochloride.
Q Is there a principal that --
A It will depend on the ph, which ions you would get from chlorine breaking down.
Q Are you able to estimate the percentage of the chlorine which will remain in the form of chlorine and the percentage which is in other forms in city water?
A Well, if it completely decomposed, it would be half chlorine probably and half hydrochloride but alkaline ph. It might

-- if you got really acid, you could get chlorine dioxide which on a large scale is very explosive but that's not of consequence here. There's an equilibrium between chlorine and water that changes with ph.

Q Is it true that the demine: lizers do remove chloride?

A Yes, and an ion demineralizer of the right type will also remove chloride.

Q Demineralizers also remove hydrochloride?

A I believe it's relatively poorly removed because, see, what an anion exchanger does is absorb acid as such. It has basic groups on it like mean groups and it will absorb acids as such whereas a cation exchanger just exchanges either sodium or hydrogen depending on the cycle for heavier things like magnesium and calcium and so forth.

Q Are you able to estimate how -- what concentration of chlorine will remain in the demineralized water after it's passed through the Midland Nuclear Plant make up demineralizer system stored in the condensates at the storage tank?

A It probably depends on whether you do some heating to drive off carbon dioxide which is also generally not absorbed by an ion exchanger. It can be very corrosive.

Q So is it correct to say that without further information, you are unable to estimate?

A I'm unable to say definitely.

Q Okay. Why do you say that the fate of the flourine ions --

is it fluorine or fluoride?

A Fluoride.

Q That the fluoride ions are uncertain?

A It's in the same chemical series as chlorine, bromine and iodine, higher up, and it's enough difference that they don't really know very much about how it acts.

Q Is it removed by demineralizers?

A I don't know. I never seen a figure for it. Usually they give a table of things in which they're likely to be removed and I've not seen a table that has those in it.

Q So at the present time, without further information, you're unable to estimate how much of that fluoride would remain in the demineralized water at the nuclear power plant?

A Yes.

Q And you state that ion exchange resins -- I'm sorry. You state that if the cation resin enters the anion exchanger, the result is uncertain.

Do you mean you don't know what would happen?

A Well, it would -- we would be having a reverse action.

Q Would you expect this to cause an explosion?

A No, no, nothing like that. It would just change the effectiveness of the exchanger, that's all.

Q Would one resin destroy the effectiveness of the exchanger?

A Well, they would be working at cross purposes.

Q Can you quantify the effect in terms of how many resins would

have to go into the anion exchanger to cause a significant degradation in its performance?

A Well, the cation -- the anion exchanger is absorbing acids. The cation exchanger absorbs and has on it, it would be absorbing minerals like calcium and so forth. So then if you put minerals into a place where there's acids, some of those, some of the calcium will be taken off by the acid groups that are there and you'll have calcium sulfate or whatever happens to be there. So if you didn't have a way of keeping finds and whatnot from carrying over, say if they were transient surges, then this can happen. It depends on whether there are filters or not and it depends on whether you're heating up from below or down from above.

Q Is it fair to say that, as you sit here, you don't know enough about the specifics of the design of the system at Midland to tell whether that may be a problem or not?

A No, I don't know that, because these resins have been improved and changed in density and that sort of thing. I have known it to happen that one carried over into another and after awhile you had to throw that resin away.

Q In Paragraph 7 at the bottom of the page, you talk about the steam generator. You state that if one assumes a factor of safety of 6, the working pressure of the tubes is about 1,500 psig.

A Yes.

Q Where did you get your assumption of a safety factor of 6?

A I calculated that from the dimensions of the tube and the wall thickness and so forth. I don't think it's an unreasonable safety factor.

Q Can you point to any official document which gave you that safety factor or is that basically your judgment about what would be a reasonable safety factor?

A I calculated that using the formula in my engineering handbook.

Q Do you know what the minimum thickness --

A If the factor of safety were say four, it would still be safe and you could go up into a higher pressure like 2,000 pounds.

Q I'm sorry. What is the factor of safety that you're defining there, because your last answer confused me. I thought if the factor of safety would be greater that you --

A You take the strength of the material and the wall thickness and you apply that in a formula and you get -- if you have -- you assume a factor of safety and then you get a pressure. If you have a pressure, then you can get a factor of safety.

Q Does that represent the ratio of the failure pressure over the working pressure of the tubes?

A Essentially. Well, let's see. No, it's a matter of the

strength of the metal.

Q Well, does your factor of safety of 6 mean that the tubes could withstand about 9,000 psig?

A That's in -- that's what it means, yes. That's essentially what it means but you, of course, aren't going to work at that. In designing all kinds of things, you use a factor like that.

Q Are you familiar with the Accident Analyses which have been done for steam generator transients at this plant and what they assumed about the minimum wall thickness of the Inconel tubes?

A I guess I'm not.

Q Okay.

A But supposedly you can have a five percent variation in tubes, wall thickness. That is, if you take a whole lot of tubes, they shouldn't vary more than five percent.

Q With respect to Page 5, you list a number of chemicals starting with ammonium chloride with respect to which you state Inconel has only partial resistance.

Do you know what the permissible quantities or concentrations of these chemicals is in the secondary system water chemistry?

A The way this is gotten at is that they took all of the data that was available in the industry at the time they made the tables for this handbook and a lot of it came from the DuPont

Company and they'd rate things as either A if they withstand the material or X if it was variable or they have another thing for complete failure. So these are average things, average resistance. Like where partial resistance is stated, it may be A at 40 degrees and five percent. It might be X at 90 degrees and three percent or 40 percent, depending on how the data has been assembled, but it isn't a complete thing that gives a test under every possible set of conditions and I will say that there weren't any at nearly as high temperatures as you're involved with now.

Q Were there any at -- first of all, do you know what the permissible concentrations are for the Midland Plant secondary water system with respect to these chemicals?

A Oh, I would imagine it was zero.

Q But do you know, sir?

A The thing is, if you've got a crack around a crystal or something, it can be relatively high even though that crystal is low in the body of water.

Q Do you know, sir, what the permissible limitations in the Midland Plant secondary water system are?

A I guess I don't know specific ones unless they were in this. There were some concentrations here.

Q And you're referring to Mr. Hillman's testimony?

A Yes.

Q Are the values in the Perry Chemical Engineer's Handbook for

concentrations as low as one might expect to find in the secondary system in the Midland Nuclear Power Plant?

A Well, there are some that are quite low but they're probably not that low.

Q Well, specifically, do you recall what the percentages were?

A The ones were lowest on things like chlorine, for example.

Q Do you remember what the concentrations, the stated concentrations in Perry Chemical Engineer's Handbook were with respect to these chemicals?

A Probably the lowest with respect to ammonium chloride would be a few percent. The calcium hydrochloride, that would be lower than that, and chlorine, it would be down very low. HCL and so forth are measured by ph.

Q But as you sit here today, sir, do you remember what those percentages were as stated in Perry Chemical Engineer's Handbook?

A Well, they were not in parts per million, if that's what you mean.

Q But you don't have any more specific recollection?

A No. Generally they were in the order of a few percent except for the ones like chlorine, as I say, which is very low parts and acids. It depends on the ph, as measured by the ph.

Q Do you know whether the demineralizer systems in other water purification systems in use in the Midland Plant secondary

water system are capable of removing these chemicals?
A Well, as I say, you can't in general remove chlorine but the others could be removed, yes. The hydrochloride would be an equilibrium with some chlorine and it would be uncertain whether you would remove it all. The calcium would be pretty completely removed. I mentioned phosphoric which has nothing to do with this here because we -- there were failures in some of these reports where phosphates had been used initially as buffering materials but you don't have any buffering materials here.
Q Paragraph (a) on Page 5, you're talking about pressure.
A Yes.
Q And temperature?
A Yes.
Q Could you explain what you mean by the critical points in this discussion?
A These temperatures and pressures are taken from a steam table. If you put some water say half full in a vacuum sealed glass tube of a heavy enough wall thickness that would be half full with water and heated it up, there would come a point -- normally water has a meniscus which is concaved downward with things like mercury and things like this in them. When the temperature --
Q Could you spell meniscus for the Reporter?
A M-e-n-i-s-c-u-s. All right. You're heating this and when

you get 705.4 degrees Fahrenheit, the meniscus will disappear. You will have only a gas. You won't have any liquid. You won't have any vapor. You'll have only a gas and the pressure will be that times 3206.2 pounds per square inch absolute.

Now, when it's a gas, it doesn't work very well for cooling and it could keep you from pumping water into your reactor.

Q Are the values in this table applicable to sub-cooled water?

A Water in general.

Q Are they applicable to super heated steam?

A Well, if your steam, your super heated steam is what's an equilibrium or is not an equilibrium, it's a higher temperature than it was saturated steam, but the critical point will apply to any kind of water.

Q When you are using the word or the term critical point, you're referring to the properties of water and not to nuclear criticality, is that correct?

A That's right.

Q And you say the reactor would run away.

A That's because there would be no cooling anymore.

Q What do you mean by run away?

A Well, it would keep heating up if you had no cooling to react. It would heat up and -- while you should have dropped down the rods by that time and hopefully slowed it up but

still you've got to keep on having some kind of coolant or it's going to get hotter and hotter.

Q I see. Do you know what --

A We have had, by the way, a very serious explosion in the lab when somebody had an ether in a metal pipe and he heated that up above the critical point and just wrecked the lab he was working in just from a few drops of it. It was like TNT or something when it went beyond the critical point.

Q But you wouldn't expect water to behave like TNT when it exceeds the critical point, would you, sir?

A Well, it would no longer cool it. It would just be there as a gas.

Q I see. Do you know at what temperature the reactor protection system is designed to scram the reactor at Midland?

A I guess I don't know for that particular reactor, no.

Q Do you know what the set points are for the various relief valves present on the Midland reactor?

A No.

Q Do you know whether the pressures could rise to 3,200 psia given the existence of those relief valves?

A I would hope it wouldn't.

Q Do you know, sir?

A No, I don't know.

Q If the relief valves, the pressure relief valves operated properly and kept the pressure below approximately 2,500 --

A Then it should be all right.

Q Okay.

A And if the pumps would work all right.

Q Well even if the pumps don't work all right, as long as pressure relief valves operate to keep the pressure below 2,500 psia, it would be all right?

A Well, you'd have to keep putting water in somehow or you'd have bare rods and everything. You don't want to have bare rods.

Q You mean the water would drop below the level of the coolant?

A Yes.

Q Do you know whether that could be done without the reactor pumps operating?

A No. I don't know what the relative volume of the reactor is to the volume of the rods for the height of the rods.

Q On Page 6, sir -- I'm trying to skip over the questions that I've already asked you.

You refer somewhere here to the liquid-vapor interface in the steam generators.

Could you describe the interface and tell me whether it occurs at a constant point?

A Well, there will be steam rising through the tubes so that they will tend to be sort of a lot -- it would depend on whether the tubes would be vertical or slanted. If you have inclined tubes, the water that is carried up as foam, say it

would tend to run down again and vertical tubes, there's sort of going to be a pulsing of water plugs carried up by the steam and then there's a separator up above which would separate that water and send it back down probably into the annulus.

Q At Paragraph 8 you talk about the condensor. Do you know what the -- is it correct to say that you were speculating about what the construction of the condensor is here?

A Yes, I'm speculating about the pressure. They probably operate with a better vacuum than that in order to make use of more heat.

Q Do you know what kind of galvanic protection there is for the condensor?

A Oh, there probably isn't any on the tubes. You wouldn't really need it on that shell side because it's just steam coming down there.

Q What do you mean by the statement that the sulphuric acid will -- which is used to regenerate the cation exchangers will enter the pond partly neutralized?

A Well, generally for most regenerations you use more salt and more acid than is actually required to do it, particularly when you're regenerating a cation exchanger with salt. For example, you have to have a big mass action effect that has much more salt than is needed in order to take such things as calcium off because calcium is held on much more firmly.

It depends on what the construction of the resin is. Y[illegible] a different kind of resin for different ph's with an anion exchanger.

Q What is your bais in Pargraph 9 at the bottom of Page 6 for your statement that the Babcock and Wilcox steam generator suffers from a lack of provision for thermal expansion?

A Well, what I said was, if the tubes were exactly the right length at room temperature, then when the tubes expand, they're going to tend to push against the tube sheet. Similarly, if they're just the right length, when the thing is held in a kneeling furnace, then it will be the opposite way when it cools down. There will be a tendency to push on the tubes. This is like a column effect. When a column is pushed on, if it bends at all, it has failed. So if the tubes bend at all, they tend to have failed.

Q I'll ask you to assume that the tubes are -- that the manufacturer of the steam generator is such that the tubes are intentioned at room temperature but in compression at operating temperature. I'll ask you further to assume that the proportional limit is not exceeded in either situation.

Under those circumstances, would there be in your judgment adequate provision for thermal expansion?

A Let's see. Intention when it's room temperature and in a slight compression less than the proportional limit, then you should be all right. But the other kind of generator, of

course, has just a floating, curved end and there have been types of exchangers where they have a floating head in order to get around from having to do all this.

Q On Page 7 you talk about tube failures.

Are you aware of any failures of this type in Babcock and Wilcox steam generators?

A Well, there's a discussion here in this literature.

Q Does the literature describe any failures involving, I guess, double-ended ruptures of tubes?

A As I recall, they were mostly single-ended.

Q I'm getting -- I am obviously not stating my question well enough.

Are there any failures described in the NUREG documents which you have reviewed in which the tube becomes a cantilever with one fixed end vibrating and rubbing against the other tubes?

A It isn't described as that but, if it were free at one end and loose at the other, it sort of would be that way. A cantilever is something that's fixed at one end and free the rest of the way even though --

Q Is it your recollection of these NUREG documents that there were tube failures in Babcock and Wilcox steam generators which involve more than just cracking of the tubes and went to this kind of baseball bat phenomonen?

A Well, it's not probably as strong as a baseball bat but I

think there were a few instances, as I remember it.
Q And your description here is based on your interpretation of the NUREG documents, is that correct?
A Yes.
Q Rather than personal experience?
A Yes. My experience has been with -- more with horizontal tubes rather than with vertical tubes except reflection condensors, sometimes they are vertical.
Q Do you know of any specific foreign bodies that would be present in the Midland steam generators?
A Not if they've been cleaned out properly. There can always be -- little pieces get caught and there are pieces of welding rod and that sort of thing that, if they were not taken out, could be there but I would presume they had been careful about that.
Q In Paragraph 10 you stated it is obvious that the use of pond water for emergency cooling will contaminate both the reactor system and the pond.
What do you mean by the reactor system?
A Well, if you're going to bring pond -- suck pond water through, you can bring whatever materials there are in the pond.
Q Are you referring to the secondary system, sir?
A No, I understood that there was -- there were emergency pumps that would send pond water through the primary system. I may

have misinterpreted this.

Q Okay. If the pond water goes through the secondary system, not the primary system?

A Then it wouldn't get into the primary system but, in the same way, if the pond water went the same way in the secondary system, it would bring whatever is free in it.

Q Are you also assuming that after the pond water goes through the secondary system, that it is discharged back into the pond?

A I would think so.

Q If it is in fact converted to steam and discharged into the atmosphere, would that change your testimony?

A Well, if it's converted to steam, it will have some. Whatever, sludge or ions or whatnot were in the water, that would be partly in the steam and partly drop out, partly in the atmosphere and partly drop out.

Q If the water only goes through the secondary system and if there is no steam generator to leak, will there be any radioactive contamination of the pond water into the atmosphere?

A Only through the second, not unless there was a steam generator leak.

Q Do you have any basis to believe that the -- strike that.

Do you have any reason to believe that pond water can't be used on a short term basis to shut down the plant as described both in Mr. Hillman's testimony and also Mr.

McCrackin's testimony?

A Oh, it could be used.

Q I am a little confused about your statement that clearly the best way to cool a reactor would be to lower the control rods, to keep the liquid level above the rods and to remove vaporized steam. Steam removal would provide two and a half times the heat removal per pound of water that liquid cooling would as a minimum.

Do you have any evidence as to the practicability of operating a pressurized water reactor in such a mode?

A You wouldn't normally operate it that way but, if you had to get a lot of heat out in a hurry, taking it off a -- steam for a pound of water would remove a lot more heat than if you just pass water through.

Q Do you know whether it's practical to establish circulation within the primary system with a steam and water mixture of the kind you are describing?

A Well, I think you would be doing both really, but if you were in a really emergency cooling system, you put as much water in as you can. You probably have the vent open both to lower the pressure and to let off steam, but you wouldn't rely on cooling by putting it into the -- just by putting it into the steam generator.

Q All right.

A There's about 1,200 BTU's or so per pound that pass -- that

heat steam in these conditions whereas to just put liquid water through, you only at the most could remove probably less than 100 BTU's.

Q Would you please look at the sentence in which you state that a serious source of atmospheric contamination is the use of pop valves for relief. Such valves are subject to wire-drawing and generally do not receipt properly. They are unsatisfactory for use where toxic vapors and gases are involved.

Q Now, regarding that portion -- I'll ask you about frangible safeties later on.

A Okay.

Q When you are referring to atmospheric contamination, are you --

A That would be a pop valve on the primary system.

Q Do those valves open to the atmosphere?

A They probably go through some kind of tank before they get to the atmosphere. That kind of tank will have a pop valve on it then.

Q Do you know whether any of the valves on the primary system are outside the containment structure?

A Well, regardless of where the valve was, it would have a pipe leading from it probably to someplace.

Q Is it your impression that, therefore, the gases that go through the pop valve would be vented outside the containment

to the atmosphere?

A Well, they might go through a tank first.

Q But it's your impression that that is -- that it does lead directly or indirectly to the atmosphere?

A Well, it's common to vent into sort of a surge tank perhaps with a water spray or something in it and hope that it will contain most of it so that it won't pop anymore.

Q If the pop valves, as you call them, were all vented inside the containment structure which was isolated, there would be no atmospheric contamination, would there?

A If it would hold it, that's right.

Q Now, what are you talking about when you say pop valve? I'm just not sure of the term.

A A relief valve that operates against a spring.

Q And what does wire-drawing mean?

A Well, for an example of wire-drawing, supposing you have a gate valve, it has a gate that goes down into a V-shaped place. If you open that up just a little bit, a little bit of steam or water or whatever will go through there and it will gradually cut a little notch.

The same thing can happen in one of these pop valves at high volicities and even though most of the thing is all right still, you never quite see it because of this little place like a wire had been shoved through.

Q Now, going to your suggestion about parallel frangible

safeties with their stems locked together so that if one accessible, the other is not, it would be much safer, could you please describe again what you mean?

A I'll make you a little sketch or something.

Q This is going to end up as Savage Deposition Exhibit No. 2.

A Okay. See, you have a valve here, for instance, something like that. You wouldn't necessarily have valves with rotary stress. You could have some kind of slide device that moves back and forth.

See, in that particular picture, one valve is closed and the other one is open. So if the safety is to blow, those ones where it's open will relieve the pressure. Then when you want to replace one, then you'd close it, move the valve the opposite way and it would do it.

Q I'm trying to figure out how this works and you'll have to forgive me because I'm a lawyer and not an engineer.

A Okay. We've got a valve here that's open so the pressure is up against this one. If that one should blow, it will come up here. You close the valve there. There would still be this one to hold it. If they both blow, then you haven't got any more safeties on this side and it would be venting.

Q Yes.

A However, then you would move this valve over so that it was here and then it would be up against these other ones again.

Q I see. Okay.

A It's something like -- on a large scale you might get something like a slide valve on a cylinder locomotive perhaps.
Q So this --
A But you can change one that's been blown by going over to the other side.
Q So this sketch essentially shows a parallel system?
A Yes.
Q Of pressure relief devices?
A Yes.
Q First a valve and then two frangible safeties in series?
A Yes. You'd have two valves so fixed together that if one is -- they can't both be closed at one time. Only one can be closed and the other open or they will both be partly open. That's a common device really.
Q If the valves at the bottom of the page are pop valves, are they not subject to wire-drawing?
A No, they could be -- they could be pop valves or they could be any other kind of valve that could open or shut readily. It could be a gate valve.
Q What happens in this system if the pressure at the bottom of the page and let's say in the reactor vessel or in the primary system is extremely high?
A Well, you better have made them big enough to take care of whatever it is.
Q Such that it ruptures -- well, it's an accident scenario,

such that it ruptures your first frangible safety.
A Yes, then you could bleed some out to the outside if you want.
Q Okay. Now, until you take operator action to shut the bottom valve on the right side, the steam or gases are going to come out and be bled out on the right?
A Bled out on the right or, if it's enough pressure, it will go up through the next one. That might just have an instrument on it there.
Q Well, assume that now the pressure has dropped and you do not want any more vapor or gases escaping from the reactor vessel system.
A Yes.
Q So then you would move the valve shut at the bottom?
A Yes.
Q And open up the other parallel path?
A Yes, and then you could change the ones back here.
Q Well -- and then on the left-hand side the pressure rises again and you pop through your frangible safety on the left-hand side.
Then are you not left with at least one venting route?
A Yes.
Q Which cannot be closed?
A Well, it's only a moment to change the safety.
Q Is that true?
A They're mounted in a frame that sits between two flanges.

You loosen half the bolts and pull the one out and shove the other one in, for example.

Q Do you know whether the containment is excessible during reactor accidents where very high temperatures and perhaps even radiation conditions exist?

A Well, you'd have to provide -- if you have accessibility to it in a case like this.

Q So that's the nub of the thing?

A Yes, that's just another way of doing it other than pop valves.

Q Okay. But the advantage of a pop valve would be that to the extent it would work, it would recede itself after time?

A Yes, but it generally would recede at somewhat different pressures then what they have before because the heat works on the spring.

Q Are you familiar with the American Society of Mechanical Engineers Boiler and Pressure Vessel Code?

A I've looked at it.

Q Are you familiar with the rules in that code governing the use of isolation valves in series with pressure relieving devices?

A You're not supposed to have them.

Q Why not?

A Well, in a case like this you aren't valved off.

Q I see. Is the basis of the rule that, if you had it in

series -- I'm sorry.

A You have it at parallel here.

Q So you believe that the intent of the A.S.M.E. Boiler and Pressure Code Rule prohibiting the use of isolation valves in series with pressure relieving devices is not violated by this parallel frangible valve scheme?

A The rules are different for fired and unfired pressure vessels and I presume there's still a different rule for nuclear reactors.

Q And you're not familiar with that specific rule?

A I'm not familiar with that specific rule, no, but there was a place where there was a diagram of a vent valve in one of these that had a plug valve or something ahead of it which they could shut off if they didn't have the vent valve working which I -- and then if that was closed, then the pop valve would have to go off and that was my comment a little farther on down here about an air-operated venting valve.

MR. STEPTOE: Can we have this sketch marked as Savage Deposition Exhibit 2?

(Whereupon Savage Deposition Exhibit No. 2 was marked for identification by the Court Reporter.)

Q I guess I didn't understand why the use of air-venting valves in the primary system is inappropriate.

Could you explain it again for me, sir?

A Well, it's a matter of what happens if the air fails for one

thing and it was in the illustration of one of these books where it had some kind of a blocking valve before it which they would shut off if they didn't like the way the venting valve was acting but if -- an air valve can work very suddenly and cause transients for one thing and then if it's -- some valves, so-called direct acting, they close if the air fails. Other valves that are reverse acting would open if the air fails. So either way, if the air fails, you could be in trouble.

Q Do you know which is in use at the Midland Plant?

A It depends on the kind of valve it is.

Q Do you know what kind of valve is in use?

A No, I don't.

Q Do you know whether they use air or other compressed gases and does that make a difference?

A Well, these valves, if they fail, they usually have a rubber diaphram in them and, if they fail, it's by rupture of the rubber diaphram.

Q So it doesn't make a difference what the compressed gas is?

A Air can also give you trouble if it has any water in it, too.

Q Do you know whether the piping in the Midland Plant is designed to withstand transients that might be caused by associated valves?

A I doubt that you have valves that work so fast that they would give very serious transients.

Q Is that a principle of good design, to make sure your valves don't close too fast?
A If they close too fast like a whole thing, you have to have some kind of an air space or something that is quite large in proportion to the amount of liquid that's involved. The classic study on such transients was in Russia a long time ago and, for instance, they had a three inch line and 2500 feet long, I think it was, and if the valve closed slowly the pressure was about 32 pounds. But when they closed fast, it was about 500 pounds because of the movement of all this changing from velocity to pressure. But where you just run water into a chamber that has steam in it, you aren't likely to get very much of a transient from that. But you get more -- if you're putting bubbles, putting steam into cold water, for example, that's a worse transient then just running water into steam.
Q Is it correct -- strike that.
Do you know what has been done at the Midland Plant to deal with this problem?
A The problem of transients?
Q Yes.
A No, I don't.
Q The last sentence, sir, you refer to the discussions of steam tube integrity and the studies at Brookhaven and Franklin Institute are excellent. Are you referring to the

--

A Both of these are very good reports. The thing is they are more mechanical than chemical.

Q Are you referring to NUREG-0916?

A Yes.

Q I see.

A I think so, yes.

Q Yes, these are Appendix A and Appendix B to the Ginna NUREG-0916, is that right?

A I think that was one of them, yes.

MR. STEPTOE: That concludes the questions I want to ask, Mr. Savage. With Mr. Wilcove's indulgence, I might just say that after this is over, he may want to ask you a few more questions, but after this is over the transcript will be prepared and we'll make you a copy or give it to Ms. Sinclair, one of the two.

You have the right to review that and correct anything that you want to do. There will be a form on the back that allows you to sign it with any corrections that you would like to make. We don't care what notary you use. You can sign in front of any notary. Also, I believe that under the NRC Rules, you're entitled to the witness fees that are standard under the Federal Court System. They're not very much but we will calculate them and provide you with a check.

THE WITNESS: I don't need that. This was just to

answer some questions originally. I'm not a consultant or anything like that.

MR. STEPTOE: Well, that concludes everything I want to say. Mike, do you have anything?

EXAMINATION

BY MR. WILCOVE:

Q First off, I realize it's been a long evening for you and I appreciate the time you have given us and I will try to go as fast as I can.

My first question -- and as Mr. Steptoe said when he started, anytime you wish to take a break, by all means say so.

A Okay.

Q And if you don't understand any of my questions, please say so. I have been criticized by many people for talking too fast on occasion and for slurring my words. If I start to do that, then please correct me.

A Okay.

Q Mr. Savage, as I know you are aware, there is a contract by which Dow uses steam generated from the Midland Plant.

In your employment with Dow, in any of the work you did, any of the projects that you understood, did they touch upon any work with that contract at all?

A You mean work with the Consumers -- I don't quite understand you.

Q Okay. The contract between Consumers Power Company and Dow.
A You mean, did they discuss it?
Q Well, in any work you did, was any of it connected with the plans for Dow to take --
A No.
Q And your testimony speaks of the demineralizer system used in the Midland Plant.
A Yes.
Q For instance, it is first referenced in the second paragraph of Page 1 of your testimony.
Is it your understanding that in the demineralizer system, the cation exchanger and the anion exchanger are separated somehow?
A Yes, it goes through one and then the other.
Q Could you explain for me how they are separated?
A Well, there would be separate tanks. The powerhouse, when I was working, had only a cation exchanger. In one of the departments where I had worked, we had a separate cation exchanger which were separate tanks. The water went through first the cation exchanger which was regenerated with acid so it was on the hydrogen cycle. Then it went through the anion exchanger where the acids were absorbed as such so the water came out essentially more or like distilled water and the -- like the generator, the -- the exchanger had to run out and then, of course, you'd get contamination.

Q As the water goes through one exchanger and then the other, does that leave either an acidic or a caustic residue?

A When it goes through a cation ion exchanger, if it's on the hydrogen cycle, then hydrogen will be removed from the resin and calcium or magnesium or whatnot will remain on the resin. So what comes through would then be an acid.

Q And the resins are regenerated?

A Yes.

Q And in the process of regeneration, there is often some waste, am I right?

A Yes. The liquid goes through and then you wash it off after you have treated it with acid. In the early days, what they did was take the resins out into a tank and stir the tank while they did this, but then they got so they could regenerate right in the exchanger.

Q Is the waste neutralized?

A I don't remember.

Q And what then happens to the waste after it's washed and --

A Well, when you have regenerated the anion, you would regenerate the cation exchanger on the hydrogen cycle with caustic or hydroxide and it happens that, where this plant was, there was a fair amount of sodium hydroxide being used so that presented no problem and was not neutralized. Then when you regenerate the one that has absorbed the acids, yes, the one that has absorbed the acids -- oh, I misspoke myself.

When you do the one that's on the hydrogen cycle, the cation exchanger, you remove acid groups and leave on magnesium and so forth. That has to be removed with acid like sulphuric. We used hydrochloric acid and that gave salt essentially. When you regenerate the one that has absorbed acids, you do that with caustic and that leaves an alkaline which was no problem, as I said, because we happened to have a lot of caustic around where it was working. But if you were -- so those were just discharged with all of the rest of the plant water.

Q Is it your understanding that the demineralizers at Consumers at Midland will operate in the same way?

A Well, they may have different resins. That's the usual way to operate them, yes.

Q And it's your understanding that the water at Midland would first pass through a cation exchanger and then an anion exchanger?

A Yes.

Q And any waste from that, where would that be discharged in particular, would it be discharged into the cooling pond?

A I understood it would be discharged into the cooling pond.

Q I believe Mr. Steptoe did question you about the statement in your testimony that the chemicals chosen are not well suited to the materials of construction and I believe you answered you were referring to ammonia.

A Ammonia, yes, particularly.
Q Are there any other type of chemicals you would like to see added?
A You mean for --
Q To reduce --
A To reduce corrosion?
Q Yes.
A One thing that has occasionally been used is a little silicate that's used in papermills quite often to reduce corrosion. It forms a very thin silicate layer on places that might otherwise cause trouble and, if the ph is kept so it doesn't get too near neurtraler acid like perhaps a trace of alkali, I really think myself that would be better than ammonia, but that's my personal view.
Q I understand. Are these chemicals you're suggesting, silica or alkali, are they solid or are they volatile?
A They would be solid so they'd get -- accumulate and eventually you'd have to blowdown a little.
Q Would you suggest adding phosphate?
A No, that is stated to have caused trouble when they used it in the start up of several plants. Phosphate is a buffer. You have no buffer here but you don't really need it and, as a buffer to prevent corrosion, it's not a very successful one.
Q Do you know if the use of phosphate has ever been a problem

at a Babcock and Wilcox plant?

A I don't know. I don't remember which plants it was a problem at but, when you buffer, you've got to have a relatively large amount of buffer to do any good and you're really worse off than if you don't do it.

Q In your testimony, Page 5, you discuss what you feel to be the problems with using Iconel, in particular its reaction to NH_4Cl to Ca_2, for instance.

A I should say I'm in a way not completely informed on the source of Iconel. Monel happens -- Monel which is somewhat similar to nickel and copper happens to be an ore that they found up in Canada and they have mined that and refined it as such to make a metal that they can sell for any purposes and I have never heard whether Iconel is one like that. If it were, it would have native copper in it.

Q Is there any type of material you would prefer to be used instead of Iconel, stainless steel, for instance?

A Well, the eighteen types, stainless types of steel containing molybdemun, m-o-l-y-b-d-e-m-u-n, I guess, molybdemun gives a much harder one. None of them are particularly good materials from a screen, when you come right down to it. They tend to tear a lot.

Q Are you saying that the type of stainless steel that you just mentioned, and I won't even begin to try to pronounce it again, would be --

A Well, 316 is an example of the type that is the most satisfactory for corrosion. There are others related to it.
Q Would you say that they would be more resistant to the chemicals and compounds listed here than Iconel would be?
A It's my personal feeling it might be but I can't produce any evidence to that.
Q I see.
A Particularly at these high temperatures and things, there just isn't much data. They may have tested them and found that Iconel was better, I don't know.
Q You do speak here of copper which is a part of Iconel being dissolved by ammonia.
How much ammonia would it take to dissolve the copper?
A Well, as I said to him, you can have these little cracks around the edges of crystals, if you happen to have any crystal structure. It's very fine and it wouldn't take very much at one of those places to deepen that a little bit. That's the thing. It isn't a big, mass affair. It's just a little, tiny thing.
Q If you could turn to Page 3 of your testimony for me, are you aware whether there are any traveling screens either at the point where water from the Titabawassee enters the cooling pond or at the point where the cooling pond water enters the circulating water?
A Yes, there are some, but you would be amazed how small a pipe

a small fish could go through. I found a fairly big fish once in one of these filters out of service water. It must have been six or eight inches long. It must have gone through just a tiny pipe.

Q Where did you -- on what document or what -- from what source do you derive your knowledge of the screening system used to control water both going into and coming out of the cooling pond?

A There was a discussion in one of these that I read, I forgot whether it was the green one or the yellow one or something, that mentioned that there was such a screen.

Q Now, for the circulating water system, that's where the water comes in the pipes, water from the cooling pond comes into cool the condensate. Do you know what material those pipes are?

A No.

Q Do you know if there's any coating on the inside of those pipes?

A No.

Q Do you know if there's any cathodic protection for part of that system?

A Well, if there's a link through the pond, there should be.

Q Or do you know or have you looked at or reviewed any discussion of any procedures for monitoring the condensate to determine if there's any leakage into it?

A There was a place before the polishing exchangers where they were going to monitor it and also take a daily grab samples.

Q Is that discussed in Mr. Hillman's and Mr. McCrackin's testimony?

A Yes, but what I had said to the other gentleman was, that doesn't necessarily sample what's concentrating in the bottom of the generator because there could be more and you'd have to have a way of sampling that there, too.

Q On Page 3 of your testimony again, Paragraph No. 6, the one about water quality, you mention that the Titabawassee River will contain 30 parts per million of NaCl.

A That depends on the time of year. When there's a lot of water run off in the spring, it might be much lower than that, but there is this little stream up by Sanford that has as much as 90 parts of salt and it's called the Salt River.

Q What is your basis for saying 30 parts per million?

A Well, originally the City of Midland took its water from the Titabawassee River before the Huron water system was put in. I dimly remember an analysis that was done at that time.

Q So as I understand, --

A But that's just a rough figure. It could be more or less, probably mostly less. It may even be a lot less.

Q So as I understand it then, the basis for this number is your recollection of some studies that were done sometime ago?

A It wasn't a study. They used to run routine tests on the

water because they had to soften and chlorinate it before it went into the city. It was lousy water.

Q When you say it was lousy water, what do you mean?

A It tasted terrible.

Q Do you feel that the water in the Titabawassee or even in this part of the country is any more corrosive than might be water from rivers or lakes in other parts of the country?

A No, it's pretty good water here in the Titabawassee.

Q Would you say on the average that this water is less corrosive?

A I couldn't say less because a lot depends on oxygen and things like that and whether there's sewage and so forth, but certainly less than in some hard water areas, in New Jersey or --

Q I realize that this next question is a little bit outside the scope of your work at Dow, but do you feel that there is more -- that the atmosphere in this area is more corrosive than in other parts of the country?

A No, the atmosphere here is very good. If you want to see a corrosive atmosphere, go down to Tanawanda, for instance.

Q Tanawanda, New York?

A And watch that smoke go out for miles across the country, nitrous oxide. Dow doesn't have any nitrous oxide.

Q Do you mean Tanwanda, New York?

A Yes.

Q I'm from Buffalo so --
A You should know then.
Q Which, for the record, is about one mile from Tanawanda.
A Once in awhile there is a little chlorine leak but that disperses in a prevailing wind. It's really pretty good air here.
Q Are you familiar with the wavy dewatering system in operation at Midland?
A I guess I don't know what you mean by the dewatering system.
Q It's been the subject of all too many days of hearings and, as of ten to ten tonight, I don't think it's worth describing at any great depth but assuming -- let me ask you another question.

Assuming radioactivity were to enter the water, the cooling pond, do you feel that radioactivity would increase the possibility of corrosion of the steam generator 2?
A Well, it's going to be either light in gases or very heavy things probably and I don't really believe it would increase it, no. Very heavy things might easily settle out. Of course, I don't know really whether there's any amount of deuterium in the water. I would doubt that there was very much, but that would be just like any other water and shouldn't be corrosive.
Q I think I'm just about finished. Let me just check my notes here.

Do you know of any incidents at a nuclear power plant where there has been a problem with the break up of resins?

A That's probably -- that's not the kind you would hear about in general, but I have known Dow to have -- take back resins that are broken up.

Q But I'm speaking of something that might have happened at a nuclear power plant.

As I understand it, you don't have any knowledge of that ever happening?

A No, I don't. The resins -- occasionally there will be a resin that will tend to crack very easily like popcorn that was crushed or something. Also, there are finds over a period of time and those could make their way through the system.

Q Okay. I believe Mr. Steptoe asked you earlier if you had read the staff response to your comments.

A Yes.

Q And you answered yes.

A Yes.

Q Were you satisfied with that response?

A Well --

Q If you'd like to take a look at it --

A No, I recall it. The response on the hydrazine was perfectly reasonable. When I said in small amounts, actually I was thinking more of its storage than of its actual use, but

it would act something like ammonia in there.

The one on the fogging, I was not particularly satisfied with. I calculated that as well as I could using charts and so forth but the moisture content of air and the temperature of the water at various times of the year and they seem to disagree with me on that, so time will tell who's right.

Q In fact, it always, too.

A But as it happened, when I worked in the papermill, sodium sulfide and such things got distributed out for about 10 miles around the plant and we had to go out and take samples and bring them back and analyze them, so I've had some experience there. Also, we've had problems of this type in graduate school but --

Q Okay. Just a couple more questions.

On the first page of your testimony, the fifth paragraph down from the top, you mentioned that stress during construction and so forth will contribute to steam generator tube failure at a driving force of 1,00 psig.

A Yes, that's -- if there were pressure forcing water through the oriface, there would be a differential pressure of 1,000 psig whereas in the case of the condensor, the pressure is only 50 or 60 pounds per square inch. So it would have to be a much bigger orifice to let the same amount of water through.

Q This, I think, will be my last question.

On Page 6 of your testimony, you state that 3,400 of sulphuric acid will be used to regenerate the cation exchangers and will enter the pond, partly neurtralized.

Am I correct that this is your -- that this is your understanding of what will happen at Midland based on what you know from --

A The figures are out of one of these papers. In general, you use more acid than is required for exact neutralization, so there would be some that was not neutralized.

Q Did the figures come from this document here, the final environmental statement?

A It could have been from that or it could have been from Hillman, either one, but I assume that it was concentrated sulphuric acid.

Q All right.

A Because that can be handled in ordinary metal containers where weaker ones can't.

MR. WILCOVE: I don't believe I have anymore questions. I very much appreciate you're taking the time tonight to answer our questions. It's been most responsive and most helpful.

REEXAMINATION

BY MR. STEPTOE:

Q Can I ask just one more?

Mr. Wilcove was asking you questions when he first

began about the cation exchangers and the anion exchangers.

Were you responding with respect to the system at Dow?

A Well, Dow -- as I said, in the powerhouse, Dow had just a cation exchanger in my time and another plant in which I worked or did development work and so forth, we had both the cation and the anion exchangers in order to get the equivalent of distilled water. You get soft water with just a cation exchanger. With both you get like distilled water.

Also, experimentally, we worked on it in various ways on smaller scales.

Q But you weren't answering specifically with regard to the system at the nuclear plant?

A No, just in general.

MR. STEPTOE: That's all.

MR. WILCOVE: I believe, and by all means correct me if I misunderstood you, but I believe you also told me that it was your understanding that the demineralizer at Midland would operate in the same way?

A Yes.

MR. WILCOVE: Okay.

MR. STEPTOE: Okay. Thank you. That just clarified for me what you were talking about.

MR. WILCOVE: Also, the staff will stipulate that you may sign the transcript of your deposition before any notary. That's all.

(Deposition concluded.)

-oOo-

STATE OF MICHIGAN)
) SS
COUNTY OF BAY)

I, Albert Savage, being first duly sworn, depose and say: That I have read the transcript of the deposition given by me on the 28th day of March, 1983, at or about 6:20 o'clock P.M., at the Holiday Inn, in the City of Midland, Michigan; that the same is correct and is an exact transcript of my testimony in the above-captioned case subjectto the corrections hereinafter listed: And further, deponent sayest not.

____
Witness's name.

Subscribed and sworn to before me

this ________day of_________,19__.

____
Notary Public

My Commission Expires:__________

STATE OF MICHIGAN)
) SS
COUNTY OF BAY)

I, Deborah A. Parent, Notary Public in and for Bay County, State of Michigan, acting in and for Midland County, State of Michigan, do hereby certify that I stenographically recorded the examination of ALBERT SAVAGE, the deponent in the foregoing deposition; that prior to the taking of said deposition the said deponent was duly sworn to tell the truth, the whole truth and nothing but the truth; and that the foregoing deposition is a true and correct transcript of the testimony of said deponent.

I further certify that I am not a relative, employee, attorney or counsel of any of the parties; a relative or employee of such attorney or counsel; or am financially interested in the transaction.

I further certify that the record of said deposition was submitted to the deponent who examined it and signed it.

Deborah A. Parent
Deborah A. Parent, RPR, CSR-2364
Notary Public, Bay County
Expires: 7-6-83

bjg: 3-29-83

Page No. Line No. Corrections

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Statement of A.B. Savage as to Siclair Contention #4.

Conclusions:
Sinclair Contention No. 4 properly addresses the problem of steam tube failure.

The corrosion and sludging of condenser tubes by pond water may induce leakage of pond water of variable composition into the secondary cooling system at a driving force of perhaps 50-60 psig.

A more serious cause of steam generator corrosion, particularly of that unit which supplies steam to The Dow Chemical Company, will be careless operation of the cation and anion exchangers, very common in the chemical industry, combined with the use of ammonia for neutralization and of hydrazine for oxygen scavenging [and failure to establish adequate controls for when blowdown should be performed.] Stricken BRC

Contact of dissimilar metals in and of the tube and shell components of the steam generator will set up corrosive couples. Such couples, chemical components and mechanical stress will aid in the initiation of intergranular corrosion. The chemicals chosen are not well suited to the materials of construction.

Stricken BRC [Stress during construction and because of expansion and vibration, liquid and vapor impingement at high velocities, transients and high pressure during operatiob will contribute to generator steam tube failure at a driving force of 1,000 psig.]

Stricken BRC [Such tube failure will necessitate shutdown of the unit.The shut-down procedure in the Ginna system(NUREG 0537) was haphazard and erratic. Considering the narrow margin of safety as to potential pressure and temperature, the result coupd have been a disaster.]

The incidence of tube failures in steam generators is increasing with time.

Improved materials of construction, improved design and fabrication and compatible water chemistry are needed before permission is given for any more units to start up.

SAVAGE DEP. EX. #1
3/28/83
DP.

1Kw= ~1.35 HP

1kwh = 3415 BTU/hr.
1Hp = 2546

Eff. turbine 95%
Gen - 95%
~ 74%

fired boilers - ca 80%

Reference is made to attachment C in the testimony of C. Hillman. The sketch is inadequate and confusing.

1. Primary coolant.
The primary coolant is shown circulating up through the reactor, down through the tubes of the boiler, and through a centrifugal pump back to the reactor, at a stated pressure of 2,000 psig. Any gases will tend to accumulate above the upper tube sheet in the generator.

2. Steam flow.
Feed water is introduced into and preheated in the lower annulus of the generator, vaporized in the shell, and the steam leaves the upper annulus of the generator below the top. The steam flows to turbo-generators in tandem, where it expanded and ultimately condensed under vacuum conditions, and is recycled by a centrifugal pump through a "full-flow" demineralizer and back into the annulus of the generator.

3. Condensation.
The vapor leaving the turbines is condensed in the shell of the condenser under vacuum, as evidenced by the hot-well. Cooling water(service water) from the pond passes through the tubes of the apparently horizontal condenser, and is returned to the pond.

4. Steam sold to The Dow Chemical Company.
In NUREG 0537, steam production of from 1.4×10^6 to 4.05×10^6 pounds of steam per hour is stated, or from 46.5 gal./sec. to 134 gal./sec., or perhaps an average of 109 gal./sec.. of feed water. It is stated that reactor #2 will produce 825 MV, reactor #1 504 MV of power, and thus the difference, 148 MV of power equivalent will go to steam:

3.6×10^6 lb./hr. at 175 psig., plus

0.4×10^6 lb./hr. at 600 psig.

The point where the steam is withdrawn is not stated.
One may suppose that the steam is withdrawn interstage between two turbogenerator stages:
(a) Stage 1. Expansion of steam at 1,000 psig.(approximately 575°F) to 600 psig.(approximately 485°F through a turbine; and
(b) Withdrawal of 600 psig. steam for Dow at this point.
(c) Stage 2. Expansion of steam at 600 psig.(approximately 485°F) to 175 psig.(approximately 375°F) through a turbine;
(d) Withdrawal of 175 psig. steam for Dow at this point.
(e) Stage 3. Expansion of steam at 175 psig.(approximately 375°F) through a turbine to 20 inches of mercury vacuum ,190°F. [maybe 1"Hg ~ 80°F]
(f) Condensation of the remaining steam at this pressure.
(g) The vacuum could be maintained by an Ingersoll-Rand type steam jet powered vacuum unit, discharging through the hot well, and removing air from the system.

5. Makeup.
Perhaps 80 per cent of the steam sold to Dow would be returned as condensate and reused. The balance would be made up from fresh water, amounting to a maximum of 810,000 pounds per hour, or 97 gal./sec. This amount of water would be passed through ion exchange purification units. It would also be used for makeup to offset any leakage from the primary or the secondary cooling system.

resins (Basic) | resins (acid)
NH2 aromatic / aliphatic — acid-rate 3 | -SO3H very low pH
" | -COOH low-neutral pH
=NH not fully ionized | Φ-OH high pH

6. Water quality.

(a) Pond, or service water.

The water pumped from the pond will contain algae, salts, rust and other contaminants from The Dow Chemical Company's upstream operation, sediment, small fish and other materials. Hopefully it will have been passed through a set of bars and through a magnetic separator. The listed materials may be expected to collect behind the tube sheet on the inlet side of the condenser and to contribute to its corrosion. As the pond water will come from the Tittibawassee Reiver, it will contain perhaps 30 ppm. of NaCl. One of the upstream tributaries, the Salt River can contain as much as 90 ppm. of salt. Otherwise, the river comes from a sandy, low mineral area. It may contain organic materials from the forest floor, salt from highways, agricultural contaminants, etc. The volume of the pond is not stated, so concentrations are uncertain. Doubtless they vary widely. Concentrations will depend upon the volume, upon the relative locations of inlet and withdrawal sites, and upon the amount of blowdown discharged. The pond will contain acid and alkali from ion exchange u nit regeneration and all of the ions that had been removed by the exchangers. The pH will vary.

It was estimated some years ago that the equivalent of the entire river flow passes through the plant of The Dow Chemical Company several times before continuing down the river. In any case the pond water will be corrosive and will tend to carry sludge.

(b) Water supply for ion exchange.

It is intended initially to use Midland city water (Huron water would serve as well) as makeup, and after the first year to use ion exchange water from The Dow Chemical Company. The Saginaw-Midland Water Authority takes water from a crib several miles out in Lake Huron at Whitestone Point and pumps it about 140 miles. The crib intercepts a Lake Superior current that is low in impurities because it comes from a granite bed. [The Dow Chemical Company uses raw Huron water in several operations.] According to the Midland water plant laboratory, city water and Huron water have much the same typical composition, differing chiefly in pH:

Stricken BRG

Ions	Huron	City
Na^+	2 ppm.	4 ppm.
Ca^{++}	26	30
Mg^{++}	8	8
Cl^-	12	15
SO_4^{--}	30	20
pH	7.9	9.0-9.4

OH, I, Br, Cl, PO4, SO4 | H, Al, Cu, Zn, Mg, Ca, NH4, K, Na

The Huron water is limed to reduce hardness, treated with chlorine for purification, and fluoridated.

(c) Cation exchange water.

The Dow Chemical Company passes Huron water through a cation exchanger operating on the Na^+ cycle. This removes all heavy metal ions, replacing them with Na^+ ions. The exhausted exchanger is regenerated with NaCl solution and washed. From a cation exchanger on the Na^+ cycle fed with Huron water one might expect:

Na^+	28 ppm.
Cl^-	14
SO_4^{--}	25
pH	8.6-9.1

(d) Hydrogen ion cycle.

In order to be able to obtain the equivalent of distilled water, the first step cation exchanger must be operated on the H^+ cycle, that is, it must be regenerated with strong acid, for example with H_2SO_4, rather

 1×10^{-6} H^+ = ~6 pH

than with salt, and washed. One might expect from Huron water:

HCl	14.5 ppm.	H^+ = ~0.43 ppm
H_2SO_4	25.6	H^+ = ~0.53 ppm
		Sum ~ 0.96 ppm ~1 ppm
pH	6, approximately	

When a cation exchanger of either type is exhausted, Na^+, Ca^{++}, etc. ions will pass through, and it must be regenerated. It is the commonest thing in the world for operators to permit this to occur.

The output of acids from the operating exchanger depends upon the anions present: HCl, H_2SO_4 and H_2CO_3 for example. Different resins are used for weak and for strong acids. CO_2 is generally boiled out, little absorbed.

(e) Anion exchange water.

An anion exchanger does not exchange ions, but, instead, absorbs acids (or if intended for bases, it absorbs bases) as such. The product is essentially pure water. When the exchanger is exhausted, acids pass through. This results in a drop in pH and an immediate increase in specific conductance. However, it is common for operators to not notice this. Some specific conductances of ions at 25°C. include:

Λ/Λ_∞

H^+	349.8	Cl^-	76.3
Na^+	50.1	OH^-	198.0
$\frac{1}{2}Ca^{++}$	59.5	$\frac{1}{2}SO_4^{--}$	79.8

The specific conductance due to HCl is thus, for example, about 3.4 times that due to NaCl.

The anion exchanger is regenerated with NaOH or with Na_2CO_3.

(f) Other considerations.

If city water is used, it will contain chlorine, which is not removed by an exchanger. The fate of F^- ions is uncertain.

Water, consisting of returned condensate and fresh water makeup, will be demineralized and stored. It will be introduced into the secondary cycle, which also contains so-called "full-flow polishing" demineralizers. These, too, can exhaust and pass cations and acids. Ions passed will accumulate in the steam generator and can only be removed by blowdown. Meanwhile they will corrode the equipment.

Ion exchange resins can be subject to cracking of the beads and to erosion. Eventually resin will enter the steam generator, whether due to erosion or to excessive velocity of the feed water. No mention is made of a polishing filter to retain resin. Cation resins contain acidic groups. Anion resins contain basic groups. If cation resin enters the anion exchanger, the result is uncertain. Resins must be added or replaced after long usage.

(g) Other chemistry.

It is stated that ammonia will be used for pH control and hydrazine for scavenging oxygen. NUREG 0571 says that hydrogen will be used. Ammonium chloride is very corrosive. It hydrolyzes to an acid pH. Hydrazine hydrochloride or sulfate will be corrosive. Silicate, if present, might reduce corrosion.

7. The steam generator.

The Babcock and Wilcox once-through steam generator has primary coolant on the tube side and secondary coolant on the shell side. The secondary coolant is preheated in the annulus and converted to steam in the shell. NUREG 0571 states that the tubes are of Inconel, 0.625 inch O.D., 0.035 inch wallthickness. [If one assumes a factor of safety of 6, the working pressure of the tubes is about 1,500 psig.]

Stricken

BRG

Inconel, a product of International Nickel Company, contains:

Nickel	79.5%
Chromium	13.0
Iron	6.5
Carbon	0.08
Copper	0.20
Manganese	0.25
unknown	0.47

Of these components, copper is undesireable; iron less so. I am not certain whether Inconel is a developed alloy, or whether, like Monel, it is a composition found in natural ore. Inconel resembles stainless steel 316 in many properties.

Inconel has only partial resistance to NH_4Cl, to $Ca(OCl)_2$, to Cl_2, to HCl, to H_3PO_4 and to $Ca(OH)_2$, as well as poor resistance to $FeCl_3$, according to Perry's Chemical Engineer's Handbook.

Tube failures have occured when phosphates were used initially in the system.

Stricken BLB

(a) Pressure. The pump pressure to the reactor is stated to be 2,000 PSIG., in order to prevent vaporization in the reactor. The working pressure of the generator tubes is stated above to be about 1,500 psig. Steam is to produced at 1,000 psig., or about 555°F. The pressure temperature relationship for water includes:

Temp. °F	Pressure, psia.
555	1015
600	1543
640	2345
700	3093
705.4(c)	3206.2(c)

Should the primary water temperature rise from near 555°F. to 640°F., it is questionable whether pump pressure could be maintained. Should it rise to 705.4°F., the critical point, the reactor would run away. Tube failure in the steam generator could occur for chemical or for mechanical reasons. The driving force for leakage to the secondary side would be 1,000 psig.

(b) The corrosion resistance of metals such as nickel and stainless steel depends upon the formation of a passive film of oxide or the like upon the surface. This is initially established by oxygen and promoted by alkaline conditions. In an oxygen-free atmosphere, if it is lost, it cannot be reestablished. Chloride and sulfate ions interfere with passivity.

(c) When dissimilar metals are in contact with an electrolyte, a galvanic couple is formed and a potential set up. The metal at the higher potential will be the anode and will tend to go into solution. Couples can occur between dissimilar metals, between an alloy and undispersed components of it, between dissimilarly heat-treated metals and between metals that have experienced dissimilar stress. Inconel contains copper, for example. Copper not only sets up a couple, but it is dissolved as a complex by ammonia. [A welding rod of the wrong composition, such as a Monel one, might have been used.] If the metal has a crystalline or a granular structure, corrosion can begin at the interfaces between crystals. A few single electrode potentials include:

Stricken BRG

18°, hydrogen scale (N soln)

$Fe/FeSO_4$	-0.44
$Ni/NiSO_4$	-0.23
$Cu/CuSO_4$	+0.34

(d) The water in the primary cycle will contain impurities that occur in the initial feed water, or in water introduced to replace leakage and blowdown. Besides the initial components of the feed water, it can contain metallic components of the reactor, the generator, the piping and the pump. I have not seen a stuffing box nor mechanical seal on a pump that will not leak sooner or later. Gases and vapor will collect above the tube sheet in the generator.

(e) **Secondary cycle.**

As one unit is to produce steam for sale, the secondary cycle of that unit will be more subject to corrosion than will that of the other unit. There will be a buildup of ions from the feed water and from ion exchange operations, and from chemical treatment: acids, chlorine, cations, anions, air and contaminants from the materials of construction. [These will be removed by blowdown.] The shell side of the steam generator is stated to contain iron baffles as spacers and supports. These and the shell are subject to corrosion and to electrolysis. There is no mention of attached anodes. Sludge will collect on baffles, supports and the lower tube sheet. As steam is removed, these will concentrate, [and blowdown will be necessary.] It is essential that all construction debris shall have been removed. The driving force for leakage will be 1,000 psig. A critical point of corrosion will be at the liquid-vapor interface, and in the area above this where entrainment occurs. The vapor velocity will be much greater than the liquid velocity.

8. The condenser.

Nothing is said of the construction of the condenser, but for operation at perhaps 20 inches of mercury vacuum, 190^{o}F and with nominally salt-free water on the tube side, it may be assumed to be of conventional iron construction. Corrosion products will develop in the shell, and remain there, or pass into the hot-well.

The tube sheets and tubes will be corroded and sludged up by components in the cooling pond. In case of a leak, these will be sucked into the shell and pass into the hot-well, from where they will enter the secondary water system. The driving force for leakage will be about 50 psig. Fouling of this condenser will be extensive, but, aside from leaks, the chief danger to the secondary water supply lies in the uncertainties of ion exchange operation and chemical control, and improper materials of construction.

Admittedly, 3400 tons per year of sulfuric acid, presumably 66^{o} Be., or 775 pounds per hour will be used to regenerate the cation exchangers and will enter the pond, partly neutralized.

9. Mechanical.

The Babcock and Wilcox steam generator differs from others in having two rigid tube sheets, rather than hairpin tubes fixed to a single sheet. It should be relatively free from vibrational stress and accompanying wear, but suffers from lack of provision for thermal expansion. A floating tube sheet, occasionally used, is not practical. If the tubes are straight and rigid at room temperature, they will expand and be bowed at operating temperature. Conversely, if they are rigid and straight at operating temperature, they will be drawn at normal temperature, perhaps beyond their proportional limit. It is not stated, but the tube sheets are probably drilled. Boring, or broaching (in the sense of burnishing) would give smoother contact surfaces. When the tubes are expanded to fit the holes in the tube sheet, the stress exceeds the proportional limit and thereafter they are liable to further expansion under stress. If the tubes are expanded only on the outer side, crevices will surround the tubes on the shell side and corrosive components can build up. If the tubes are expanded through to the shell side, it makes their removal more difficult and strains extend further into the shell. In either case the stress on a slender column under axial load is added

to the stress of pressure. Stresses will initiate intergranular corrosion of the tubing.

Should a tube fail, it would be a cantilever with one fixed end. It would vibrate and rub, both against other tubes and against the tube supports, although not as much as in other designs.

The Babcock and Wilcox tube spacers are broached, rather than drilled. If by broaching is meant burnishing, they would present fairly smooth contact surfaces.

NUREG 0571 indicates tube failure due to fatigue near the top of the generator, that is, near the liquid-vapor interface or in the vapor space. Stress is caused by vibration of the tubes in the vapor space plus column action and corrosion at the interface.

Foreign material can collect at the tube sheets and supports, and could wear the tubes. Construction residues must be completely removed.

The tubes can be dented by foreign bodies, or thinned by stress and corrosion. If faulty tubes are plugged, the resulting flow currents may errode nearby tubes.

So-called "sleeving", that is, the placement of a piece of smaller tube inside of a stressed tube at the tube sheet, and expansion to provide tightness, is not a desirable procedure. It further stresses the tube, and increases velocity through the sleeved area, and may cause cross-currents above the tube sheet.

10. Other comments.

In the case of generator tube rupture, primary cooling water will leak into the secondary system at 1,000 psig. driving pressure, resulting in some loss of cooling and introducing some radioactivity. Shutdown for repair will be necessary.

It is obvious that the use of pond water for emergency cooling will contaminate both the reactor system and the pond.

Clearly the best way to cool a reactor would be to lower the control rods, to keep the liquid level above the rods and to remove vaporized steam. Steam removal would provide $2\frac{1}{2}$ times the heat removal per pound of water that liquid cooling would, as a minimum. NUREG 0916 indicates that the aplomb of the operators in the Ginna plant tube failure event resembled that of a cat on a hot stove, with little attention to engineering principles, and continuous indecision.

Steam evolved in an emergency could be directly condensed with water sprays in a suitable vessel and the inert gases vented.

A serious source of atmospheric contamination is the use of pop valves for relief. Such valves are subject to wire-drawing and generally do not reseat properly. They are unsatisfactory for use where toxic vapors and gases are involved. Parallel frangible safeties, with their stems locked together so that if one accessible, the other is not, would be much safer.

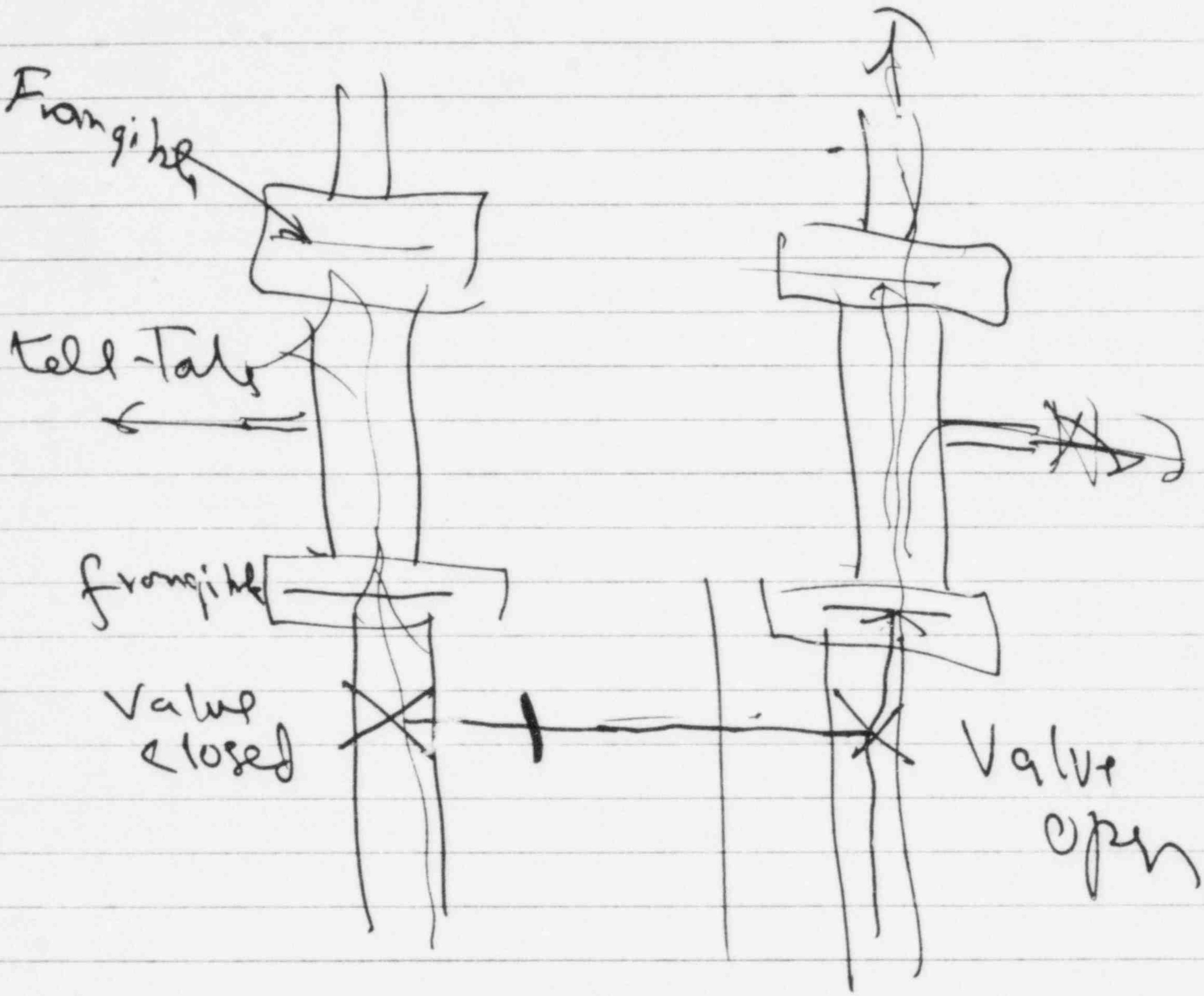
The air-operated venting valve in the primary system is inappropriate. First, it can be valved off by a blocking valve, which would make it ineffective and might cause transients if closed suddenly, and, second, if it is direct acting, air failure would close it, even if needed, and, if reverse acting, air failure would open it, causing unwanted venting, equally bad. Closure of valves to the turbine would cause transients.

Finally, the discussions of steam tube integrity and the studies at Brookhaven and the Franklin Institute are excellent.

My name is A.B. Savage. I am a retired Dow Chemical Company research engineer. I do not speak for the company, nor have I used its facilities in this matter.

I attended the University of Minnesota and received the degree of Bachelor of Chemical Engineering with Distinction in 1935. Courses of special relevance included resistance of materials, metallography, industrial electrochemistry, electric power and mechanical engineering. I was elected to Tau Beta Pi, honorary engineering society, and to Phi Lambda Upsilon, honorary chemistry society.
I had a fellowship with and worked in the plant of the Minnesota and Ontario Paper Company, now owned by Boise Cascade, 1935-1937. I received the Degree of M.S. in Ch.E. and was elected to Sigma Xi, honorar research society. Experience included reactions involving corrosive acids under pressure, pH control and the observation of evaporator operation and maintenance.

I worked as a research chemical engineer under various titles for the Dow Chemical Company for 39½ years. I was an active member of the American Institute of Chemical Engineers and the American Chemical Society. I was elected to the Research Society of America. Experience included operation of reactors at about 500°F, operation of reactors at about 200 psig., operation of ion exchangers, water quality, pH, conductometric and potentiometric measurements, removal of salts from products and regulating their pH, testing for corrosion, and design and operation of continuous and batch stills, condensers and heat exchangers and operation of a process involving corrosive acid under pressure. I also had to do with prevention of possible runaway reactions, and many aspects of safety, including frangible safeties, relief valves, etc.
I took a course in continuous reactor design from a University of Michiga instructor.
I hold more than 40 U.S. or foreign patents and have written technical book chapters and encyclopaedia articles.



SAVAGE DEPO. EX. # 2
8-28-83
DP

CORRECTIONS OF ALBERT B. SAVAGE
TO
TRANSCRIPT OF DEPOSITION HAD ON
MONDAY, MARCH 28, 1983

Page No(s).	Line No(s).	Corrections
7	8	Change "diploma from" to "certificate from Sigma Xi,"
7	13	Change "the Beta Phi" to "Tau Beta Pi"
8	1	Delete "1934 or in"
9	5	Change "polytex" to "polymer or latex"
12	4	Change "craft" to "kraft"
12	5	Change "barbonate" to "bicarbonate"
13	5	Change "sulfuric" to "sulphurous" in both locations
13	6	Change "bi-sulfide" to "bisulfite"
13	8	After the word "eighteen" add "-eight"
15	24	Change "steel" to "still" in both locations
16	6	After the word "maybe" add "200 to"
17	17	Replace "pump" with "bump"
20	21	Change "aneeling" to "annealing"
25 et seq.	22 et seq.	Change "condensor" to "condenser"
26	6	Change "corroided" to "corroded"
30 et seq.	5 et seq.	Change "ph" to "pH"
31	18	Change "move" to "remove"
32 et seq.	5 et seq.	Change "CO^2" to "CO_2"
34	3	Change "ammonia" to "ammonium"
37	21	Change "cation" to "anion"
38	6	Change "straight" to "stray"

Page No(s).	Line No(s).	Corrections
40	24	Add the word "are" to the beginning of line
42	13	Change "Incondel" to "Inconel"
43	10	Change "hydrazine" to "hydrogen"
53	8	Change "through" to "to"
55	4	Change "lime" to "line"
58	13	After the phrase "St. Louis is on the" add the phrase "Pine, which flows into the"
61	17	Change "hydrochloride" to "hypochlorite"
61	25	Change "hydrochloride" to "hypochlorite"
62	8	Change "hydrochloride" to "hypochlorite"
62	11	Change "mean" to "amine"
64	10	Change "finds" to "fines"
69	3	Change "hydrochloride" to "hypochlorite"
69	22	After "downward" add the following phrase: ", while things like mercury are concave upward, if you have things like this in them (i.e., in a tube)"
70	4	Change "that times" to "at that time"
74	2	Change "an anion" to "a cation"
74	11	Change "a kneeling" to "an annealing"
74	18	Change "intentioned" to "in tension"
74	23	Change "intention" to "in tension"
76	7	Change "reflection" to "reflux"
81	8	Change "stress" to "stems"
84	3	Change "excessible" to "accessible"
84	12	Change "recede" to "reseat"
84	13	Change "recede" to "reseat"

Page No(s).	Line No(s).	Corrections
90	18	After the word "cation" add "and anion"
91	4	Change "removed" to "released"
92	1	Change "do" to "operate"
92	6	After the word "acids" add ", the anion exchanger,"
93	12	Change "neurtraler" to "neutral or"
94	8	Change "Ca_2" to "Cl_2"
94	18	After the word "eighteen" add "-eight"
94	21	Change "from a screen" to "for machining"
98	20	Change "Tanawanda" to "Tonawanda"
98	21	Change "Tanawanda" to "Tonawanda"
99	7	Change "wavy" to "temporary"
100	4	Change "take" to "taken"
100	12	Change "finds" to "fines"
100	20	Change "the oriface" to "an orifice"

APPLICANT'S ADDITIONAL CORRECTIONS TO
TRANSCRIPT OF DEPOSITION HAD ON
MONDAY, MARCH 28, 1983

Page No(s).	Line No(s).	Corrections
52	11	Change "infinite tesamil" to "infinitesimal"
60	16	Change "secondary primary" to "secondary or primary"
60	24	Change "secondary primary" to "secondary or primary"
72	10	Change "coolant" to "core"
74	4	Change "bais" to "basis"