UNITED STATES OF AMERICA

BEFORE THE

NUCLEAR REGULATO COMMISSION

In the Matte. of:)
)
HOUSTON LIGHTING & POWER)
COMPANY) Docket No. 50-466CP
)
Allens Creek Nuclear Generating)
Station, Unit 1)

Capricorn Room
Ramada Inn
7787 Katy Freeway
Houston, Texas

Monday,
May 18, 1981

PURSUANT TO ADJOURNMENT, the above-entitled matter came on for further hearing at 9:00 a.m.

APPEARANCES:

Board Members:

SHELDON J. WOLFE, Esq., Chairman
Administrative Judge
Atomic Safety and Licensing Board Panel
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

GUSTAVE A. LINENBERGER
Administrative Judge
Atomic Safety and Licensing Board Panel
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

DR. E. LEONARD CHEATUM
Administrative Judge
Route 3, Box 350A
Watkinsville, Georgia 30677

APPEARANCES: (continued)

For the NRC Staff:

STEPHEN M. SOHINKI, Esq. and LEE DEWEY, Esq.
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

For the Applicant - Houston Lighting & Power Company:

J. GREGORY COPELAND, Esq.
-and-
SCOTT ROZZELL, Esq.
Baker & Botts
One Shell Plaza
Houston, Texas 77002

BOB CULP, Esq.
Lowenstein, Reis, Newman, Axelrad & Toll
1025 Connecticut Avenue, N. W.
Washington, D. C. 20037

For the Intervenors:

JOHN F. DOHERTY
4327 Alconbury
Houston, Texas 77021

I N D E X

P R O C E E D I N G S

9:00 a.m.

JUDGE WOLFE: All right.

The hearing is resumed. Would counsel and the parties identify themselves for the record, beginning to my left.

MR. COPELAND: Good morning, Mr. Chairman. My name is Greg Copeland.

With me this morning on my right is Bob Culp from the firm of Lowenstein, Reis, Newman and Axelrad.

On my left is Scott Rozzell from my firm of Baker & Botts here in Houston. We're all here on behalf of Houston Lighting & Power Company.

MR. SOHINKI: Good morning, Mr. Chairman, and members of the Board. My name is Stephen Sohinki of the Office of the Executive Legal Director of the Nuclear Regulatory Commission.

With me this morning is Mr. Lee Dewey of the same office. And together we represent the Commission's Technical Staff.

MR. DOHERTY: Good morning, Mr. Chairman, and Members of the Board. I'm John Doherty, Intervenor.

JUDGE WOLFE: All right.

We have -- Mr. Sohinki, has Mr. Dewey filed a Notice of Appearance?

MR. SOHINKI: Yes, he has, Mr. Chairman.

JUDGE WOLFE: We have a couple of preliminary matters.

We may have been served with the written testimony that was due to be filed on May 11th. And we were probably served in Bethesda and in Georgia with those documents.

We're not as much conerned about that, although we would like to be advised if this prefiled written direct testimony has been filed. Further, we're also more concerned about being advised about the order of presentation of direct testimony at the forthcoming June 1 through June 12 session.

Can you bring us up to date on that, Mr. Copeland?

MR. COPELAND: Well, the testimony has been filed, Your Honor; and we are attempting to work out a schedule for the order of presentation.

We have drafted it up. I still have not had a a chance to talk to Mr. Scott about it. And I think we can probably have that before the week's end.

JUDGE WOLFE: All right.

MR. COPELAND: -- if that's acceptable.

JUDGE WOLFE: All right.

Would the Board like copies of the testimony before they leave town?

JUDGE WOLFE: No, we have enough to do.

(Laughter.)

MR. SOHINKI: If the Staff testimony was filed on the 11th, then we'll be checking with the Project Manager back in Bethesda within the next day or two with regard to availability of witnesses; and then, hopefully, the parties can get together and set up an agreed-upon schedule.

JUDGE WOLFE: And, Mr. Doherty, I don't remember that you -- Well, it's my recollection that you had no direct testimony, is that correct, for this forthcoming session?

MR. DOHERTY: I have no direct testimony for the forthcoming session.

JUDGE WOLFE: All right.

Another matter: On April 22, 1981, Mr. Doherty filed a Motion for Additional Testimony and Cross-Examination on Conservation Techniques, Interconnection and the Effects of Delay of Construction from Applicant and Staff.

Therein, Mr. Doherty requested that the record be reopened to take additional testimony on the need-for-power issue because of Applicant's announced plans to introduce a load management program, which is expected to save 1200 megawatts by 1990 and thus, Applicant could stretch out construction of all new power plants to ease financing requirements.

This is what Mr. Doherty urged -- or stated in his motion. In its response on May 8th, Applicant states that Mr. Doherty's motion is moot because as indicated in its letter of March 27, 1981, it will, toward the end of the hearings, update its testimony on the need for power, and at that time present its evidence on the financial qualifications contention.

Thus, Applicant urges that the Board will have, quote, "the most current information available to it on demand and capacity projections at the time it hears testimony on financial qualifications," closed quote.

Since we herewith direct that Applicant update its need for power testimony at the time it presents its testimony on financial qualifications, Mr. Doherty's motion is now moot; and it is denied.

We will have to -- at a later date hear from Applicant as to when it proposes at a specific date to present this additional testimony.

This will be in writing, won't it, Mr. Copeland?

MR. COPELAND: Yes, sir.

JUDGE WOLFE: And, obviously, all copies of k05

the testimony will be served on the Board and parties.

Another matter: Mr. Doherty, on May 13th at Transcript Pages 10,222 through 10,223 stated that he would probably have to request withdrawal of his Motion for Subpoena of certain sections of the Reed Report dated May 4, 1981, because of substantial expense.

Parenthetically, I would bring to everyone's attention that on May 12th at Transcript Pages 10,024 through 10,025, I was confusing Mr. Doherty's contentions numbered in his letter of February 16, 1981 with the Reed Report items numbered in his Motion for Subpoena.

There was this confusion as to this matter, resulting in my query of Mr. Doherty about the question of mootness.

There was that confusion. And, Mr. Doherty, I do recognize that your Motion for Subpoena requests eight sections of the Reed Report that were not identified or numbered in your letter of February 16th.

In any event, we ruled on May 12th that the Board saw no reason at all for the Board to secure, or to ask Applicant to furnish us with copies of the verbatim extracts of the Reed Report sections relating to Mr. Doherty's Contentions 5, 15, 24, 33 and 45 as formally requested in his letter of February 16, 1981.

Mr. Doherty, are you now prepared to present

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oral argument, or as indicated, on May 13th, your desire to withdraw your Motion for Subpoena?

I understand that you said that you were going to discuss the matter with Applicant's counsel.

Would you advise the Board what you desire to do at this time?

MR. DOHERTY: I discussed the matter with Applicant's counsel Copeland on, I believe, the 13th.

At this time I am going to withdraw that Motion, which has been the subject of this discussion --

JUDGE WOLFE: That's the Motion for Subpoena?

MR. DOHERTY: That's correct.

JUDGE WOLFE: All right.

Motion for withdrawal -- request for withdrawal is allowed.

All right.

One other matter, I was reviewing some of the transcripts over the weekend and -- these are minor matters.

But I noted at Transcript Page 9849, Line 9, there was, apparently I misspoke myself or there was a typographical -- at Line 9 at Transcript Page 9849, there appears the word ... the possessive of "Applicant's."

That word should be "Staff's," possessive. So the entire sentence reads, as corrected: "As indicated, Mr. Scott, you, according to the revised rules, may have time in which to respond to Staff's response supporting Applicant's Motion for Summary Disposition on this air-plane latching problem."

As I say, this was error. And as indicated by the prior questioning -- or statements by Judge Linenberger, for example, at the bottom of Page 9847 and as indicated subsequently, by my statement at Transcript Page 9850, wherein in both cases the words, possessive Staff, were utilized.

Further, in somewhat of a more humorous nature, as a correction -- at Page 10,011 at Line 15 -- and I'm sure this is a typographical -- at Line 15 of that page and again -- well, at Line 15 instead of the word, a-v-e-r t, it is a-d-v-e-r-t.

And, again, at Line 24, the word "averting" is incorrect and should be changed to a-d-v-e-r-t-i-n-g.

With that behind us, I understand now that Mr. Copeland --

MR. DOHERTY: Mr. Chairman --

JUDGE WOLFE: Yes.

MR. DOHERTY: May we go off the record just for a second?

JUDGE WOLFE: Off the record.

(Discussion off the record.)

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JUDGE WOLFE: Back on the record.

Mr. Copeland, I understand you are presenting direct testimony on Doherty Contention 9, is that correct, as the first thing this morning?

MR. COPELAND: I thought we were going to start with 27.

JUDGE WOLFE: I'm looking at the proposed schedule.

MR. COPELAND: Yes, sir, you're right. I'm sorry. I had it backwards.

Okay. Yes. We would now like to call as our first witness Kamran Mokhtarian.

Whereupon,

KAMRAN MOKHTARIAN

was called as a witness herein and having been first duly sworn, was examined and testified as follows:

MR. COPELAND: Your Honor, before we start, we thought if it was all right with the Board that what we would do this morning, since the Staff's witness is here to testify on both of these contentions, that we would put on our two witnesses --

JUDGE WOLFE: First --

MR. COPELAND: Yes, sir. And then --

JUDGE WOLFE: That's on 27. And who is that witness?

MR. COPELAND: That's Duran Sinpadian (phonetic).

And that way we wouldn't have to put the Staff witness on twice. We'd just put him on after our two.

JUDGE WOLFE: That sounds reasonable. All right.

DIRECT EXAMINATION

BY MR. COPELAND:

Q. Mr. Mokhtarian, do you have in front of you an eight-page document entitled the "Direct Testimony of Kamran Mokhtarian on Behalf of Houston Lighting & Power Company on Doherty Contention No. 9-Containment Buckling"?

A. Yes, I do.

Q. And does that testimony have attached to it a three-page statement of your professional qualifications?

A. Yes.

Q. Was the testimony and the attachment prepared by you or under your supervision?

A. Yes, they were.

Q. And do you have any corrections to make at this time?

A. I only have one correction. On the testimony on Page 2 --

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MR. DOHERTY: Page what, please?

THE WITNESS: Page 2, Line 5. The words "building loads" should be changed to "buckling loads."

BY MR. COPELAND:

Q. With that correction, is this testimony true and correct to the best of your knowledge and belief?

A. Yes, it is.

Q. And do you adopt this as your testimony in this proceeding?

A. Yes.

MR. COPELAND: Your Honor, I would ask at this time that the testimony of Kamran Mokhtarian, together with the attachment, be incorporated into the record as though read.

JUDGE WOLFE: Is there voir dire and/or objections to the offer?

MR. SOHINKI: No objection, Mr. Chairman.

MR. DOHERTY: I have some voir dire, Your Honor.

JUDGE WOLFE: All right.

VOIR DIRE

BY MR. DOHERTY:

Q. Mr. Mokhtarian, I want to ask you about your company, Chicago Bridge & Iron. Are they a subsidiary of any other company?

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A. Chicago Bridge & Iron Company is a part of CBI Industries.

Q. What does CBI stand for, please?

A. Chicago Bridge & Iron.

But Chicago Bridge & Iron Company happens to be a good part of CBI Industries. So CBI Industries took its name from Chicago Bridge & Iron.

Q. Okay.

Is it more than 75 percent of CBI?

A. Yes, it is.

Q. Okay.

Are you getting paid today for your testimony?

A. My regular pay.

Q. Your regular pay. All right.

In your education and professional qualifications -- Do you have that before you now?

A. Okay. I do now.

Q. On Line 24 you speak of "nuclear reactor vessels." Now are these reactor pressure vessels?

A. Yes.

Q. Okay.

A They're both ... reactor --

Q Say it again, please?

A. Really, that would mean both nuclear reactor vessels and containment vessels.

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Q. Which was it for you at that time, please?

A. Well, I don't have the version with the line numbers on it.

THE WITNESS: Do you have that one?

A VOICE: It's attached to the testimony.

THE WITNESS: Except that I didn't get that part of the testimony.

(Pause.)

THE WITNESS: Line 24, now.

BY MR. DOHERTY:

Q. Yes.

A. June '66 ... Okay. At that time it was the reactor vessel.

Q. Okay.

Now, on the next page, at Line 18, you state you helped develop buckling criteria to be used for the design of that vessel.

Was that buckling criteria for use of your company only?

A. It was buckling criteria for use on that particular containment vessel ... the distributor breeder containment vessel.

Q. Uh-huh.

Now, on the issue of buckling on a containment shell for the BWR-3, have you followed any of the NRC's research on this issue?

MR. COPELAND: Objection, Your Honor. That's cross-examination.

JUDGE WOLFE: Sustained.

MR. DOHERTY: Well, I think it does go to his qualifications because if he's going to speak on this issue, I want to know how acquainted he has gotten with the issue.

And it seems to me that that is an attempt to find out if he's qualified to speak on the issue.

MR. COPELAND: I don't see how, Your Honor. It just goes to the question of how well prepared he is, how much knowledge he has.

MR. DOHERTY: But I don't think the question can be asked during cross-examination very well.

JUDGE WOLFE: Why not?

MR. DOHERTY: It doesn't relate to anything he stated here.

It could be objected to on the basis of no testimony.

JUDGE WOLFE: Your question, you say, would relate not to anything at issue in his testimony?

MR. DOHERTY: I don't see anything to hook it onto there, Your Honor.

JUDGE WOLFE: Well, if it doesn't relate to

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anything that he's testifying to, how does this bear upon his competence?

MR. DOHERTY: Because his competence might or might not be established by whether he has kept up with research on the issue that he's going to speak about.

JUDGE WOLFE: But I thought you said that this had nothing to do with what is at issue in Doherty Contention 9.

I'm trying to understand your position.

MR. DOHERTY: As best as I can recall without making a sudden explanation, there is mention in the testimony of only one NRC contractor report.

JUDGE WOLFE: Where are you now, please?

MR. DOHERTY: There is mention on Page 5 of the testimony of one of the NRC's contractor reports, which deals a little bit with the issue, not very much.

But that's all.

(Bench conference.)

JUDGE WOLFE: Well, you can ask the question later during cross-examination, Mr. Doherty.

Next question.

BY MR. DOHERTY:

Q Did you, Mr. Mokhtarian, contribute anything to the Preliminary Safety Analysis Report for the Allens

Creek Plant?

A. Not directly. We did work with EBASCO on developing some of the buckling critera; then EBASCO in turn put that information in the PSAR.

Q. I see.

Now, was the same true as with the Containment Systems Design Report, December 1979?

A. No. Again, I had no direct involvement with that at all.

Q. All right.

MR. DOHERTY: No further questions on voir dire, Your Honor.

JUDGE WOLFE: Any objection to the testimony -- incorporation of the testimony?

MR. DOHERTY: No, Your Honor.

JUDGE WOLFE: Absent objection, the direct testimony of Kamran Mokhtarian on Doherty Contention 9, inclusive of his written qualifications, is admitted -- is incorporated into the record as if read.

(See attached pages.)

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
HOUSTON LIGHTING & POWER COMPANY	)	Docket No. 50-466
	)	
(Allens Creek Nuclear Generating Station, Unit No. 1)	)	

DIRECT TESTIMONY OF KAMRAN MOKHTARIAN ON BEHALF OF HOUSTON LIGHTING & POWER COMPANY ON DOHERTY CONTENTION NO. 9-CONTAINMENT BUCKLING

Q. Please state your name and place of employment.

A. My name is Kamran Mokhtarian. I am employed by Chicago Bridge & Iron Company. My business address is 800 Jorie Boulevard, Oak Brook, Illinois.

Q. Please describe your professional qualifications.

A. A statement of my background and qualifications is attached as Exhibit KM-1.

Q. Why have you prepared this testimony?

A. The purpose of this testimony is to address Doherty's Contention No. 9 which alleges that the Applicant's steel containment shell will not be strong enough to resist buckling under the design loads. Doherty's Contention No. 9 alleges:

> That Intervenor's health and safety interests are inadequately protected because Applicant's steel containment shell is not strong enough by design to resist dynamic and static loads which may plausibly occur in the life of the atomic plant.

The only specific basis stated in the contention for the above allegations are four observations on containment vessel bucking evaluation methods paraphrased from a preliminary (Jan. 1978) report of an NRC consultant, namely:

(1) Adequate experimental data for determining design criteria did not exist.

(2) Computer programs for determining ~~building~~ buckling loads do not predict experimental buckling results very well.

(3) That the ASME Section III Buckling Criteria Regulatory Guide 1.57 NE-3224 (sic) "permits designers to select the method which yields a buckling stress which is least conservative."

(4) Until more test data is obtained to study the effects of imperfections, asymmetric loading, load interaction, dynamic and nonlinear effects, a conservative factor of safety such as 3 should be used."

Q. Will you describe how the containment for Allens Creek is being designed?

A. The steel containment vessel for ACNGS, as specified in Subsection 3.8 of the PSAR, is being designed in accordance with the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section III, Subsection NE. Chicago Bridge & Iron Company (CBI) is designing the steel containment vessel and its appurtenances for the ACNGS. The Applicant, through Ebasco, has prepared the design specification required by Paragraph NA-3250 of the ASME Code for use by CBI in their design of the ACNGS steel containment vessel and its appurtenances. This design specification establishes the minimum requirements for the design of the vessel. These requirements include the identification of the load definitions and the establishment of appropriate load combinations and related acceptance criteria to be employed in assessing structural stability and buckling capacity.

CBI is performing the required analyses and design activities to configure the steel containment vessel which will comply with the Applicant's design specification. CBI upon completion of their ongoing design activities, will prepare and submit to the Applicant a Certified Stress Report in accordance with Article NA-3350 of the ASME Code.

Q. How does this design process account for buckling?

A. The PSAR Table 3.8-2 outlines the buckling criteria in use for ACNGS. This criteria is based on the classical linear theory with reductions applied to account for imperfections in vessel geometry and other differences between theoretical and actual load capacities.

Basically, the method used on ACNGS for the buckling evaluation is the following:

1. The containment vessel is mathematically modeled using Kalnins' Shells of Revolution Program which has been verified as producing results for axisymmetric shells comparable to those of finite element programs recommended in NUREG/CR-0793. The Kalnins' Program is based on linear theory. The loads, as specified for ACNGS, are imposed on this mathematical model of the containment vessel in accordance with the specified loading combinations. The program has capabilities for axisymmetric and nonaxisymmetric stress

analyses of axisymmetric shell structures.

2. For the buckling analysis, the maximum compressive stresses at any azimuth are assumed to act uniformly all the way around, resulting in a conservative analysis.

3. The maximum stresses resulting from the sum of the static and dynamic loads will be compared to critical buckling stresses using the specified stress interaction equations which include the appropriate factors of safety.

This method of analysis accounts for the amplification factors on stresses due to dynamic loadings. These resulting stresses, however, are treated as equivalent static stresses for comparison with critical buckling stresses. This is a conservative approach, since a structure can withstand stresses due to dynamic loadings that are equal to or, in many cases, greater than critical stresses from statically applied loadings.

The buckling capacity of the shell is based on linear bifurcation (classical) analyses reduced by capacity reduction factors which account for the effects of imperfections and nonlinearity in geometry and boundary conditions and by plasticity reduction factors which account for nonlinearity in material properties.

In addition to the above reduction factors, factors of safety are employed in the assessment of structural stability. A factor of safety of 2.75 is applied wherever the critical buckling stresses are in the elastic range. The safety factor is linearly reduced from 2.75 to 2.0 between the proportional limit and the yield stress of the material. Where the critical stresses approach the yield strength of the material, material deformation becomes the controlling factor rather than buckling.

In addition to meeting the requirements of PSAR Table 3.8-2, the design of ACNGS containment vessel will meet the requirements of ASME Code Case N-284, titled "Metal Containment Shell Buckling Methods," issued August 25, 1980.

Q. What do you understand to be the basis for Mr. Doherty's contention?

A. Mr. Doherty filed, as a basis for his contention on containment buckling, his summary of a preliminary progress report submitted to the NRC Staff in January, 1978, by International Structural Engineers, Inc. (ISE). ISE was under a consulting contract with the NRC to study containment buckling analysis. The preliminary report included a number of preliminary observations which were cited by Mr. Doherty as criticisms of the present predictive methods used for buckling evaluation of containment vessels. ISE's final report was published as NUREG/CR-0793, "Buckling Criteria and Application of Criteria to Design of Steel Containment Shell" (May, 1979).

Q. Would you discuss each of the observations made in the consultant's preliminary report which Mr. Doherty cites?

A. Those preliminary observations as paraphrased and cited by Mr. Doherty in his contention are quoted and responded to in the following four paragraphs:

1. "Adequate Experimental data for determining design criteria did not exist."

Over the past decade a systematic collection has been made by CBI of several hundred technical papers known to contain experimental data on shell buckling. These tests include stiffened and unstiffened shells subjected to a variety of loads or loading combinations. Several of these tests have been performed on models fabricated with procedures representative of those used on containment vessels.

The final consultant's report recognized the fact that adequate experimental data does exist for shells subjected to axisymmetric static loadings. The concern seemed to remain that there may be a lack of data for shells subjected to dynamic asymmetric loadings. This concern will be conservatively accounted for in the methods employed in design and analysis of ACNGS containment vessel. The specified dynamic loadings will be applied to a mathematical model of the vessel. A shells of revolution program having dynamic analysis capabilities will be used. The resulting stresses, which include the effects of dynamic amplification factors, will then be used as equivalent static stresses for buckling evaluation of the vessel.

The asymmetric stress effects are also conservatively treated by applying the maximum stress around the entire azimuth as an axisymmetric (uniform) stress. The final consultants' report recommends this procedure as a conservative approach.

2. "Computer programs for determining buckling loads do not predict experimental buckling results very well."

It is well recognized that the results of computer programs based upon classical theory must be modified to predict the buckling capacity of imperfect shells. For the ACNGS vessel, the classical buckling values are reduced by knockdown and plasticity reduction factors, which conservatively account for the difference between the theoretical elastic buckling value for a perfect shell and the critical buckling capacity of a fabricated shell.

Both the preliminary and the final consultants' reports endorsed this approach as the preferred method of arriving at the critical buckling loads.

3. "That the ASME Section III Buckling Criteria Regulatory Guide 1.57, NE-3224 (sic), permits designers to select the method which yields a buckling stress which is least conservative."

The classical linear buckling analysis with reductions based on test results, which is the buckling evaluation method used for ACNGS vessel, is the method preferred and recommended by the consultants. This approach, outlined in previous paragraphs, is the most widely used approach for shell buckling evaluation. Applicant does not intend to perform any buckling evaluation for the ACNGS vessel using either of the other two methods permitted.

4. "Until more test data is obtained to study the effects of imperfections, asymmetric loading, load interaction,

dynamic and nonlinear effects, a conservative factor of safety such as 3 should be used."

The final consultants' report recognized that imperfections, asymmetric loadings, load interactions, dynamic loadings, and nonlinear effects can all be treated in a conservative manner, and that a safety factor of 2.0 will be adequate. As the final consultants' report states, "It is felt that a safety factor of 2 is sufficient to achieve a conservative design for all states of stress, if applied to reduction factors obtained as the minimum of experimentally obtained data." This recommendation of the consultants' Report is consistent with the buckling criteria of the ASME Code Case N-284, the requirements of which will be met for this vessel.

Q. Would you summarize your opinions concerning Mr. Doherty's contention?

A. The four (4) observations cited by Mr. Doherty's contention have either been superceded in whole or in part by their own authors in the final consultant's report to the NRC (NUREG/CR-0793, May, 1979) or they are well accounted for in the design of the ACNGS containment vessel. The method of analysis employed for the design of the ACNGS containment vessel will result in a conservative prediction of stresses and the buckling evaluation method employed will produce a safe and conservative design.

Exhibit KM-1

EDUCATION AND PROFESSIONAL QUALIFICATIONS

KAMRAN MOKHTARIAN

RESIDENCE:

442 Claremont Court
Downers Grove, Illinois 60516

BUSINESS:

Chigago Bridge & Iron Co.
800 Jorie Blvd.
Oak Brook, Illinois 60521

EDUCATION:

B.S. Degree in Civil Engineering, Cleveland State University, 1963

M.S. Degree in Structural Mechanics, Northwestern University, 1964

Graduate level courses at Illinois Institute of Technology

EXPERIENCE:

Employed by Chicago Bridge & Iron Co. from 1964 to present.

August 1964-August 1965 - Design Engineer: Working on design of vacuum chambers and pressure vessels.

August 1965-June 1966 - Field Engineer: Working on fabrication and construction of tanks and vessels in an oil refinery.

June 1966-August 1967 - Design Engineer: Working on design and analysis of nuclear reactor vessels.

August 1967-May 1972 - Group Leader: Having responsibility for stress analysis of nuclear reactor vessels and preparation of ASME Code Stress Reports.

May 1972-Sept. 1975	- Supervisor of Stress Analysis: Having responsibility for complete design and analysis of nuclear structures. Supervising groups of engineers performing heat transfer analysis, fatigue and fracture analysis, shell and finite element analysis, and buckling analysis. Reviewing and certifying complete Code design and stress reports.
Sept. 1975-July 1977	- Project Engineer: Having overall engineering responsibility for design and analysis of the containment vessel for the Clinch River Breeder Reactor Project. Helped develop buckling criteria to be used for the design of that vessel.
July 1977-To Date	- Design Supervisor: Having responsibility for design of various nuclear structures. Supervising groups of engineers working on design and analysis of various containment vessels. Helped with developing buckling criteria to be used for design of Mark III containment vessels. Helped with

the development of and authored portions of the ASME Code Case N-284, titled "Metal Containment Shell Buckling Design Methods".

PROFESSIONAL REGISTRATION:

Registered Professional Engineer in State of Ohio

HONOR SOCIETIES:

Tau Beta Pi

Pi Mu Epsilon

PUBLICATIONS:

"Hotspot Flexure of Plate on Circular Support", Journal of the Engineering Mechanics Division of ASCE, June 1968

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JUDGE WOLFE: Is there anything, Mr. Copeland?

MR. COPELAND: No, sir.

JUDGE WOLFE: Cross-examination, Mr. Sohinki?

MR. SOHINKI: We have none, Mr. Chairman.

JUDGE WOLFE: Mr. Doherty.

CROSS-EXAMINATION

BY MR. DOHERTY:

Q. Mr. Mokhtarian, how do you define "buckling"?

A. I would define "buckling" as instability failure of the structure ... without getting too technical about it.

When the deformations of the structure become very large, that is a buckling failure.

Q. In your definition, would there have to be a loss of strength of the structure to have buckling occur?

A. Well, the buckling failure would cause loss of strength.

Q. You wouldn't call it buckling then if no loss of strength occurred; is that correct?

A. Not necessarily. As long as you do get large deformations, it could be called a buckling failure. But that doesn't necessarily mean that you've lost all of the strength.

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Q. Okay.

I have some questions with regard to the containment shell now. Where will be the shell be fabricated?

A. Right now the plans are that this particular shell would be fabricated at CBI's plant in Birmingham, Alabama.

- - -

Q. Does that mean, sir, that when it arrives on the site it will be in its entirety?

A. No. No way.

There'll be plates fabricated, individual plates fabricated in the shop and those are shipped to the site and put together at the site.

Q. Can you give me an idea, a rough guess, how many pieces?

A. Um-hmm. I would say it could be forty or fifty different pieces that would have to be put together in the field.

Q. Okay.

So, then, those pieces are created at CBI?

A. Correct.

Q. The final building of the contraption is where? At the site?

A. At the site.

Q. Okay.

JUDGE LINENBERGER: Sir, is this normally what is referred to -- I won't say normally -- but, sometimes referred to as field direction?

THE WITNESS: Yes, it is. This is a field directed vessel.

JUDGE LINENBERGER: Thank you.

2-2

BY MR. DOHERTY:

Q. Now, are the pieces through which any doors will go single when they arrive at the site?

A. Yes. Generally, speaking they are, unless you get a door which is too big to be shipped in one piece; and we have had cases where the frames for those openings have had to be shipped in two pieces, and then put together in the field.

Q. All right.

A. As for as I know, for this and everything, you know, all that reinforcing the framing for openings will be shipped in one piece.

Q. Now, let me see if I got this right?

Are you saying that at Allens Creek there will not be any of this unusual circumstance?

A. That is correct.

Q. Okay.

Now, how has the containment been designed at this point?

A. Has it been designed?

Q. Yes.

A. Not completely. We have had some preliminary design work done; but, no, it is not final design by any means.

Q. What input is needed before you can complete the design?

A. Well, some of the loads would still have to be finalized.

Q. Well, can you give me an idea of what those loads are, please?

A. Basically, SRV and local loads and seismic too. We have had some preliminary loads that we have worked with, but from what we understand they haven't all been finalized yet.

Q. Are all the static loads arrived at, though?

A. We do have a set of static loads, yes.

Q. Okay.

Now, I'm looking at Page 2 now of your written direct testimony.

(Pause.)

Now, on Page 19 (Line 19), you state the vessel ". . . is being designed in accordance with requirements of the ASME Boiler and Pressure Cole Section III, Subsection III."

Is this to your -- to the best of your knowledge a requirement?

A. Yes, it is.

Q. So, then, you have to meet these requirements and then meet other requirements not specified.

Is that correct?

A. That is correct.

Q. I see.

(Pause.)

Now, do all of the loads, particularly, the loads such as SRV and LOCA, must the design also meet an additional loading due to seismic events?

A. Yes.

Q. All right.

And, unless -- I want to be clarifying this. Is that seismic load, then, the so-called safe shutdown earthquake --

A. We design for two different seismic loads. One being OBE, Operating Basis Earthquake; and one SSE, Safe Shutdown Earthquake.

Q. Okay.

(Pause.)

JUDGE LINENBERGER: Before we leave this question of loads, when you mentioned seismic loads in the context of your answer to Mr. Doherty, are these loads that are additive in addition to the SRV --

THE WITNESS: Yes. LOCA.

JUDGE LINENBERGER: -- and, LOCA loads.

THE WITNESS: Yes, sir.

The loading combinations that we have so far have either the OBE or SSE in combination with SRV's, some of the SRV and LOCA loads.

JUDGE LINENBERGER: Would you just clarify SRV, please?

THE WITNESS: Safety Relief Valve load on loading.

BY MR. DOHERTY:

Q. Now, I'm interested to know a little bit more about the certified stress report.

That's a responsibility of CBI, is that correct?

A. That's correct.

Q. And, you give this to Applicant?

A. Yes. We give it to Houston Lighting & Power.

Q. I see.

What is your understanding of what happens to that after you give it to the Applicant? Do you --

A. What happens to it?

Q. (Counsel nods.)

A. I don't know.

Q. Okay.

What is the ultimate strength of the steel shell? As planned?

A. The ultimate strength for what kind of a failure?

Q. Well, I'll give you a for instance.

A. Uh-huh.

Q. Let us say that it is subject to internal pressure --

A. Okay.

Q. -- from a gas.

A. Right.

Q. At what point will the pressure vessel fail? Do you have any idea -- will that vessel fail. Do you know? Do you have any idea?

A. Well, we have looked at that.

We have some preliminary numbers, but I don't have those here with me.

That really wouldn't have anything to do with buckling with that internal maximal pressure would be by yielding, which is just a different kind of failure than the buckling failure we are talking about.

Q. Well, that's what you'd call a dynamic load, wouldn't it be? What I've described?

A. It could be either a dynamic or static internal pressure load.

The study that we did was with an equivalent static pressure, internal pressure.

Q. All right.

Now, in this instance, the only difference between dynamic and static is that one is rapid and the other is you let time take its course, too? Right?

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A. Yes. That's correct.

Q. Okay.

Now, under that same condition, do you have a figure or an amount for a yield strength of the shell at this point?

A. Well, the load strength of the material that we are using for this containment vessel is known as specified. The code has some minimum values that the material supplier has to meet before the material is used.

Q. I see.

Now, what code? Can you tell me what that is? That code?

A. That is the ASME Code.

The ASME Boiler and Pressure Vessel Code, Section 2 of that is on materials; and for every type of material it has some requirement on the material properties that have to be met, and one of those properties is the minimum yield strength.

Q. I see.

So, you have at this point, would you say, a better idea of the yield strength than the ultimate strength?

A. Well, we know what minimum values both of those have to have for the material we are using.

For every piece of material that we use, they will test samples of that material and they will have to to meet the specified minimum values for the yield and ultimate strength of that material.

Q. Okay.

Now, on Page 3, Line 15, you begin to get into what you are going to do a little bit; or perhaps what you've done already. And, you speak about reductions applied to account for imperfections in vessel geometry.

Now, what I want to ask you about is how are the reductions determined?

A. Those reductions are determined from available tests data.

Q. So, then -- Let's back this up a minute. In order to determine -- Excuse me. Strike that.

Now, does your statement there say that your reductions are cause by imperfections in the vessel geometry?

A. Yes.

Q. Well, then, what is a -- in this case, now, what is an imperfection in vessel geometry to you?

A. In perfection could be a local variation from the theoretical radius, for example.

Q. Theoretical -- pardon, what was the next word?

A. Radius.

Q. Radius?

A. Right. You know it was at flat spots, you know. Part of the vessel may not be exactly to the theoretical radius.

Q. Okay.

(Pause.)

So, do you use something like a previous experience with this type of vessel in order to get some idea of the necessary reductions you will have to apply due to these imperfections?

A. I don't know if I would call it previous experience; but you look at the test results, you plot those and based on those you come up with the values of those so-called "not known factors" and then you use those on various jobs.

You know, previouse experience, you know, on other containment vessels, of course, you never test those to failure so you don't -- you don't learn anything from previous experience in that sense.

Q. Okay.

Has there ever been a failure of a containment shell as large as this one, to your knowledge? And, this shape?

A. Buckling failure?

Q. Yes.

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A. Not that I know of.

Q. (Pause.)

Along that line, are all BWR designs, do they use this type of inner shell, that is currently called the BWR's functioning to your knowledge?

A. Do they use what, sir?

Q. This type of internal shell inside of the concrete shield?

A. Not all the BWR's. The Mark III BWR's, the steel Mark III BWR's are basically the same type of a thing. Steel containment vessel inside a concrete shield building.

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Q. How many Mark III's are there right now?

A. At various stages of construction?

Q. Well, how many shells are complete at this point?

A. How many shells are completed?

Q. (Counsel nods.)

A. I know of about three or four which are close to completion. There is probably more. I don't have an exact count of how many there are.

Q. All right.

What else would be an example of a reduction besides this lack of, I don't know, symmetry, I guess or --

A. Another thing which contributes to a reduction would be the boundary conditions. You know, you never have idealized boundaries at these things, and those would show up in your reduction factors.

MR. SOHINKI: Mr. Chairman, may we go off the record for a second?

JUDGE WOLFE: Yes.

(A brief discussion was held off the record.)

BY MR. DOHERTY:

Q. Now, through the history of the design of the Allens Creek plant, there was a change in the steel shell in terms of its shape. The roof, I would call it as a layperson, was changed from a semi-ellipsoidal to a hemisherical?

A. That is correct.

Q. Now, what I'm interested in is what does that improve? Does it improve the ultimate strength of the shell?

A. It may, although, that wasn't the reason it was changed in geometry. The containment vessel itself was strong enough with the ellipsoidal roof to take the loads which were specified at that point in time.

The reason for it, from what I understand, was the attachment to an ellipsoidal because it has a flat top. The top is fairly flat. Deflections were getting excessive for some of the attachments to that head.

So, a hemispherical head is a little bit more stronger. It doesn't deflect as much, and it doesn't shake as much.

Q. Was the problem vibration up there?

A. Yes.

Q. Well, briefly, what is -- does anything hang from the center of the roof at this point?

A. Yes. There are things hanging. I don't exactly know everything that's hanging, but I know that some sprayheaders are hanging from the roof there.

Q. Okay.

Now, does this change of design we spoke of a moment ago, improve the yield strength?

A. You mean, the yielding capacity of the containment vessel?

Q. Yes.

A. Again, it probably does just because you don't have that flat radius on the top it improves the capacity for yield.

Q. All right.

Does it improve in any way the buckling resistance?

A. Well, if you just compare any dome with an ellipsoidal dome, then the answer is yes. It is definitely stronger from the buckling standpoint, the hemispherical dome.

But, when we had the ellipsoidal dome, we were going to put some stiffeners up there, so we wouldn't add stiffeners on a flat head to make it as strong as it had to be.

Q. Will there be any stiffeners now? Or are they --

A. No.

With a hemispherical dome you don't need any stiffeners.

With the ellipsoidal you probably did.

Q Now, would it improve the buckling resistance with regard to, what I would call, the sides or I guess the barrel of this shell?

Would it have any affect on that?

A. No. No, I would say the cylindrical part -- the cylinder part of the vessel?

Q Yes.

A. No. That shouldn't really be affected by the shape of the head.

Q Oka..

Now, you spoke down here of Kalnins' Shells of Revolution Program --

A. Okay.

Q I want to find out where that was published?

A. Where is it published?

Q Yes.

A. There is a published paper on the theory behind that Program. I couldn't tell you right now where it is published. I know it was published quite a number of years ago by Professor Klnins. He as a professor at Yale University. No.

Q Is it used extensively in the industry?

A. Well, I know it is used by other than CBI. I don't know what you would call extensively. It is -- I would say: Yes, it is being used by a number of different companies.

(Pause.)

Q. Well, would you call it the standard method for determining buckling load?

A. I beg your pardon?

Q. Oh, I'm sorry.

Would you call it the standard method for determining buckling load?

A. Oh, this Kalnins' Program?

Q. Yes, sir.

A. Well, the Kalnins' Program, part of the analysis really doesn't have anything with the buckling analysis. We used that Program to arrive at the stresses from the specified loads that would take those stresses and do the buckling analysis with those.

This Program doesn't have anything to do with the buckling analysis.

Q. Is there a standard program for buckling analysis, then?

A. I don't know of a standard program.

There's quite a number of programs available for doing theoretical buckling analysis.

Q. Now, what are the names of some of those, please?

A. Well. BOSOR is the one that I'm most familiar with. There is a SAP series of programs, S-A-P.

There is ANSYS Program, by the name of ANSYS. Those are the ones that I'm familiar with, but there is quite of few of those.

Q Well you -- So, then, you used one of these programs, is that right?

A. No.

We didn't use any programs.

Well, we probably will use BOSOR, eventually. But, up to now -- You use a program to come up with a theoretical buckling values. Some of those you can just get out of the textbooks there rather than run a program for it.

And, so far we've done that.

Q So, that's B-O-S-O-R?

A. Right.

B-O-S-O-R.

Q Okay.

(Pause.)

Now, have you familiarized yourself with some of the NRC's publications and research in this area?

A. Yes.

I'm fairly familiar with those.

(Pause.)

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Q Have you familiarized yourself with NUREG-0747?

A. That is International Structural Engineers Report, Weingarten and --

Q No, sir. If you'd like, I will bring it over to you. You can tell me if you're familiar with it or not.

A. I'd appreciate it.

MR. DOHERTY: May I approach the witness.

JUDGE LINENBERGER: Why don't you read the title at the moment, also, please, sir.

MR. DOHERTY: It's called "A Description of Current and Planned Research in Structural Engineering."

THE WITNESS: I have seen that document, yes.

BY MR. DOHERTY:

Q Did you familiarize yourself with the section on buckling of steel containments?

A. I've read through it.

Q I see. Do you agree with their statement on the adequacy of current standard methods of determining buckling loads of steel containment vessels?

MR. COPELAND: I object to that question, Your Honor, unless he shows the witness the document and lets him read the statement before he answers.

THE WITNESS: Yes. That is a true statement.

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BY MR. DOHERTY:

Q. Would you read that short statement to the Board?

JUDGE WOLFE: At what page is this, please?

THE WITNESS: Page 46. It says, "The current standard methods for determining the buckling loads of steel containment vessels that are subjected to axisymmetrical dynamic pressure loads have not been verified by testing or accurate analysis."

But I have some more explanation on this.

MR. COPELAND: I'd like for the witness to complete his answer, then, Your Honor.

BY MR. DOHERTY:

Q. If you have some more to add to that, please do so.

A. Okay. That's one area where test results are not available, and we recognize that and we account for that by using conservative assumptions.

The catch there are two words. One is dynamic loads and one is axisymetric analysis.

Now, the way we account for dynamic loads is by doing a dynamic analysis, calculating the dynamic amplification factors and then multiplying the static stresses by those amplification factors, coming up with an equivalent static stress which has the effect of all the dynamic loadings.

That is applied to the shell as a static load and is well-recognized that that's a conservative way of doing the analysis.

In other words, the analysis assumes that the peak stress, the maximum stress during that dynamic event acts there on the vessel shell as a static load.

This is -- Like I said, there are papers on this and it is well-recognized that this is a conservative way of accounting for the dynamic fact.

The other word is axisymmetrical loading. Again, it's difficult to similate some of these non-symmetric loadings on vessels for testing purposes.

Again, there we recognize that, and the way we account for it is we calculate the stresses around the containment vessel, and then we take the maximum stress at any point around the circumference and assume that that maximum stress acts all the way around.

That, again, is a conservative assumption.

Q. However, though, you do say that you agree with the statement that you read; is that right?

MR. COPELAND: Objection, Your Honor, asked and answered.

The witness has given a lengthy explanation as to why he agrees with that.

BY MR. DOHERTY:

Q Having given your lengthy explanation, as Counsel has called it, do you still agree with your original statement?

MR. COPELAND: Same objection.

JUDGE WOLFE: With the original statement being what?

MR. DOHERTY: Being that he agreed with the statement which he read.

JUDGE CHEATUM: Mr. Doherty, he has already agreed with the statement.

MR. DOHERTY: Well, sometimes people, on getting a little chance to really think things over and explain themselves, begin to think they've been a little too liberal and want to change their minds; and I just think it's fair to ask him.

JUDGE WOLFE: All right. I'll allow the question.

THE WITNESS: I agree, subject to the explanation that I just gave.

BY MR. DOHERTY:

Q Okay. Now, you spoke that this procedure you described is well recognized. Well recognized by whom?

A By, I would say, experts in this field, people who are involved with buckling analyses, or at least the ones that I have been in contact with, the ones that I have talked to.

Q. And who are they, for example?
A. You want names or --
Q. Yes. Do you have any names that are handy in your mind?
A. Well, we have a number of them within CBI organization. One of them would be Clarence Miller.
He is -- I would consider him one of the leading authorities on the subject, and he's published a number of papers, and he definitely agrees with that.
We have a number of others, Tommy Koff, John Hegstrom, and a number of people within the EBASCO organization. We've talked to them, and a number of other architect/engineering organizations that we've worked with over the years.
I mean, I could go on naming names.
Q. Please don't. I don't want to do that to you, sir. That's not fair.
A. Okay.
Q. Now, were you saying, sir, that in this summation of dynamic loads, you include every one of them?
A. Every one of what?
Q. All right. I'll rephrase that. It's difficult to get notes right there. I'll try it again.
Okay. Scratch that last question, if there was one.

I am going back to page 3 in that discussion of buckling evaluations.

In line 23, I wanted to get a little more into this word "comparable" that you used there.

You state that the Kalnins' Shells Revolution Program produces results comparable to the finite element program recommended in NUREG/CR-0793.

Do you mean that there has been replicable results from these two different approaches?

A. Yes. Some studies have been done to compare the results and they have been in reasonably good agreement.

MR. SOHINKI: Off the record, Mr. Chairman, that's going to be going on for another ten minutes.

JUDGE WOLFE: All right.

BY MR. DOHERTY:

Q. I would like to ask you another question with regard to the NRC's publication, NUREG-0747.

It might be easier if I approached you, rather than try to do it at a distance.

I would like to ask you to read that last statement and then give us anything you have on it, please. It is on page 47 of the document we discussed a moment ago, NUREG-0747.

A. "Also, the problem of dynamic buckling of the containment shell in the presence of axisymmetrical loads, such as that due to seismic and safety relief valve blowdowns, has not been adequately addressed."

MR. COPELAND: Is there a question about that, Mr. Doherty?

BY MR. DOHERTY:

Q. Do you think that statement accurately reflects the situation with regard to the shell plan for the Allens Creek Nuclear Plant?

A. No, I don't.

Q. All right. What are your reasons for not agreeing with that, please?

A. Well, I just explained a minute ago how we do account for the dynamic effects of the loads and for the axisymmetric effects of the load.

We account for those by using a conservative approach.

JUDGE WOLFE: Why don't we take a ten-minute recess.

(Recess taken.)

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BY MR. DOHERTY:

Q Mr. Mokhtarian, we broke off after you read something into the record about the dynamic buckling or containment shells and loads from seismic and safety relief valve blowdown.

I think in the beginning we indicated that these loads had not been ... what? What was the problem ... in the very beginning?

I think you said they had not been completed, is that correct, for the shell?

A. The loads have not been finalized.

Q Why haven't they been finalized, please?

A. I don't know. Those loads are specified to us by EBASCO, and EBASCO does not have all of the final loads yet.

Q Okay.

Turning to page four of your written direct testimony, please, you speak of the appropriate factors of safety.

How are these appropriate factors of safety included in the stress interaction equation?

A. Well, once you have set up your criteria on how you add up the effect of stresses in the two different directions, then you throw a safety factor at the end -- on the end result.

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And, in other words ... if that criteria would indicate that the critical interaction -- what we call the interaction value, where you combine the stresses in different directions, the critical value would be one.

You keep that value to one. Then we would divide that one by the safety factor, in this case 2.75, so that the sum of the interaction from the different -- from the stresses in different directions don't add to more than one divided by the safety factor.

Q. Where does the 2.75 come from?

A. That's the safety factor that is in the buckling criteria right now for the elastic buckling gradient.

Q. You said "right now." Has it ever been otherwise?

A. No. The 2.75 has always been there.

Q. Who has determined that the use of this factor is conservative?

A. The use of which factor?

Q The appropriate safety factor of 2.75.

A. Well, we're not saying that is conservative. Where are you reading that now?

Q. All right. Let me ask you this.

Do you think the use of a safety factor of 2.75 is conservative?

A. Yes, I think 2.75 is an adequate safety margin.

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Q. Is there anyone outside of Chicago Bridge & Iron who agrees with that?

A. Well, I think so. There's -- a code document which was recently published ... That was a result of that, about three or four years work of a task force of experts. That's a code case that has been published.

And that document recommends a safety factor of two for normal operating conditions.

Q. All right.

That's for normal operating conditions. Would normal operating conditions include a loss-of-coolant accident?

A. No.

Q. Doesn't the plant have to be constructed in order to take in the loss-of-coolant accident?

A. I'm sorry. I will take that back.

It does include some non-coolant local condition What is normal operating condition and what is in ASME terminology a Level C or a Level D type operation, those are again specified to us.

And some of the local loads are specified as Level A or B, which would make them normal operating condition.

Q. Could you repeat just the last of what you said? I lost it; I couldn't hear it.

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A. I said some of the local loads are specified as normal operating conditions.

JUDGE LINENBERGER: Sir, you mentioned a moment ago an ASME code case that addressed the adequacy of the safety factors that Mr. Doherty was just asking you about.

Does that happen to be the code case referenced in your testimony at Page 5, the first full paragraph?

THE WITNESS: Yes, sir. Code Case N-284.

JUDGE LINENBERGER: Thank you.

BY MR. DOHERTY:

Q. Well, then the safety factor, 2.75 -- isn't this correct -- it does not take in abnormal operating transients?

A. Right now the criteria that's in the design spec doesn't differentiate in normal and abnormal conditions.

Where I was referring to a safety factor of two for normal operating condition was from the code case.

And in the code case they do differentiate between normal operating conditions, which would be -- in their terminology again -- Level A and B service conditions; and then they reduce -- or they recommend a reduction in the safety factor for Level C and D conditions.

Q. Okay. Now, I want to get something straight here before I go on.

This safety factor ... now, if everything else is the same but the safety factor in a hypothetical problem, will the containment shell be stronger if the safety factor put into the calculation is low or high?

A. It will be stronger if the safety factor is higher.

Q. Okay. Thank you.

Now, on Page 4 still, starting at the end of Line 13, there is this statement: "This is a conservative approach, since a structure can withstand stresses due to dynamic loadings that are equal to or, in many cases, greater than critical stresses from statically applied loadings."

Why is that?

A. Applying those equivalent static loadings, again assume that the peak value of the stress during that loading transient stays on the structure for a relatively long time, whereas for a very quickly applied load -- dynamic load of a short duration, that peak value of stress is there for a very short amount of time.

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And if that time is short enough, then the structure is not going to have a chance to buckle. So, assuming that you have this maximum peak stress there for a relatively long period of time is at least as bad, or in many cases, worse than having that maximum peak accorded as a very short period of time and then dropped down.

Q Okay. Thank you.

Are the control rod hydraulic unit platforms attached to the shell as a static load?

A We have some platforms -- some platform loads specified to us. I don't know exactly what all of those platforms are used for. But those are accounted for in the design, yes.

The platform loads that are specified to us are accounted in the buckling design of EBASCO.

Q So at this moment you're not certain on this question; is that correct?

MR. COPELAND: I object to that, Your Honor. The witness answered the question. He didn't say he was uncertain.

He said that they were given the loads for those structures and accounted for them in the design of the containment.

JUDGE WOLFE: I'm going to permit the question;

if the cross-examiner thinks there's any uncertainty or whatever, the witness is always capable of handling his own responses.

Answer the question.

THE WITNESS: Well, again, the answer is that the loads are given to us as just platform loads. We don't -- We're not given a description of what the platform is for.

You mentioned some CRD hydraulic system returns or whatever. All I'm saying is that ... you know, I don't know exactly what the platforms are for.

But we know where the platforms are, and we know what the loads on them are. And we do design for all those loads.

BY MR. DOHERTY:

Q. Further down on that page, you state: "The buckling capacity of the shell is based on linear bifurcation (classical) analyses reduced by" some other factors that you mention.

Now, have you determined the buckling capacity of the shell yet?

A. Again, the design of the vessel has not been finalized. We've had some preliminary designs. And for those we have determined the buckling capacity.

Q. Is a linear bifurcation analysis planned to be done at some future date then?

A. Well, we have done some of that on our preliminary designs.

Q. I see.

When did you plan to do this?

A. It's a continuing thing. Like I say, we've done some and will be --

Q. Uh-huh.

A. -- you know, the design is an interactive type of procedure. We just assume a design and apply the loads that we have up to that point and see how it works out.

And this is something that we've been doing and will continue doing for a while.

Q. At the very beginning of this project, were you asked to determine the buckling capacity, or told that that would be eventually something that would be done ... of this shell?

That would be asking you to think back a few years.

A. Well, when we take on a contract for a design of a vessel, we recognize that buckling is one of the things which has to be looked at.

And I guess, by assumption, we knew that we were going to have to do a buckli.g evaluation ... yes.

Q Did Applicant contact you about asking interrogatories from me or anyone with regard to this contention?

A. When?

Q That would have been in the past three years.

A. We have talked with EBASCO, because EBASCO acts as the Applicant's agent; and they have kept us informed of your contention.

Q You were never personally asked -- "Can you answer this question that Intervenor Doherty has given us"?

MR. COPELAND: You mean prior to the time he was asked to testify, Mr. Doherty?

MR. DOHERTY: Well, it could have been prior, or after the time he was asked to testify.

MR. COPELAND: Are you speaking about interrogatory answers now?

MR. DOHERTY: Yes. I'm speaking about specifically an answer to Interrogatory No. 8-16 of mine.

THE WITNESS: Which is what? I don't know what you mean by 8-16.

JUDGE WOLFE: You can identify it.

What was the question, Mr. Doherty?

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MR. DOHERTY: It was a question which had several parts. The question stated: "How does Applicant determine loads on the steel containment shell?"

C Part -- Part C said: "Regardless of code used, please indicate if a linear bifurcation analysis has been used or is planned in the future."

And the answer was: "A linear bifurcation analysis has not been performed for ACNGS steel containment, nor is one planned."

That's what I'm getting at. I'm just wondering --

JUDGE WOLFE: Whether he responded to your interrogatory?

MR. DOHERTY: Uh-huh.

JUDGE WOLFE: Did you personally respond to that, or were you queried about the answer to that interrogatory?

THE WITNESS: No, I don't remember that that question was discussed with me.

BY MR. DOHERTY:

Q. What is a plasticity reduction factor?

A. Okay. All the theoretical type or classical solutions ... like it says linear bifurcation ... that means that some of these theoretical solutions, whether by a computer program or you go to a text and get your

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values, they assume an elastic behavior for the material, meaning that the stresses and strains are related on a straight line basis, but the actual materials ... they reach a point (normally referred to as a proportional limit); and from then on the stress/strain behavior is not exactly straight line.

And recognizing that, you have to apply a correction factor to any analysis that you do on a linear basis.

So if you calculate stresses which go beyond the proportional limit of the material, then you throw this correction factor, which again is based on test results ...

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4-12

BY MR. DOHERTY:

Q. And the correction factor is then the plasticity reduction factor; is that correct?

A. That's correct.

Q. And that's because the material no longer snaps back into shape, or something like that?

A. Well, it's basically because the material doesn't behave linearly. In other words, there's not a linear relationship between the load and the deflection.

And the linear analysis assumes that that linear relationship still exists, whereas for the real material, when it reaches a certain point, it doesn't.

In other words, the modulus of elasticity is not constant after the proportional limit. There is a reduction in the modulus of elasticity, and that reduction is known; and it's applied to the results of the linear analysis.

Q. Would this be the same for both dynamic and static loads?

A. Yes. It's the value of the stress that determines where yc' are on your stress/strain here ... regardless of the nature of the loading.

Q. Okay.

I notice you mention a progress report by the International Structural Engineers Company, and that

4-13

you mentioned it on Page 5 on Line 15.

Did that document recommend a safety factor of 3.0?

A. I can't remember if it actually recommended it, but it did have something to the effect that 3.0 should be used.

Q. Do you have that document with you today?

A. I just noticed a copy of it in the folder. Let me get it.

(Pause.)

I do now.

Q. Do you see in there that it recommends a safety factor of 3.0?

A. What page are you on?

Q. I'm not looking at the document.

A. Well, okay ... I know that they do have -- they do say something about a safety factor of three. But then that was changed in the final report.

The final report came out clearly recommending a safety factor of two, provided that you do your buckling analysis in a certain way.

JUDGE WOLFE: Sir, don't you have the final report before you --

THE WITNESS: I have the final report, yes.

JUDGE WOLFE: Is that what you have before you?

4-14

THE WITNESS: No. This is the preliminary report that Mr. Doherty is referring to.

JUDGE WOLFE: I thought you were referring to the final report, Mr. Doherty.

Maybe I misunderstood you.

MR. DOHERTY: Well, I'm sorry if that happened. I was referring at this time to an item mentioned on Page 5, around Line 15, and does speak about as a Preliminary Progress Report.

JUDGE WOLFE: I see. I was looking at Line 21. All right.

We're talking about the Preliminary Report.

BY MR. DOHERTY:

Q. But you, sir, have the Final Report in front of you now; is that right?

A. No. This is a preliminary.

Q. Still preliminary?

A. Yes.

Q. So then --

A. I have found that statement in there, yes.

Q. Would you read that, please.

A. "Until more test data is obtained to study the effects of imperfections, axisymmetric loading, load interaction, dynamic and non-linear effects, a conservative factor of safety, such as three, should be used."

Q All right.

MR. COPELAND: Is there a question, Mr. Doherty, pending?

MR. DOHERTY: Yes.

BY MR. DOHERTY:

Q Can you tell us any of the -- What was done? Can you tell us what they did to arrive at this lower figure and their conclusion that the safety factor could be lowered?

What did they do? Do you know, sir?

A The ISE?

Q Yes.

A -- the consultants?

Q Yes.

A I'm speculating. As far as I know, they studied this a little bit more and -- this is my own speculation -- that they recognized that some of these effects that they are mentioning here can be accounted for by some of these conservative methods that we have discussed. And their Final Report does recognize some of these methods that we are using on Allens Creek.

And the final conclusion of the Final Report is that if you do use some of these conservative approaches, then a safety factor of two is adequate.

Q Okay.

4-16

Now, with regard to the foot of Page 4, it states: "A factor of safety" -- This is of your testimony, sir.

"A factor of safety of 2.75 is applied wherever the critical buckling stresses are in the elastic range. The safety factor is linearly reduced fr..m 2.75 to 2.0 between the proportional limit and the yield stress of the material."

Now, in that second sentence then, is this the inelastic range or the plastic range? Might it be spoken of that way?

A. No. This is the inelastic range between the proportional limit and the yield strength of the material. That safety factor is dropped over that region, from 2.75 to 2.0.

Q. Okay.

Now, were the buckling stresses analyzed using a model developed, either by the so-called SAP-6 code?

A. No, they were not.

Q. What about the NASTRAN code?

A. No.

Q. Okay.

A. They were calculated by using the Kalnins' shell of revolution program --

4-17
bm

Q. Uh-huh.

A. -- like we said before.

The results of that shell program have been compared with some of these finite element programs that you mention. And they give -- They give comparable results.

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BY MR. DOHERTY:

Q. On Page 5, now, at Line 4, you state, ". . .material deformation becomes the controlling factor rather than buckling."

Now, my question is: How does material deformation as used here differ from bucking?

A. Well, the material deformation that we have used here means yielding, really. You know, we could have used "yielding failure becomes the controlling criteria" rather than buckling which is just that sudden type of a failure.

Q. Okay.

And, moving on down there, you state, "In addition to meeting the requirements of PSAR Table 3.8-2. . " You also will meet the requirements of ASME Code Case N-28. . . ."

Now, in what way will meeting Case Code N-284 benefit the strength of this shell or improve it?

A. I don't think it will.

Right now I am speculating since we haven't done that.

I don't think using the Code Case would add anything to the vessel design.

The only reason we would do it is that the Code Case rules are a little different than the rules that we have in the design spec; and the Code Case rules are considered by a panel of experts and we want to -- that would be just a double check on our own criteria and design spec.

Q Were you, yourself, involved in the formulation of this case -- Code Case, by any chance?

A. Yes.

I worked with the task force which developed that Code Case.

Q Okay.

(Pause.)

Kind of a broad question here.

In your opinion, are we considering this issue too soon?

MR. COPELAND: Objection, Your Honor. That question is too vague.

I don't know what he means by too soon.

If he means that his contention shouldn't have been admitted, it seems to me that that is not a proper question for the witness to answer.

MR. DOHERTY: I couldn't hear all you said, Counsel. There's -- It is noisy, you know, particularly at the end.

MR. COPELAND: I don't understand why you're asking this witness a question as to why your contention should have been admitted.

JUDGE WOLFE: I think you can rephrase your questions.

I think I know where you're going; but I want the witness to know as well.

MR. DOHERTY: All right.

I'll rephrase.

BY MR. DOHERTY:

Q. In view of the fact that several of the loads have not been specified to you, do you believe that the contention can be fully dealt with at this time?

A. Yes.

I didn't think that the contention had anything to do with the load.

We're really talking about the criteria, once you have the loads, how do you treat them to show the adequacy of the containment vessel; and, you know, we can't do that before we have all the loads.

Q. All right.

Now, is the last part of your answer based on the idea that you've dealt with the most extreme load?

A. No. I'm saying that we can set up our criteria so that when we do have the load we know how we're going to design for it. That's what this criteria is all about.

Q. Okay.

(Pause.)

At the foot of Page 6, the last five lines, you do state, "The final consultants' report recommends this procedure" which is given above, "as a conservative approach."

Now, is that Nu Reg 0793 - Nu Reg CR -- pardon me, 0793, is that the ISE Final Report?

A. I don't remember the number. If you'll read the title to me, I'll tell you if it is or not.

Q. "Buckling Criteria and Application of Criteria tc Design of Steel Containment Shell".

A. Yes.

That's what we're talking about.

Q. Is that conclusion in this document?

A. Yes.

Q. Do you have the document with you, too?

A. I have it in by briefcase.

Q. Well, I could loan you mine if you want it.

(Document handed to the witness.)

Q. Can you find in that document where that statement is substantiated?

A. (Pause to look through document.)

Something to the effect on Page 4-10, down about two, four, six, seven, it says, ". . . for ten moderately long shells the circumferential buckle wave length is small. The results reported in 28 and 29 indicate relative insensitivity of critical magnum stress to consequential distribution of stress."

Now, that's for cylindrical shells with predominately circumferential stress states.

Is that correct?

A. Well, okay, I guess, yes we want to -- No. I know there is more on that. There is a little bit more specific . . .

(Pause.)

Well, I can't find that particular statement, although, I know there is something in there which is very clear.

But, on 4-10, Page 4-10, I think we can draw the same conclusion from the statements there. It says on one-third of the page down, it says, ". . . in 29, the maximum experimental pressure due to a quite variable wind-loading distribution, is experimentally about 40 percent than the critical uniform pressure."

So, all of that is saying, if you read that whole Paragraph 4.1.1.2, there are indications throughout that when you have a non-uniform load --

Q Yes.

A. -- loading, if you use -- if you use a uniform loading in its place, with the maximum value assumed all the way around. It is conservative.

Q. Okay.

Would you agree that was from Section 4.5.1.2?

A. I think that conclusion can be drawn from 4.5.1.2 --

Q. That is just correction.

I think you said 4.1.1.2.

A. Oh. I'm sorry. 4.5.1.2.

Q. Oh, okay.

What's the difference between an operating basis earthquake, and a safe shutdown earthquake?

A. Operating basis earthquake is that earthquake for which the plant has to be designed to operate and would keep operating when that happens. Whereas, with a safe shutdown, you just design for the safe shut-down of the vessel.

In other words, there is no requirement for the vessel to keep operating --

Q. I see.

A. -- after such an event.

Q. Okay.

I believe a while back, you mentioned knockdown factors.

A. Yes.

Q. What are those, please?

MR. COPELAND: Asked-and-answered, Your Honor.

He's explained what knockdown factors are.

MR. DOHERTY: Well, there is difficulty hearing back here. It was quite a while ago; and, I think, what he said was -- I think he alluded to them without defining them.

JUDGE WOLFE: I don't recollect.

Overruled.

The witness may answer.

THE WITNESS: Okay.

The knockdown factor is a factor to account for the differences between a perfect shell and an imperfect shell.

BY MR. DOHERTY:

Q. Is there much experimental evidence on the value of these knockdown factors?

A. Yes. There is quite a bit.

Q. Where is that evidence -- or, excuse me. Where is this experimental evidence from, please?

A. From various sources. There have been, I would say, literally hundreds of papers published over the years on the results of buckling tests all over the world practically.

(Pause.)

Q. Can you give me one source for that statement. One, perhaps, collection of literature; one bibliography on the experimental evidence for the value of the so-called knockdown factor?

A. You want one source?

Q. Yes. Where that would be available.

A. Well, here is a paper that Clarence Miller, he is with CVI, has published reporting the results of some experimental tests that he has performed.

And, at the end here he has a bibliography of some of other peoples work.

But, like I said, you know, there is hundreds of papers published.

Q. Can you give us the number of the CVI report that you're speaking of?

Does that have a report number?

A. Well, this is an ASCE publication --

Q. Yes. Sorry.

A. -- I don't have the date of the publication; but the paper was given at the ASCE Structural Engineering Conference in Madison, Wisconsin, August 22 through 25, 1976.

And, then, subsequently, it was published in the ASCE Journal.

Q. Okay.

(Pause.)

Do you know if the recommendations and final report of the group, I guess it's called ISE, I can't really think of their name right away -- International Structural Engineers.

Do you know, if their recommendations with regard to safety factors are accepted by the Commission, the NRC at this time?

A. No. I don't know if it has been accepted or not.

Q. I see.

Okay.

MR. DOHERTY: Your Honor, this concludes my cross-examination of this witness; and I appreciate his time and efforts with me this morning.

JUDGE WOLFE: Is there redirect, Mr. Copeland?

MR. COPELAND: Just one minute, Your Honor.

REDIRECT EXAMINATION

BY MR. COPELAND:

Q. Would you look at the top of page 4-16 of the Consultant's Final Report?

(Pause.)

A. Okay.

JUDGE WOLFE: Would you further identify that

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by number, Mr. Copeland?

Is that Nu-Reg CR-0793?

THE WITNESS: Yes.

MR. COPELAND: Yes.

BY MR. COPELAND:

Q Is the very top paragraph on Page 4-16, the source of your testimony, perhaps?

A. Yes. Yes. That was the statement we were looking for.

Q All right.

Thank you.

MR. COPELAND: That's all the questions I have, Your Honor.

JUDGE LINENBERGER: Mr. Copeland, excuse me; but you and the witness both know what you're talking about. Maybe we could read it into the record if it is not too long.

MR. COPELAND: It is not too long.

Would you read that statement into the record, Mr Mokhtarian?

THE WITNESS: Okay.

This is where we had in the document something to the effect that using this axissymmetric distribution would be conservative.

Okay. I am quoting now, "There are apparently "no experimental results for cylinders with varying circumferential stress other than the test results of 29.", reference 29. "The only conclusion that seems reasonable and conservative is that the critical uniforms of circumferential stress can be used as a measure of the critical maximum circumferential stress. This approximation is more conservative than using the critical uniform actual stress as a measure of critical maximum actual stress."

MR. COPELAND: Thank you.

That's all I have, Your Honor.

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5-12

(Bench Conference.)

JUDGE CHEATUM: Yes.

I have one question.

MR. DOHERTY: Mr. Chairman, purely procedureal; and I'm sorry to interrupt.

I get confused easily. But, we had redirect questions. Does Staff have any --

JUDGE WOLFE: No.

MR. DOHERTY: Oh. I'm sorry.

Pardon me, Dr. Cheatum.

JUDGE CHEATUM: You're pardoned.

BOARD EXAMINATION

BY JUDGE CHEATUM:

Q. You mentioned that in shipment of a shell plates to the site for assembling, something the 40 or 50 of these plates that were shipped. I was wondering: How thick are these plates.

A. The design we have right now calls for shell plates most of them one and one-half or one and three-quarter inches thick.

The shell plates themselves are one and one-half to one and three-quarter inches. Only local areas around openings and so on, they do get thicker than one and three-quarter inches.

Q. I didn't understand that

A. Well, where you have a -- Okay.

The vessel shell itself is all made up of one and one-half or one and three-quarter inch plates. Around opening or other attachments where you have concentrated loads or you have cut into the vessel shell, you do have a local area that could be thicker than that.

Q. Well, the implication of loads not yet finalized by EBASCO, so that your design can be complete, might be that these shelves might be thicker or they might made of different materials or changed material or what?

A. Well --

Q. What kind of changes might you visualize if you made the design once you have all the final loads?

A. Okay.

The changes would be in the number and the location of stiffeners.

The shell thickness would not change if you go over one and three-quarter inch shell, then you would have to postweld heat-treat them which would be almost impossible in the field. So, the shell thickness would not change the way that you would strengthen that containment vessel would be by adding additional stiffeners on it.

Q. Well, could you describe what these stiffeners might be like?

A. Okay.

The stiffeners would be either rings, which would wrap around the containment at certain intervals; or they could be, what we call, stringers which are vertical stiffeners which are up and down the shell at certain intervals.

Q. How thick would those be?

A. Those, again, would be limited to one and three-quarter inches.

They would be either one and one-half or one and three-quarter inches thick; and, then, the width would be varied. How wide they are would be a variable.

Q. Now, on the outside of this steel shell, I understand it would be poured concrete, concrete reinforced concrete or --

A. No, sir.

Not on this plant.

Q. Oh!

A. On this plant, it has been decided that all of the stiffening would be done by steel stiffeners.

Q. No biological container --

A. Oh. I'm sorry. There is a biological shield wall, but I thought you were talking about pouring concrete on the outside of the containment shell.

We don't have any concrete butting right against the containment itself. We don't have that.

But, there is a concrete shield building surrounding the containment vessel.

Q. I see.

And, there is no function of that concrete shield building that would add any strength to the shell because there is no contact?

A. That is correct.

JUDGE CHEATUM: That's all I have.

Thank you.

THE WITNESS: Yes, sir.

BY JUDGE LINENBERGER:

Q. While we're on the subject of stiffeners, after the final loads or stress values are given to you persumably from the Applicant through ABASCO, who makes the determination as to whether stiffeners will be needed. And, then, who makes the determination as to which types, how many and what placement the stiffeners would be used.

A. As the vessel designers, we would do that. Chicago Bridge and Iron would determine whether stiffeners are needed, and, then, what would be the best way of adding the stiffeners.

Q. You may have answered this question. I'm not sure. But, how many field erected containment structures has CBI accomplished built for nuclear power plants I'm talking about.

A. Containment vessels for nuclear.

Well, I know that we have built more than any one else in the world.

As far as the number, I would be, again guessing, but I would say something in the number of 30 or 40 containment vessels that we have built.

Q. In the field assembly process, what -- to whom does CB&I turn for the assembly welding of these plates into the containment building structure?

A. It is all done by CBI.

Q. You have your own welders?

A. Oh, yes. Oh, yes.

Q. Now, presumably, the weldment, at least I would suspect that the weldments are potentially a very critical part of the structure in terms of the strength of the shell, could it have been made from a single rolled sheet versus the shell as an assemblage of plates.

So, it seems to me that the way the welds are performed, treated and inspected must be extremely important to the final performance of the structure.

A. Yes.

Q. Therefore, when we talked throughout your -- When you have talked throughout your testimony here about the kinds of analytical things that are done, I say to myself, "Okay, this all sounds nice. But, suppose a few of the welders come to work with a hangover --

(Laughter.)

-- "isn't all this final analysis out the window?"

I would appreciate your commenting on that.

A. Okay.

It is a good question.

These vessels are built to the ASME Boiler and Pressure Vessel Code, and that Code has some very strict elaborate rules on how you make welds and how you control them and how you inspect them.

First of all, every welding procedure, every type of weld that you have on these containments, those procedures have to be qualified. Which means that you weld test pieces the same thickness, the same procedure; and you test those pieces and you make sure that the weld is as good as the material itself.

Every welder who works on these containment vessels has got to be qualified. He goes through a testing program and he has to pass a qualification test before he is allowed to do any welding.

So, these are all of the controls that you do before you even start welding. Then, after the welds are made every piece of weld are radiographically examined.

You take an x-ray of every foot of the weld on these containment vessels.

Q. You're saying a hundred percent radiographic inspection or x-ray inspection?

A. Yes.

The full penetration welds, which would be the main seams in the vessel are all one hundred percent radiographed. T.. surfaces are all magnetic particle tested.

So, there is quite a bit of examination of those we..s so that, you know, no problem has crept into the welding process.

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A. There are requirements on preheating of postweld heat-treating and by some of these controls you make sure that your welds are as good as your parent material?

Q. Are you saying that in this field erection process, the plates are either pre or post heat-treated or both?

A. When you weld them, you apply a preheat. Right.

But, whether you have to postweld heat-treat or not depends on the thickness; and the welds that you make in the field you usually keep your thicknesses to the limit so that you do not have to postweld heat-treat.

But, some of these l al framing around penetrations and so on where the thickness go beyond the one and three-quarter thicknesses inches, you do those in the shop and you postweld heat-treat them before you ship them to the field.

Q. How is the heat applied in the preweld --

A. Preheating.

Q. -- preheating application.

A. It is usually gas burners. They have a number of burners that directs a flame to the edges of the plates where they have to be welded and heats it up to a certain -- certain value specified by the Code.

Q. On Page 2, of your testimony, Line 25, you reference certain design specification requirements that are cited in a certain section of the ASME Code and a number is given there, "NA-3250".

What, basically, is the scope of that document? That NA-3250.

A. Okay.

That's a paragraph number. That Paragraph NA-3250 says that the owner or its agent would have to prepare a certified design specification which would be provided to the designer of the containment vessel.

In this case that design specification would be provided by a ABASCO and provided to CBI.

(Pause.)

Q. By the way, what is the -- What is the date of the ASME Code requirement?

Do you happen to know?

From which NA-3250 comes?

A. What is the date of it?

Q. Right.

A. Well, NA-3250 has been in the ASME Code for quite some time.

Q. Has it been updated recently?

A. That particular paragraph, I don't know if it has changed recently. I know that paragraph has been

Q. On Page 2, of your testimony, Line 25, you reference certain design specification requirements that are cited in a certain section of the ASME Code and a number is given there, "NA-3250".

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(Pause.)

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Do you happen to know?

From which NA-3250 comes?

A. What is the date of it?

Q. Right.

A. Well, NA-3250 has been in the ASME Code for quite some time.

Q. Has it been updated recently?

A. That particular paragraph, I don't know if it has changed recently. I know that paragraph has been in there for a while.

Now, the Code is updated every six months. Certain paragraphs are revised or certain things are added. But, as far as I remember, I don't think any revisions have been made to this particular paragraph for the past several years.

(Pause.)

Q. On Page 3, approximately the middle of the page, Line 14, there is a discussion of buckling criteria and it indicates that, "This criteria is based on the classical linear theory with reductions applied to account for imperfections in . . . geometry and other differences . . . ."

Do those reductions that you referred to in any way relate to geometry imperfections resulting from the fact that the vessel is made up of discrete plates rather than one huge rolled sheet?

A. Yes. The fact that the vessel is made up of a number of plates contributes to these imperfections.

But, again, I would like to point out that the ASME Code has some rules on how much imperfections they allow. So your out of roundness or imperfections can not excede some specified amounts.

Q. Should I infer from that that during the field assembly operation, you make a number of checks of out-of-roundness?

A. Oh, yes.

Q. And, does it ever happen that a plate that has been welded in place has to be cut out and redone or replaced because of geometrical nonadherence to specifications?

A. I can't think of any instances on containment vessels that we have had to cut things out.

Normally, you know, we take care when these things are going up so that we are aware of some of these tolerance limits; and I don't know of any problems we have had in meeting them.

But, you are right, we have to check them every once in a while and on the final completed vessel we have to go and take these measurements and put them on a drawing, which we call as-built drawing, so that they will all be documented and kept what the exact measurements of that vessel are.

Q. At Line 25, of Page 3, it stated that, "The loads, as specified for the Allens Creek vessel, are imposed on this mathematical model", etc.

I am just curious about the "as specified". Is this -- Are you referring to loads as specified by Houston Lighting & Power, or by EBASCO, or by who generates load specifications?

A. ABASCO. That certified design report that we talked about a few minutes ago. Really, one of its functions is to specify the loads and the loading combinations to us. And, ABASCO is doing that as the agents for HL&P.

(Pause.)

Q. Suppose these load specifications are given to you as -- and represented as final -- but, somewhere along the way somebody does some blow-down force analysis or something that says, "Well, gee, maybe there are some asymmetric loads that are a little larger than we thought. And, if this word gets to EBASCO and EBASCO and Houston Lighting & Power talk it over and they come back to CBI and say, 'Well, gee, you know, we now realize that under certain conditions we're going to have a 20 percent larger force in some direction, in some location".

How did -- What kind of flexibility is there to accommodate to that situation?

A. Well, this kind of a thing has happened before. And, I suspect it will happen again.

And, we have quite a bit of flexibility in accommodating it. For one thing, normally, you know, we have -- we don't really cut things that close. We have enough margins so that if the loads go up just a few percent, we can go back and look at the numbers and accomodate them without any change in the design.

But, if it did require any change to the design, again, you would accommodate it by adding stiffeners on the outside of the containment vessel.

Q Okay.

Now, sticking with that hypothetical for just a moment, let's say that -- Well, this is going to be an imprecise question: but, to illustrate a point.

It was determined somewhere along the way after you're fabricating the plates, that a higher stress must be accommodated, and you say you can -- One flexibility you have or option you have is to take care of this by adding stiffeners.

Now, conceptually, is or is not the kinds of safety factors you were discussing with Mr. Doherty earlier involved in this.

In other words, if you have a 20 percent increase in load and you are talking about, as you were ealier, a safety factor of 2.5, I could jump to the conclusion, "Well, 2.5 is an awful lot bigger than 1.2, so that 2.5 would accommodate it".

Now, is that the kind of process that goes on or not?

A. No. Normally, as far as I know, once the safety factor has been decided on and specified to us, the safety factor stays there.

But, the safety factor that is specified to us is a minimum value, like I said.

You know, in most cases we have much larger safety factors than that, but the minimal we would always keep.

Q. Okay.

Fine. Thank you.

By the way, what -- Has an alloy been specified yet for these plates?

A. You mean the material?

Q. The material.

A. Yes.

The material has been specified.

Q. Do you happen to know what it is?

A. It is SA-516, grade 70 --

Q. Seventy?

A. Grade 70, and that's very standard for use on containment vessels as far as I know. Just about all the containment vessels built in the last few years have been of that material.

Q. On Page 4, Lines 13 through 17, you talk about conservatism deriving from the consideration that the structure can withstand a dynamic load that exceeds critical stresses more readily than it can stand the static load that exceeds critical stresses.

When Mr. Doherty announced about that, you answered, I believe, solely on the b. is of the consideration of time at stress. Long term or static, short term or dynamic.

Now, does that answer assume that stresses are never high enough to reach the yield point or inelastic response part of the stress-strain curve or is it only true -- Or is it true for elastic and inelastic or linear, non-linear stress-strain relations.

In other words, is that statement generally true or only if you stay below the yield strength of the material?

A. Well. that statement is true when you talk about a buckling failure, as versus yielding failure.

Q. Okay.

Now, that -- So, this really must be restricted restricted to the buckling instability failure mode not the deformation failure mode.

Is that correct?

A. That's correct.

Yes.

Q. A couple of line later, the term linear bifurcation analyses is used.

I think I know what bifurcation means; but what in that analysis is being bifurcated?

A. Well, bifurcation analysis is just that term used as kind a buffing analysis. And, the term comes from the fact that if you plot the load versus deflection for the structure, there is a straight line which keeps going up. As the load goes up, the deflection goes up and then, normally, you know, it gets flattened out as you reach the inelastic region it will be just a typical strength here.

But, if the structure is thin enough, unstable enough, somewhere along that instead of the loads going up as the deflections increase, that curve starts dropping so you will have a fourth type of a figure. In other words, the elastic -- the stress strength here would tell you that this thing should be going up. The deflection -- or rather the load should be going up with the deflection. But, when it reaches that bifurcation point, then that structure has another path that it could take; and that path would be down. The load would drop down with increases in the deflection.

So, that's where the word "bifurcation" comes from. Two paths to follow then.

Q. At the bottom of Page 4 and the bottom of Page 5, there's a discussion of safety factor values

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and it is indicated that in the stress regime where material is behaving elastically rather than plastically, a safety factor on the order of, say, 2.5 I believe you list, is appropriate; and as stress increases and you get into the inelastic or plastic regime that a -- I thought I understood from this, that it was more appropriate to use a smaller safety factor.

Now, conceptually, I just don't understand why that makes sense. Because it seems to me that as the material leaves the elastic or leave the hook small regime, or whatever you want to call it, your approaching possible problems and why is one satisfied with a smaller safety factor there?

A. The reasoning there is that in the elastic region a buckling failure is a sudden failure. It could be a catastrophic failure without any warning once you reach that bifurcation point, it just, you know, the structure fails very suddenly.

But, once you get over the elastic limit, if you have a structure which can support stresses which are in the inelastic region, then the failure becomes more and more of a gradual thing until you reach yielding. And, if the structure is thick enough or stable enough so that i will yield before it would buckle, then it is a much more gradual type of a thing. It is not a catastrophic failure. You just get some large deformations but it doesn't fail catastrophically so you don't need as much safety factor for that kind of a failure.

(Pause.)

Q What maximum internal pressure is the -- a containment vessel such as Allens Creek stresse for or is it designed for?

A. What is the design pressure?

Q Well, let me not -- Let me try to reduce the ambiguities here.

There's containment pressure at normal operation, I guess.

There's containment pressure at peak pressure as a result of loss of a coolant accident.

So, I'm really asking what peak pressure is the vessel designed to accommodate?

MR. DOHERTY: Mr. Chairman, pardon the intrusion. I need to leave for about one second for a call of nature. And, I just want to do it -- I didn't want to interrupt this at all. I mean --

JUDGE WOLFE: We'll have a ten minute recess.

MR. DOHERTY: I'm sorry.

JUDGE WOLFE: It's all right.

(Whereupon, a brief recess was taken.)

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BY JUDGE LINENBERGER:

Q. Sir, I had put a question to you before the recess. I'm really only interested ... not in the precise value for Allens Creek, but a representative value for this kind of containment structure.

A. Okay.

The design pressure specified to us is 15 psi.

Q. All right.

Now, again, this is not for the purpose of recording on the record the specific pressure for Allens Creek, but I'm just interested in containment structure performance, phenomenologically.

15 psi ... now, I would presume that that is a pressure somewhat below -- represents a pressure somewhat below, or perhaps well below, the pressure that would generate a stress approaching the yield strength of the containment material. Is that true?

A. That's correct.

There is quite a bit of margin between this pressure and what would give you yielding -- general yielding of the material.

Q. Now, can you indicate approximately what that margin is ... if 15 psi is design, where would yield be approximately? I mean, a factor of two higher --

7-2

A. For yielding failure?

Q. I wasn't talking -- Well, now, maybe we need to define terms here. To me the yield stress is not necessarily the stress that results in failure.

A. That's correct.

Q. Okay. Now, I'm just talking about wnere you first reach the yield strength of the material.

A. I would say there is at least a factor of two.

Q. At least a factor of two?

A. Yes.

You know ... the factor of two is in ASME code limits. But it may be more than that.

Q. All right. That's the kind of thing I was interested in.

Okay. Now, 15 psi is design -- approximately a factor of two higher, and we're into or close to the yield strength regime.

Now, I would presume that to achieve vessel failure, you'd have to go considerably higher than the yield strength pressure. Is that correct?

A. That's correct, yes.

Q. And can you approximate that? Is this another factor of two, or a 50 percent increase, or what are we talking about?

7-3

A. Well, anything I say would be a guess because we really haven't done any analysis beyond the yield.

Q. From -- Do you have information from sample tests or coupon tests or pool tests or something that would give you some feeling for --

A. There are some test results on small models, but I don't have any numbers here that I could give you. I know that NRC has a testing program going on, to determine that value.

They are going to do some bursting experiments of fairly good sized models. Again, CBI is cooperating with that effort. But it's going to be a while before those tests are performed and results are available.

Q. Well, very qualitatively, if you're at a pressure that ... corresponding to stress from -- which puts the material in -- at -- into the yield regime, very qualitatively, are you -- with this alloy is one getting close to the ultimate failure regime; or is a considerably higher pressure required to --

A. No. J st this material is a very ductile material. There is quite a bit of margin between the yield and the ultimate strength of the material.

So again, when you get the yielding, you still have considerable margins left to failure.

-4

Q. All right.

That's the sort of thing I was interested in. Now, again, considering that the stress derives from an internal .ressure on the vessel and the kinds of failure we've just been talking about is -- I would classify in my ignorance -- a deformation failure, rather than a buckling failure under this circumstance. You just gradually build up pressure.

The vessel ultimately bursts. That's a failure from deformation. Is that the way you would characterize it, rather than buckling?

A. That's correct.

Q. All right.

Now, there's something I don't understand because the entire -- or most of the discussion with respect to this contention is addressed to the consideration of failure by buckling.

Now, I guess my problem is: I don't quite understand how it is that pressure buildup within the containment vessel can give rise to buckling.

A. That's a good question. I guess the pressure that you've been talking about ... that's a uniform internal pressure.

And if you have that, you are not -- obviously you are not going to get buckling because everything is going to be in tension.

Q. Okay.

Now, why is buckling --

A. But the buckling comes in where you have some of these non-symmetric loadings --

Well, not only they're non-symmetric, but the SRV, if you look at the time history of the pressure loading that's generated on the containment vessel, when you blow down one of these safety relief valve loadings, this bubble goes through an expansion and contraction type of thing, so it generates a kind of dynamic loading which gives you tension and then compression; in other words, internal pressure and then internal vacuum.

So that is one source of compressive stresses where this bubble is on the contracting mode, it actually pulls in the containment.

So that gives you compressive stresses in the shell.

But another source of compressive stresses, which would -- which could cause buckling is the fact that these pressures are not axisymmetric all of the way around.

In other words, you do have a load on one side of the vessel, which would give you an overturning load, so the vessel would tend to turn over. So on one side you would get compression; on the other side tension.

So you'd get an axial compressive load due to these SRV or local ... non-symmetry loads.

Q. So it's not just radial buckling that is of concern here, but the axial?

A. Right. We look at a combination of the two. That's where the interaction comes in. You have some hoop compressive stresses, and you also have axial compressive stresses.

And you combine the two to check your buckling.

Q. I infer from what you've said that the responsibility of your organization is that of taking certain load or stress specifications from the Applicant or EBASCO as givens and determining what kind of vessel to build for them to meet these.

In other words, I infer from the discussion we've gone on that Chicago Bridge & Iron does not look behind a question such as -- well, given a loss-of-coolant accident, is 15 psi really a reasonable pressure, or ought it to be 18.3?

Do you or do you not get into that?

A. We do not.

Q. All right.

Still on page five, the paragraph beginning at line six indicates that the design of the containment vessel will meet the requirements of ASME Code Case N-284.

As you understand it, whose responsibility is i^ to assure that the design will meet that Code -- the requirements of that Code case?

A. It's ours. EBASCO would specify that. That would be in the design specifications. The design specifications would spell out what rules we are to meet, and then it would be our responsibility to make sure that we do that.

Q. Okay.

On page six, I refer you to the paragraph beginning at Line 11, beginning with the third sentence in that paragraph -- well, there are four sentences there, each of which express certain activities in the future tense.

At Line 15 it says: "This concern will be conservatively accounted for."

At Line 17 it says: "The ... dynamic loadings will be applied to a mathematical model ...."

Line 20: "A shells of revolution program having dynamic analysis capabilities will be used."

There are a whole bunch of "will be dones" here. Approximately where do we stand in time right now with respect to these things that will be done?

To say it another way: How far in the future are we from getting to those things that you indicate there will be done?

A. Well, some of those "will be dones" have been done.

It's really an ongoing type of a thing, even if the loads aren't finalized ... you know, with whatever loads you've had so far. We've been doing some of these things.

Like I say, the design of one of these containment vessels is an interactive type thing. It's not something that you just assume a design and just run through it and say, "Well, fine, everything works out."

You have to assume a design. Then you go through, and the chances are that ... you know, you have a problem with one thing or another; and then you revise it; and you go through the whole procedure again.

So it takes quite a number of tries before you zero in on a containment vessel that would meet the various design requirements.

So we've been doing some of that with the preliminary loads that we've had so far ... to just get a feel for what this vessel should look like.

Q. Okay.

At the top of page seven in the paragraph

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beginning at line four, you talk about classical buckling values being reduced by knockdown and plasticity reduction factors.

And you indicated earlier to Mr. Doherty that wha you call knockdown factors here reflect the factor that the actual vessel is an imperfect representation of a mathematical cylinder (if you will).

Again, even if you attempted to build a cylinder out f a single piece of sheet steel, you would have something less than the mathematically perfect cylinder.

But here we have not that. We have something made out of plate.

Do these knockdown factors accommodate the consideration that the vessel is made of welded discrete pieces?

A. Yes, they do. Like I said, the ASME code has some limits on some of these imperfections.

And I guess the test results that you would look at in the buckling -- Imperfections are a very significant thing.

So any time you look at a set of test data, the first question you ask is: Well, show me how perfect that model was and how much imperfections you had in it.

And then the knockdown factors that you pick

7-10

reflect those models, which were representative of the tolerances permitted by the ASME code.

You know, you do take that fact into account.

Q. Is there a body of test information that in any way allows one to assess the adequacy of these knockdown factors? You can, I'm sure, arrive at certain factors by theoretical considerations.

But are there any test results or -- I don't know what ... vessel failure experience, or what have you, that lends confidence to the knockdown factors that are being used?

Or do you just say, "Well, we trust in ASME, and they won't let us down"?

A. Well, no, you have to have, of course, the test results. But what gives you a little confidence is that the results of those tests translated into these knockdown factors have been used for many, many years.

Chicago Bridge & Iron has built -- I don't know how many thousands of structures which are very similar to containment. We use the same kind of a buckling criteria and the same kind of a knockdown factor on all kinds of steel structures.

And the experience has been that those result in very safe structures. The same kind of a thing has been used on aircraft structures ... the same kind of a knockdown factor based on test results have been used on aircraft structures ... all kinds of seamed structures.

So there is quite a bit of experience involved with using some of these knockdown factors.

Q. Well, then, at line eight on page seven, where you say these factors conservatively account for the difference between theory and real life (if you will), what is your basis for saying that there is conservatism?

A. The basis for that is that normally you would use a lower bound of the test results to come up with your knockdown factors. In other words, you plot up all the test results, and then where you draw the line would be generally on the lower bound of those test results.

So you're bringing in a little additional conservatism there.

Q. At Line 24 of the same page, there is a qualitative description of evaluation methods. And the statement is made: "Applicant does not intend to perform any buckling evaluation for the Allens Creek vessel using either of the other two methods permitted."

How do you know that to be true?

A. That there's no intention of using the other two methods?

Q. Right.

A. Basically because right now I'm in charge of the design and analysis of that containment, and I know what I'm going to do.

Q. I see. All right. Very good.

So in this case it's not really Applicant's doing; it is CBI?

A. Yes. That would be up to CBI again to decide the method of the analysis and evaluation.

Q. Okay, fine.

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JUDGE CHEATUM: Why didn't you say, "I don't intend to"?

(Laughter.)

JUDGE CHEATUM: -- rather than "Applicant does not intend to."

JUDGE LINENBERGER: That's all I have, Mr. Chairman. Thank you, sir.

JUDGE WOLFE: Does Staff have cross on Board questions?

MR. SOHINKI: I just have one question, I believe, Mr. Chairman.

RECROSS-EXAMINATION

BY MR. SOHINKI:

Q. Mr. Mokhtarian, Mr. Linenberger was just questioning you with regard to this paragraph on Page 7 which indicates which approach the Applicant is going to follow in performing the buckling analysis.

You testified previously that a safety factor of two was deemed adequate by the consultants that are referred to in that paragraph, assuming that you use a certain approach.

When you said a certain approach, did you refer to the approach that's referred to in your testimony? In other words --

A. Yes.

Q -- are you using the approach which the consultant recommends?

A Yes, we are.

MR. SOHINKI: Thank you. That's all I have.

JUDGE WOLFE: Mr. Doherty.

RECROSS-EXAMINATION

BY MR. DOHERTY:

Q Mr. Mokhtarian, I think a moment ago in reply to a question of Dr. Cheatum, he asked you about the knockdown factor and some of the evidence and some of the experience with it and how it's -- and its adequacy of calculation.

MR. DOHERTY: I'd like to approach the witness, Your Honor, and show him a letter.

JUDGE WOLFE: All right.

MR. DOHERTY: Your Honor, this is a letter from Mr. Zenon Zudans, who is -- calls himself Senior Vice-President for Engineering of the Franklin Research Center, a Division of Franklin Institute, that's addressed to a Mr. L. Igne, I-g-n-e, Advisory Committee on Reactor Safeguards, dated April 25, 1980.

It's a three-page letter.

I'd like the witness to read about ten pages of this letter -- I'm sorry, ten lines.

It's between here and here [indicating] on this page, sir, page two.

MR. COPELAND Well, I'm going to object until the witness has identified the letter and states that he's familiar with the letter and can vouch for its authenticity.

JUDGE WOLFE: You'll have to lay some foundation to establish the awareness of this witness as to the preparer of the letter.

BY MR. DOHERTY:

Q. Mr. Mokhtarian, are you aware in your experience of Mr. Zenon Zudans? Is he a person in this area?

A. I have heard his name, yes.

Q. Have you ever seen this letter?

A. No, I have not.

Q. Have you ever had any experience with M. L. Igne of the ACRS?

A. No, I have not.

Q. I see.

Would you read the ten lines that I've pointed out to you, please, starting in the middle of the page --

MR. COPELAND: I again object, Your Honor. The witness is not familiar with the letter. He said he didn't know anything about the letter, and I don't see

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how his testimony can be impeached by a letter written by somebody else.

JUDGE WOLFE: You have an objection then to any questioning along these lines?

MR. COPELAND: Yes, I do. Or any questioning off of that letter. He didn't write the letter. He has never seen the letter.

JUDGE WOLFE: Mr. Doherty.

MR. DOHERTY: Well, Mr. Copeland has correctly stated that the gentleman has not identified the letter.

I would urge that the letter, though, is relevant to the question of knockdown factors to the question that this -- excuse me -- that Judge Linenberger has raised with regard to the adequacy of knowing what these knockdown factors really are and how to deal with them safely.

I, therefore, urge that this reading be permitted to go into the record.

JUDGE WOLFE: I'll have to sustain the objection. There has been no -- This witness is not aware of the preparer of the letter. The letter itself has not been authenticated.

Any cross-examination based on that letter is precluded.

MR. DOHERTY: Well, he did state -- unless I'm

7-17

mistaken -- that he was aware of Mr. Zudans, the preparer or the writer of the letter -- that --

THE WITNESS: I've heard of the name of Mr. Zudans.

JUDGE WOLFE: Well, that's not sufficient to cross the evidentiary hurdle. You simply haven't laid the proper foundation for any further questions.

MR. DOHERTY: I'm going to take this from you, Mr. Mokhtarian.

THE WITNESS: Okay.

JUDGE WOLFE: Was there a date on that letter?

MR. DOHERTY: April 25, 1980.

BY MR. DOHERTY:

Q. Okay. I wanted to ask you one question with regard to one of Dr. Cheatum's questions. Now, would any stiffening be done by placing some type of ... oh, strut or something like that, within a steel shell cylinder across --

A. Inside?

Q. Inside.

A. No, sir. No, you couldn't. Inside of that cylinder is pretty crowded.

Q. Okay.

Now, we also spoke about field-directed welding, I guess, and field-directed assemblage of the containment.

7-18

What are the problems involved in doing that type of assemblage? What are the chief problems?

A. I don't know of any problems. In fact, the only limitation you have is that if you exceed those thicknesses, which would exempt you from post-weld heat treatment, you would have a problem performing that in the field.

?

You would also need a big huge furnace in the field.

So you just keep the thicknesses to the limits which would not require post-weld treatment. Other than that, I don't know of any problems with welding these in the field.

Q. All right.

What is meant -- in reply to a question -- again, these are all from Judge Linenberger from now on.

You spoke about the welding. You spoke about 100 percent radiographing, and then you mentioned magnetic particle testing.

What's that, please?

A. It's surface examination which would indicate whether there are any surface imperfections in the weld or not, which may cause cracking. You sprinkle particles -- steel particles there and you generate a magnetic field

7-19
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in there.

And the way those little particles form, if there is a crack or discontinuity or something, it would indicate that there is such a thing; and then you would grind that out.

Q. Is this similar to the Klidenning figure ... this kind of thing, where you can look at the particles and see how they line up?

A. -- how they are formed, right.

Q. Okay.

A. It will tell you if there's a discontinuity.

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BY MR. DOHERTY:

Q. Now, on page three, line 25, Judge Linenberger had a question with regard to the margins of safety, I believe, if the load requirements are changed, due to subsequent discoveries, I guess.

And you stated we have margins if the loads go up a few percent.

Now, did that mean that you had a margin without stiffeners?

A. No, we have stiffeners now. We already do have stiffeners.

Q. Is it then that in order to accommodate changes in load -- upward changes in load, stiffeners will have to be used?

A. Additional. Maybe I should have said additional stiffeners would have to be used. We already know from the preliminary work we've done that we are going to have stiffeners.

But the number of the stiffeners, the size of the stiffeners and the location of the stiffeners can be adjusted to accommodate the final loads.

Q. Is this true: The margin is the stiffeners at this point? It's created by the stiffeners?

A. Well, yes, if the stiffeners weren't there, you wouldn't be able to meet safety factors.

8-2

Is that what you're asking?

Q I think this is going to look unclear. Can you accommodate any increase in load at this time without doing more stiffening?

A Well, right now we don't have a final design and we don't have a final set of loads.

We've just done some preliminary work ... enough to know what that containment vessel is going to look like.

But we don't have any final numbers that I could tell you how much margin we have ... if that's what you're asking.

Q Well, I'm not going to repeat. I can't seem to think of another way to ask that. I still feel we're a little bit apart.

Okay. Now, Judge Linenberger asked you what maximum internal pressure the containment is designed for.

Now, is one of the loads that you have to design for a hydrogen explosion load?

A. Not right now there's no such design.

Q Do you expect one to be given you yet?

A. I have no idea whether there will be one or not.

Q Has there ever been one ... one hydrogen

8-3

explosion load given you for any BWR shell?

A. Not for design. In a couple of instances, we've had to do a little study, but nothing as a design basis, no.

Q. Okay. Did those studies indicate that the internal pressure load from a hydrogen explosion would have exceeded the maximum internal pressure load that the containment was designed for?

A. Well, the studies that we've done has been -- we didn't have any values. We had to come up with an ultimate value ... the same kind of a thing ... that I was asked -- what is an ultimate value -- ultimate failure value for this containment vessel.

And we have determined that value for a couple of BWR vessels and given it to the owner. But we did not have a value to use to determine whether that would cause failure or not.

The question to us was: What is the ultimate pressure for the containment vessel?

Q. So you could do no comparisons, is that correct, between that value which you found and the values that you have?

A. That's correct. Those were different designs.

Q. I think you mentioned that on knockdown factors -- you mentioned the aircraft industry. Do they use the Staggs Code for that type of calculation? Do you know?

A. Well, I know the Staggs Code has been used, but that doesn't have anything to do with the knockdown factor.

Q. Well, if it doesn't, let's not go any further with that.

MR. DOHERTY: All right. Thank you, Your Honor.

JUDGE WOLFE: Yes, Judge, another question.

FURTHER BOARD EXAMINATION

BY JUDGE LINENBERGER:

Q. I should have thought of this earlier. I want to stay away from any proprietary considerations, but I'm interested in the contractual relationship that exists between -- with CBI for the fabrication and erection of this vessel.

In the first place, is your contract with EBASCO o- with the Applicant?

A With the Applicant, HL&P.

Q. All right, sir.

Now then, let me just lay it right out as a potential safety concern that I would have. Let's postulate a situation in which design loads and stresses have been pretty well specified and fabrication of plates is 80 percent complete. And approval comes down from someplace that says, "Well, you really ought to be considering 20 percent larger stresses ... larger loads."

And somebody at CBI says, "Well, my gosh, we're not making an awful lot on this job as it is; and to go back through and plug in an accommodation for a 20 percent in the load is going to put us in a loss position. To heck with it, we'll blow it through."

Now, maybe you're not in a position to comment on this kind of thing. And if so, I don't want you to speculate.

But what -- if you know, and don't guess -- if you know, what is it about the relationship between CBI and the Applicant that precludes that kind of thing from happening?

A. The way we contract for these containment vessels, we recognize that things change. And sometimes they change very significantly.

So our contract is based on a base set of loads. At the time of the contracting they give us their best estimate of what the loads are.

We come up with an estimated design. And we document that in the contract. And we say, "Based on this design of the containment vessel, this is the price."

Now, if the loads change or the rules change, or anything changes which would require a re-design or additions to that contract, those would be negotiated.

In other words, if the loads go up and we're going to have to put 20 percent more stiffeners on that containment vessel, then what we have contracted for, we would get paid for that. It doesn't come out of our pocket.

JUDGE WOLFE: In other words, there's a change order provision in the contract?

THE WITNESS: Yes, sir, very definitely.

JUDGE LINENBERGER: Okay, fine, thank you.

JUDGE WOLFE: Any questions in light of Judge Linenberger's additional questions?

MR. DOHERTY: No, sir.

MR. SOHINKI: No.

JUDGE WOLFE: Is there redirect, Mr. Copeland?

MR. COPELAND: No, Your Honor.

JUDGE WOLFE: Is the witness to be permanently excused?

MR. COPELAND: Yes.

JUDGE WOLFE: The witness is permanently excused.

(The witness was excused.)

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JUDGE WOLFE: We will recess until 2:20.

(Whereupon, at 1:00 p.m. the hearing was recessed, to reconvene at 2:00 p.m. of the same day.)

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ACNGS -1 bm

AFTERNOON SESSION

2:00 p.m.

JUDGE WOLFE: All right.

This afternoon we have in attendance Mr. Copeland for Applicant; Mr. Sohinki and Mr. Dewey for Staff; and Mr. Doherty.

Mr. Dewey, I believe you wish to call a witness.

MR. SOHINKI: I think you meant Mr. Culp.

JUDGE WOLFE: Excuse me. Mr. Culp, yes.

MR. CULP: Your Honor, we would like to call Diran Simpadyan.

JUDGE WOLFE: All right. Would you remain standing, and raise your right hand.

Whereupon,

DIRAN T. SIMPADYAN

was called as a witness herein, and having been first duly sworn, was examined and testified as follows:

JUDGE WOLFE: Please be seated.

DIRECT EXAMINATION

BY MR. CULP:

Q Mr. Simpadyan, do you have before you a document entitled "Direct Testimony of Diran T. Simpadyan on Behalf of Houston Lighting & Power Co. on Doherty Contention 27 - Reactor Pedestal," which consists of a

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document of five pages with a three-page attachment, which contains your professional qualifications?

A. I do.

Q. Was this testimony prepared by you or under your supervision?

A. Yes.

Q. Do you have any corrections or additions to the testimony?

A. I have a few minor typographical errors to correct.

On page five, line ten, there was a "t" left out in the word "structure," in the spelling.

Q. Okay. Do you have any others?

A. On page one of the exhibit, on line 14, "MBS" should be an "A".

And the spelling of "Fairleigh," F-a-i-r.

And on line 15, the word should be "Elasticity," not "Electricity."

JUDGE CHEATUM: What line was that?

THE WITNESS: Fifteen.

BY MR. CULP:

Q. Are there any other corrections?

A. No.

Q. With those corrections that you have given us, do you adopt this testimony as your testimony in this proceeding?

A. Yes.

MR. CULP: Your Honor, I move that the testimony of Diran Simpadyan on Doherty Contention 27 be placed in the record as if read.

JUDGE WOLFE: Any voir dire or objections, Mr. Sohinki?

MR. SOHINKI: No, sir.

JUDGE WOLFE: Any voir dire or objections, Mr. Doherty?

MR. DOHERTY: Yes, Your Honor.

VOIR DIRE

BY MR. DOHERTY:

Q. Mr. Simpadyan, are you being paid for this testimony you're going to give today?

A. I get my regular paycheck from EBASCO as if I worked there, yes.

Q. I see.

Now, is EBASCO a subsidiary of any other company?

A. It's a subsidiary of ENSERCH.

Q. Of what?

A. ENSERCH.

Q. All right.

JUDGE LINENBERGER: Could we have the spelling of that, please?

THE WITNESS: E-N-S-E-R-C-H.

BY MR. DOHERTY:

Q. What other companies are subsidiaries of ENSERCH?

A. I wouldn't know.

Q. Okay.

Do you know approximately what percentage of ENSERCH EBASCO is?

A. No.

Q. Okay.

Have you ever testified before an Atomic Safety and Licensing Board?

A. No.

Q. Okay.

Now, looking at your education and professional qualifications, I had a few questions. One of them was down around line 21. You state you are Senior Civil Engineer.

Do you supervise other engineers in that capacity?

A. Yes.

Q. How many?

A. There is no set number. I supervise the people who do the design. There's no direct number of

9-5

employees that I supervise.

Q. Now, what type of responsibilities do you have when you review drawings for some of these structures that you mentioned on Line 24? What's expected of you when you do that?

A. I review for constructability to see that they are -- that they meet the intent of the design criteria and, of course, that they're applicable.

And ...

Q. All right.

Do you do any procurement work?

A. Yes.

Q. Now, you spoke on Line 25 of the containment vessel. I want to get this straight and make sure we're all the same here.

Is that a reactor vessel?

A. No. That's the containment vessel. It's different from the reactor vessel.

Q. Okay.

A. It would be comparable to the containment vessel that CB&I is designing.

Q. Yes, okay.

Now, you spoke about the biological shield wall and you work on that. Is that a concrete --

A. No, it is a steel structure which is filled with concrete.

Q. Have you studied concrete technology in your college courses or your graduate courses?

A. Yes, I have.

Q. I see.

Did you prepare any of the PSAR for the Allens Creek Nuclear Plant?

A. Not directly. I was involved in some of the amendments, yes.

Q. Did you prepare any responses to the NRC's questions for the Allens Creek plant?

A. Not that I can remember ... of any.

Q. Did you prepare any of the Containment Systems Design Report?

A. No.

Q. How long have you been working on the Allens Creek Nuclear Plant Project?

A. Three years.

Q. Have you worked on any other BWR-3?

A. No.

Q. Have you worked on any other BWR?

A. No.

Q. Do any of the responsibilities that you've listed on page two of your education and professional qualifications require the use of concrete specifications?

A. Not the ones listed there, no.

Q. Now, in your prior experience, why did you leave Sanderson and Porter Company?

A. I was offered a better position with EBASCO.

Q. Okay.

What year was that?

A. 1974.

Q. Do you remember what month?

A. May.

Q. All right.

Then why did you leave from Hardesty and Hanover? That's at the foot of page two. Why did you leave them?

A. I wanted to get out of the -- into the nuclear field and the power plant business.

Q. Would you say that again, please? I didn't hear you very clearly.

A. I wanted to get away from highway design and bridge design.

Q. And what year was that and what month, do you recall?

A. 1970, I don't recall what month it was.

Q. 1970?

A. Yes.

Q. Okay. Why did you leave Brown Engineers?

A. Basically, I went back to school to get my Master's degree.

Q. And that was in 1968?

A. Yes.

Q. Have you any publications in any professional jo nals?

A. No. As part of my Master's thesis, I did some research work, but I don't have publications.

Q. Okay.

Now, looking at your education, at the University of Wyoming, you have BSCE and MSCE. Is that chemical engineering?

A. No, that's civil engineering.

Q. That's civil. Okay.

And what did you take in the way of concrete technology in those programs?

A. We had reinforced concrete design, advanced reinforced concrete design.

Q. All right.

How many semester hours would that come to? Do you recall?

A. About 12.

Q. Okay.

MR. DOHERTY: Okay. I don't have any other questions, Your Honor.

JUDGE WOLFE: Any objection to the testimony?

MR. DOHERTY: No, sir.

JUDGE WOLFE: All right. The direct testimony of Diran T. Simpadyan, inclusive of his qualifications, is incorporated into the record as if read.

(See attached pages.)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)
)
HOUSTON LIGHTING & POWER COMPANY) Docket No. 50-466
)
(Allens Creek Nuclear Generating)
Station, Unit No. 1))
)

DIRECT TESTIMONY OF DIRAN T. SIMPADYAN ON BEHALF OF HOUSTON LIGHTING & POWER CO. ON DOHERTY CONTENTION 27 - REACTOR PEDESTAL

Q. Please state your name and occupation.

A. My name is Diran T. Simpadyan. My business address is 160 Chubb Avenue, Lyndhurst, New Jersey. I am the civil engineer for the Reactor Pressure Vessel (RPV) pedestal design for Ebasco Services, Inc.

Q. Please describe your educational background, and professional qualifications.

A. A statement of my education and professional qualifications is attached to this testimony as Exhibit DTS-1.

Q. What is the purpose of your testimony?

A. The purpose of this testimony is to address Doherty Contention 27 which alleges that:

> The pedestal concrete of ACNGS may be weakened by the heat from a power excursion accident (PEA) or loss of coolant accident (LOCA) such that restart and operation of the reactor would endanger Intervenor's health and safety through subsequent reactor movement due to the original thermal damage to the pedestal.

Q. Briefly describe the purpose of the reactor pedestal.

A. The reactor pedestal is used to provide support for the reactor vessel throughout normal plant operation and postulated accident conditions. The reactor pedestal also provides support for the reactor biological shield wall.

Q. What are the physical characteristics of the reactor pedestal?

A. The reactor vessel pedestal will consist of two concentric steel cylinders having diameters of approximately 20 and 32 feet respectively. The annular space between the cylinders will be filled with ordinary non-reinforced concrete. This concrete will have a density of 140 pcf and does not have a load bearing function.

A continuous steel plate ring will be provided at the top of the pedestal; the cylinders will be anchored to the concrete mat at the bottom. The free standing RPV will be anchored to the pedestal by bolting the RPV support skirt to the top pedestal ring. The biological shield wall will also be supported on the RPV pedestal. Vertical and horizontal stiffeners will be provided throughout the height of the pedestal for joining the two concentric steel cylinders. All loads imposed on the pedestal will be resisted by the pedestal steel structure, i.e., the two concentric steel cylinders and associated vertical and horizontal stiffeners. Heavy stiffeners will be installed at the large rectangular openings necessary for control rod drive mechanism operation, maintenance and removal.

The outline of the pedestal embedment details are shown on ACNGS PSAR Figure 3.8-3. An outline of the pedestal structure is shown on ACNGS PSAR Figure 3.8-5.

Q. What loads are the reactor pedestal designed to withstand?

A. The ACNGS reactor steel pedestal is designed to withstand load and load combinations including heat resulting from a design basis accident as specified in PSAR section 3.8.3.3.1(b) and 3.8.3.3.2(b) respectively.

Q. Why is concrete used to fill the area between the two concentric steel cylinders of the reactor pedestal?

A. The primary purpose of the steel pedestal is to support the reactor. The concrete of the reactor pedestal provides no structural support for the reactor vessel. The fill concrete is used to add mass to the pedestal in order to obtain dynamic response of the structure within the frequency envelope for which the reactor is designed. Concrete fill also provides additional shielding.

Q. What would happen if the reactor pedestal concrete were to crack?

A. All postulated loads will remain the same. No structural support credit is taken for the presence of the concrete filler material nor will cracking of the concrete create any safety hazards.

Q. In his contention, Intervenor cites three events, one which he states occurred at Dresden Units II and III; one at the SL-1 reactor and the third at TMI 2. Please comment on the relevance of these three events to the ACNGS design.

A. In his contention the Intervenor alleges that the incidents at Dresden Units II and III in 1971 and the government experimental reactor SL-1 in 1961 damaged the reactor pedestals and that the ACNGS reactor pedestal could be similarly damaged.

The Intervenor draws upon sources of information identified in his contention. These sources include the testimony of three GE engineers before the Joint Committee on Atomic Energy in 1976 for the Dresden incident and an article found in volume 1 of the Technology of Nuclear Reactor Safety regarding SL-1. These sources of information have been reviewed and show that these incidents are not applicable to ACNGS.

The SL-1 incident involved a government stationary, low power test reactor. The dissimilarities between the support arrangement of this reactor and ACNGS make a design comparison pointless. Furthermore, the source of information quoted by the Intervenor does not state that damage occurred to the reactor support nor does it imply that reactor support failure contributed in any way to the accident. The testimony of the GE engineers regarding Dresden Units II and III states that the station utilizes a basic reinforced concrete pedestal. As previously discussed, ACNGS utilizes a steel pedestal. It should also be noted that during their testimony, the GE engineers only stated that weakening of the Dresden pedestal "may already have occurred." Subsequent investigations, including those by the NRC, have failed to support their allegations.

Regarding the accident at TMI 2 in 1979, Intervenor has failed to identify a source of information. TMI 2 is a PWR and is supported by a reinforced concrete foundation. ACNGS is a BWR and utilizes a steel reactor pedestal support arrangment. This steel reactor pedestal is of a different design than the TMI 2 reactor support and as previously stated, the ACNGS pedestal is designed to withstand design basis accident conditions.

Q. What are your conclusions concerning this contention?

A. The ACNGS reactor pedestal is not a concrete strucure as implied in the contention. Since the concrete fill has no load bearing function, any postulated weakening of the concrete is not relevant to the structural integrity of the reactor pedestal.

Exhibit DTS-1

EDUCATION AND PROFESSIONAL QUALIFICATIONS

DIRAN T. SIMPADYAN

SUMMARY OF EXPERIENCE (Since 1968)

Total Experience - 13 years of Civil Engineering experience consisting of structural analysis and design of Fossil and Nuclear Power Plants, highways and research in foundation engineering.

Major Field of Interest -	Structural analysis and design of electric generating stations with special emphasis on heavy steel structures.
Education -	BSCE-University of Wyoming, 1968 MSCE-University of Wyoming, 1970 MBS-Farleigh Dickinson University, 1978
Advance Courses -	Theory of Electricity Theory of Plates and Shells
Licensed -	Registered Professional Engineer - New York and New Jersey

EBASCO EXPERIENCE (Since 1974)

Civil Engineer (7 years)

Senior Civil Engineer responsible for the structural analysis and design of PWR and BWR type nuclear power plants including establishing design criteria, supervision of design and reviewing drawings for the fuel handling building, turbine building and reactor containment structures such as the containment vessel, reactor pedestal, biological shield wall, pipe restraint structures and platforms; preparation and review of PSAR; preparation of responses to NRC questions. Responsibilities in the procurement area consist of preparation and review of specifications, evaluation of bids and making recommendations for awarding contracts and change orders for the containment vessel, structural steel, polar crane, fuel handling crane, pool liners, tanks and special doors.

PRIOR EXPERIENCE (6 years)

Sanderson and Porter Inc. New York: Senior Design Engineer

Responsible for checking the structural analysis, design calculations and drawings for the turbine building, precipitators and miscellaneous structures, resolve interface problems and details for additions to existing structures for the Milton R. Young Station, Minnkota Power Company.

Foster Wheeling Corp., New Jersey: Senior Design Engineer

Responsible for the structural analysis and design of boiler supporting structures and associated components for power plants including heavy steel framing, pipe hangers, flues and ducts, preparation of framing plans, basis and connections. Representative projects include Central Illinois Public Service Co., Public Service of New Mexico and the power companies for Abono and Puentes in Spain.

Frederic R. Harris Inc., New Jersey: Civil Engineer

Responsible for the design of retaining walls and foundations for highway bridges including drainage facilities and construction scheduling for the extension of the Garden State Parkway.

Hardesty & Hanover, New York: Engineer

Responsible for the preliminary design of a vertical lift bridge by the orthotropic deck, steel plate deck and composite design methods including the tower structures and preparation of the cost comparison.

University of Wyoming, CE Department: Research Assistant

Engaged in experimental research related to the stress distribution under footings.

Brown Engineers, New Jersey: Engineer

Engaged in design and layout of highways.

JUDGE LINENBERGER: Mr. Chairman, a very minor typo here on page two of the attachment, line 14. Shouldn't that be "Foster Wheeler"?

THE WITNESS: That is correct.

JUDGE LINENBERGER: Okay.

JUDGF WOLFE: With that correction, is there cross-examination, Mr. Sohinki?

MR. SOHINKI: I prefer to go last, if that meets with the Board's approval.

JUDGE WOLFE: Well, we have been proceeding with Staff following Applicant. Is there some particular reason why you wish to go last on this particular contention?

MR. SOHINKI: No, I was referring to that as a general approach. But if that is the approach that the Board has been following up till now, I'm willing to --

JUDGE WOLFE: Yes. Do you have --

MR. SOHINKI: I don't have any questions at this time.

JUDGE WOLFE: Mr. Doherty.

CROSS-EXAMINATION

BY MR. DOHERTY:

Q. Mr. Simpadyan, to your knowledge, are the pedestals of all boiling water reactors concrete filled?

A. No, they are not. To my knowledge, all of the

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pedestals of BWR's are not made of steel either.

Q. Well, then, do some of them have an empty space essentially?

A. Well --

Q. Let me ask this: Are they all constructed with this concentric circle or concentric rings kind of ... type of pedestal made of steel, as described by the Applicant?

A. No, they are not.

Q. I see.

Is the design for the pedestal proposed by Applicant unique?

A. No, it is not. There are other designs which use the concentric steel cylinders with the concrete in them. It's not a unique design.

But there are other types of design, such as reinforced concrete pedestals without the use of the steel structure.

Q. I see.

Are you familiar with the construction of pedestals of any other nuclear power plants right now?

A. No, I'm not.

How do you mean that? I've looked at what other A's have done in their design, if that's what you're referring to. But I personally haven't designed

9-12

other pedestals.

Q. Yes, okay.

Now, in looking at those others, what did you find with regard to pedestals? Were those pedestals similar to this or not?

A. There are ones that do have similar pedestals.

Q. Uh-huh.

Were any of these large boiling water reactors? Do you recall?

A. Yes.

Q. Okay.

Can you give me an estimate of the total weight placed on the pedestal by the reactor and the biological shield wall?

A. When full of water, the reactor would be about 4000 kips, and the biological shield wall would be almost that much ... with -- filled with concrete.

Q. Okay.

I think you said four thousand and then a word that followed that I didn't understand.

A. A unit -- Kips is a unit that refers to a thousand pounds.

Q. So it's four thousand thousand pounds?

A. Right.

Q. All right. Now, I also mentioned -- I'm not certain about what you said about shield wall. Did you give a number for that too?

A. It is alsc about 4000, and approximately 4000 kips.

Q. They've got a new unit going, I guess.

Now, in your testimony on Page 2, you state, "The annular space between the cylinders will be filled with ordinary non-reinforced concrete."

Now, is this the kind of concrete that you would find being used in street construction?

(Pause.)

A. It wouldn't be found in street construction. It's the exact -- this has a density of 140 pounds per cubic foot.

So, it doesn't have the heavy aggragate that you would find in street concrete that is used in street construction.

That's going to be a much more flowable concrete.

But, the ingredients, except for the course aggragate, would be the same.

Q. Okay.

Do any cables pass through this concrete?

A. Not through the concrete. Whatever passes through the pedestal is guarded with penetrations.

9-14
cf

Like piping sleeves, you know, or openings.

Q. So, that, actually the concrete never contacts any cables? Is that the correct inference?

A. That is correct.

Q. Now, there are -- Are there passages through the concrete?

A. Yes, there are.

Q. And, are there passages through the pedestal, the metal rings, too?

A. Whatever, you know -- When you say through the concrete, everything that passes through the concrete is lined with the steel structure.

Q. Okay.

I want to show you a diagram from the containment systems design report and I want you to tell me what the two things I point out to you are for that are in the pedestal. Actually, there will be three things.

MR. CULP: Mr. Doherty, would you identify that document, please, for the record?

MR. DOHERTY: The Containment Systems Design Report of December, 1979. On the cover it says ABASO Services, Incorporated.

The figure I am going to show him is

Figure 2.2-3.

(Pause.)

THE WITNESS: These are the piping openings at twenty-four inch lengths --

MR. CULP: Mr. Chairman, could I object to this. I'm not sure the record is going to reflect what the witness is testifying to from this particular figure. I'm not sure Mr. Doherty is asking a specific question.

JUDGE WOLFE: Well, that's the problem, Mr. Doherty. I will make no sense on the record, and not making too much of consequence at the moment either.

MR. SOHINKI: Mr. Chairman, could I suggest that possibly the document be marked for identification, and that the components that Mr. Doherty seeks identification of be circled in some way so that it can be clear on the record what we're talking about.

JUDGE WOLFE: Well, I'm not particularly in favor of marking anything for identification. If it's not admitted into evidence, once again, it is problematical whether at any subsequent briefing time any party could refer to the document -- exhibit marked for identification.

I know that may sound like turning square corners, but that's the way I react to the proposal.

Can't you just ask him -- Is there some purpose behind all of this, Mr. Doherty.

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cf

Can't you just ask him questions without referring to a document in evidence or -- and further leaving the reader at a loss just by reading the transcript as to what either one of you are talking about.

MR. DOHERTY: All right.

I'll state questions from the table. We'll see how it goes.

JUDGE WOLFE: All right.

BY MR. DOHERTY:

Q. Mr. Simpadyan, how many twenty-four inch pedestal vents are there in the Allens Creek pedestal?

A. I don't know what you refer to this twenty-four inch vents.

We have a vent system that there's air coming in to the area between the skirt and the biological shield wall which is vented down into underneath the vessel; and there are two of those.

Q. All right.

Do those vents pass through the pedestal?

A. They go from the top of the pedestal to the side of the pedestal such that they bring air into the area underneath the vessel.

Q. You say they go through the top?

A. Right.

Q. Now, is the pedestal a cylinder?

A. That is true.

Q. Now, if this is a cylinder, this tin can I'm holding. Right?

A. Right.

Q. Now, would that penetration be here?

JUDGE WOLFE: Where?

MR. DOHERTY: Pointing to the top at the side of the pedestal; or would it be here pointing to the lip of the pedestal?

THE WITNESS: The pedestal is composed of two concentric cylinders. One of them is -- that's approximately what you show there is approximately right.

JUDGE WOLFE: What are you showing there? What is the --

MR. DOHERTY: What I'm showing?

JUDGE WOLFE: What is Mr. Doherty showing to you, sir?

THE WITNESS: You have two concentric cylinders. One has an inside diameter of approximately 20 feet, and the other diameter is 32 feet.

JUDGE WOLFE: All right.

THE WITNESS: And, these are connected to each other with a series of vertical and horizontal stiffeners. And, there is a vent that goes from the top and it comes out on the inner cylinder, a few feet below the top; and it brings air from the top of the pedestal into the area which is directly underneath of the reactor vessel.

BY MR. DOHERTY:

Q. Now, is this also true of the forty-two inch by forty inch vent?

A. No.

Q. Where does that pass through?

A. There is no forty-two inch by forty that passes through the pedestal.

Q. Okay.

Now, where do the control rod drive pipe openings -- Do they enter the pedestal?

A. They are located diametrically opposite. They are about three or four feet from the top of the pedestal. And, they are 280 degrees apart.

Q. Do they pass through the top?

A. The side.

Q. Opposites, on the side though?

A. Yes.

Q. Now, in construction, then, are spaces -- is space left for these vents when the concrete is poured?

A. The vent is there and the concrete is poured around it.

Q. So there's a framework in there? The concrete --

A. The is like a duct that is placed and the concrete surrounds the duct.

Q. Okay.

Thank you.

You spoke of a continuous steel plate. Now, would that steel plate -- that's on Page 2 at the top, at the twelfth line --

A. Line what?

Q. Say again. P. e 2, Line 12.

A. Yes.

Q. Again, using the two concentric tin cans, does that plate cover this entire space so that it is like an annual ring.

Is that what that plate is like? Would that be its place?

A. I may not cover the entire top, but that's -- it is placed at the top of those cylinders.

Q. Does it cover all of the place that I would be able to reach with my finger between the two cans?

JUDGE WOLFE: Mr. Doherty, that's not going to make any sense on the record.

BY MR. DOHERTY:

Q. Does it cover the entire pedestal only in the base between the two rings?

A. If we need to, it will. But, right now it is such that we have the ring continuancy over the cylinder where the RPV is placed; and, also, the portion where the biological shield wall is placed.

And, that continuous plate is resting on the shelf and the vertical stiffeners. And, it is a thick plate and if we don't need to cover the whole top, we will not cover the whole top.

Q. So, is it your testimony then that you may leave some of the concrete exposed at the top?

A. That is correct.

Q. Okay.

A. I may.

Q. Say again?

A. I may.

I may leave the concrete exposed at the top.

Q. Yes.

Well, I think everyone understood that.

Thank you.

Now, you stated next that the RPV will anchored to the pedestal by bolting the RPV support skirt to the pedestal ring -- I'm sorry. That is on Line 16 of Page 2. So, how many bolts will there be for that? Do you know?

A. Hundred twenty.

Q. Hundred twenty.

Now, is the biological shield bolted there as well.

A. No. Biological shield is welded and it surrounds the RPV.

Q. It is welded on the ring, then, as well?

A. That is correct.

It is not the same ring, though. You have to realize that. The distance between the two shells of the pedestal is about six feet.

Q. Yes.

So, the shield, then, will sit on the outer ring?

A. The outer ring of the shield will be in line with the other ring of the pedestal if that is what you mean?

Q. Yes, that's right.

Okay.

Now, let's see here.

Would it be a fair statement to say that the concrete as proposed is more like a ballast?

Do you follow that term?

A. I'm sorry. I don't know what you mean by that.

(Pause.)

Q. Well, perhaps we jumped ahead a minute.

On Page 3, Line 14 and Line 12, you state, "The fill concrete is used to add mass to the pedestal in order to obtain dynamic response of the structure within frequency envelope for which the reactor is designed."

Now, in layman's term, does that mean that the purpose there is just to prevent shaking?

A. Well, I wouldn't put it that way.

The -- We basically need the concrete to add mass to the pedestal.

Q. Why does the pedestal need mass?

A. For one thing, we want to obtain the response -- the dynamic response to the pedestal to be companicnable to the way the RPV was designed.

And, by adding mass we get to be closer to the generic design that GE used in coming up with the design of the RPV. Because their design assumed the pedestal that had concrete in it.

Q. Now, on the stiffeners that you mentioned back on Page 2. Do these stiffeners occur as rings?

A. I'm sorry. What what line are you on?

Q. I'm sorry.

I'm on Line about 17 I think it is mentioned. Yes, on Page 2. We've moved back a page.

A. There are vertical -- On Line 17, it says, "Vertical and horizontal stiffeners will be provided

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"throughout the height of the pedestal for joining the two concentric steel cylinders."

Q. All right.

Now, do these -- Are these stiffeners like the stiffeners that are going to be used on the containment as described earlier by the witness this morning.

Are they rings around?

A. I'll tell you what -- how these will be and I will leave the containment alone.

They are continuous flat plates that span from the inner shell to the outer shell and are welded to both shells. The ones that are vertical.

The horizontal ones are flat plates that span between the verticals and the shell plates and are welded to them.

Q. So, that -- Excuse me. Between the two concentric steel rings you have in both horizontal and vertical planes plates welded to each ring.

Is that it?

A. Right.

Q. Okay.

Now, in construction, how -- Will you not have to pour some concrete in before you put some of the stiffeners in under those conditions?

A. No.

The structure will be constructed first before concrete is placed.

Q. Okay.

(Pause.)

On what do the pedestal rings sit?

What are they on?

A. You mean the shells?

Q. Yes.

A. The shells sit on the foundation matt. They have a flat plate underneath and they are anchored to the foundation matt. They are embedded into the matt.

Q. All right.

Now, the concrete. Does the concrete go to the floor -- or to the matt in such a way that the heat can be conducted from the concrete by the matt?

A. I'm sorry. I don't think I understand what you mean.

Q. Well, okay.

Concrete will be poured between the concentric circles down as far deep as it will go.

Is there anything that between the bottom of that concrete pouring and the matt?

A. No.

Q. So, the concrete will reach the matt.

Is that right?

A. Right.

Q. Okay.

I thought you'd do that.

Now, you mentioned earlier that the reason for having this concrete in the concentric steel circles.

Now, has General Electric done any studies on the necessity for this?

A. I'm not aware of any, but they have a design -- composite pedestal design.

Q. All right.

They have a design.

Did they contact either you, either through the Applicant or directly suggesting that they wanted this done that way for their particular needs or . . .

A. Not to the best of my knowledge.

They have a generic pedestal and their design includes the matt of concrete in there.

And, in designing our pedestal we tried to be as close as -- to their design as possible; and that's achieved by having the physical properties -- having similar structures.

Q. When did you learn for certain that there would be concrete in the pedestal?

A. Concrete was always placed in the pedestal.

8 AC"/

Our analysis was based on having concrete in the structure.

(Pause.)

Q. I believe you stated that you indirectly did some work on th. PSAR?

A. Yes.

Q. When did you do that work?

Do you recall?

A. I wouldn't recall the year.

Q. Um-hmm.

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BY MR. DOHERTY:

Q. Did you contribute anything to the Amendment 56 of the PSAR, to your knowledge?

A. No, I did not contribute.

Q. Okay, on page three, line 16, do you have any other basis for filling these rings with concrete than simply the General Electric -- well, whatever that was? They seemed to indicate that should be done, so you did it.

Do you have any other -- Is there any other reason?

A. It also provides additional shielding, but I would like to state that ... you know, they didn't ask to be done.

Q. What is this shield?

A. It's biological shielding.

By being there it does provide additional shielding from any radiation that might stream from the reactor vessel onto somebody who is inside the dry wall, as opposed to not having any.

Q. To your knowledge, was the ACNGS originally designed with a concrete-filled pedestal?

MR. CULP: Your Honor, I'd like to object to this question. I just don't understand the relevance of the questions that Mr. Doherty is pursuing at this point as to whether the prior design had the concrete in it, or did not.

It seems to me his contention is directed to the pedestal -- the concrete pedestal as it's designed now.

And I just don't understand the relevance of what he's asking.

JUDGE WOLFE: Yes, Mr. Doherty, what's the purpose of this line of questioning?

MR. DOHERTY: Well, I'm trying to find out why there is a disagreement between the PSAR Amendment 35 and the PSAR Amendment 56.

Amendment 35 said that the cylinders might be filled with concrete.

Amendment 56 said they would be filled with concrete.

Now, in back of this "will" or "will not" to me is a question: How come there is this maybe yes/maybe no? And is that relevant here?

Perhaps I'm right. Perhaps the concrete isn't a good idea, and they were trying to weigh some other filler, and then finally just settled on concrete.

I don't understand the discrepancy. That's what I'm trying to get at and that's why these questions have gotten time-based.

10-3

MR. CULP: Well, Your Honor, even if that's true -- which I certainly would not admit -- I don't see how that's relevant to the testimony of Mr. Simpadyan who has testified that there will be concrete inside the reactor pedestal.

And it seems to me that's the scope of his testimony. And Mr. Doherty should be asking questions directed towards the testimony.

(Bench conference.)

JUDGE WOLFE: Sustained.

BY MR. DOHERTY:

Q. Was any other substance ever considered, to your knowledge, for filler between these rings?

A. No.

Q. What is the heat of fusion of this concrete, sir?

A. I don't know.

Q. Okay.

What is the melting temperature of the solid phase?

A. As far as I know, it's not determined. I don't know what that is.

Q. Can concrete of this type be weakened without actually cracking?

A. When you drive most of the moisture away from concrete, there may be some change in the physical strength of the concrete.

But I don't know what you mean by "weakening."

Q. Did you testify a moment ago that possibly the top of the space between the two rings would not be completely covered with metal?

A. Yes, I did.

Q. All right.

Now, if that's true, wouldn't moisture be lost in the event of heating through that space?

A. The two cylinders and the stiffeners make up almost a sealed structure, such that it would be very hard for the moisture to evaporate through about 30 feet of concrete ... you know, all the way up through the top and ... you know, leave the concrete.

Q. However, there would be a space, is that correct, in which some moisture could leave from less distance than 30 feet, if it were --

A. Between the top stiffener and the area where it is not covered with steel, there is concrete.

Q. Yes. And couldn't that concrete lose moisture, if the space between the two concentric rings was not completely covered?

A. As far as I'm concerned, all of the moisture could leave the concrete. I couldn't care less if it did.

There would be moisture retained because of some water -- that -- some hydrogen that's installed in the concrete in the forming process.

So --

Q. Okay.

Turning to page four, did you investigate in any way the SL-1 pedestal, in response to this contention?

A. I --

Q. At the middle of the page, I'm sorry ... page 13.

A. I looked over the document, identified in the contention. That's as far as I went.

Q. Do you know what kind of pedestal that particular reactor had?

A. As far as I'm concerned, that reactor did not have a pedestal. It was just sitting on some foundation.

Q. Okay.

Now, in the event of a rapid deposit of thermal energy into the concrete, how can concrete be investigated for weakening without destroying it in some way?

A. How would rapid thermal energy get into the concrete?

Q. Well, I'd like for you to answer my question, please, not ask one.

MR. CULP: Mr. Doherty, are we now back to the Allens Creek pedestal and concrete?

MR. DOHERTY: Yes, we are. Yes, I'm sorry, counsel, if you had trouble following me.

THE WITNESS: For thermal energy to get into the concrete, it would have to take some time. The only way it could do that is the heat would first start getting to the surface of that concrete and then work its way into it.

It would rapidly dissipate itself into the concrete.

BY MR. DOHERTY:

Q. How can you investigate if any weakening has resulted from that?

A. As far as -- if it's a structure that's concerned ... if it's just the surface of the concrete that's exposed to heat for a very short duration of time, I wouldn't think there would be any weakening of that structure from such a short exposure to that heat.

Q. Okay.

But my question doesn't cover short exposure.

A. Well, you would have to do a thermal gradient analysis and evaluate the structure and get the stresses within the structure to determine what the effect of that

10-7

thermal load is on the structure.

Q. Can you do a thermal gradient analysis without actually getting to the material itself?

A. I'm sorry, I don't understand ... What do you mean by "getting into the material itself"?

Q. Would you have to take some of the concrete out and look at it?

A. There are other tests done on concrete materials from which you could derive what the strength of the concrete would be, when exposed to temperature.

Q. Would you need some of the concrete itself, or could you do that even though the concrete was behind an inch or three inches of steel?

A. You wouldn't be using the same concrete that was placed behind the steel. You'd make a sample ... a different sample and test that sample.

Q. Sort of simulate?

A. Yes.

Q. Uh-huh.

Do you know what design-based accident produces the largest thermal loading on the pedestal?

A. A small line break from the system. The largest thermal temperature is inside the dry wall.

Q. Doesn't steel soften on heating?

MR. CULP: Mr. Chairman, I'm going to object to that question. It seems to me that Mr. Doherty's contention is directed to the concrete pedestal.

The contention says that the pedestal concrete of Allens Creek may be weakened. And now it seems to me that Mr. Doherty is getting into the question of the steel pedestal.

JUDGE WOLFE: He's using the word "concrete," though.

MR. CULP: I thought he just used "steel," just a moment ago.

MR. DOHERTY: Yes, I did. That's correct.

MR. CULP: I think he's getting a little beyond the scope of this contention.

MR. DOHERTY: Well, the reason the question is asked is much of the testimony here is that the concrete is not load bearing.

That is simply because the steel is doing the load bearing.

Now, if the steel softens, that's going to change the conditions a little bit and perhaps put the concrete under a load-bearing situation.

I want to find out -- That's my suggestion. I want to find out if that's true or not ... if that's possible or not.

MR. CULP: I still believe that's outside the scope of the contention. The contention has to do with weakening of the pedestal concrete.

MR. SOHINKI: I have to agree with that, Mr. Chairman.

The Staff's view of the contention is that if the concrete is weakened in some manner, then the pedestal is going to be weakened.

JUDGE WOLFE: So we stop at the ankle and we don't get to the knee bone. I agree.

Sustained.

(Bench conference.)

JUDGE WOLFE: After a conference with the other Board members, the ruling is reversed.

The objection is denied. You may answer the question.

THE WITNESS: I wouldn't use the word "soften." I would say that the yield strength of the steel would be slightly reduced when exposed to temperature.

But this is accounted for in our design.

BY MR. DOHERTY:

Q. What is the maximum rate of temperature change expected for the most severe design based accident to the pedestal?

A. The worst thermal load that's expected inside

1-10

the dry wall -- air temperature of 330° that lasts from zero to three hours. And 310° is predicted from three to six hours.

Q. How rapidly does the temperature change during this event?

A. It's various containers.

As far as I know, it's rapidly changed. I don't know exactly how many seconds it takes to go from one temperature to one temperature.

Q. Okay.

Is there a commercial name for the concrete product that you're going to be using?

A. No. We may use -- maybe grout.

It's not a commercial name.

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1-11

BY MR. DOHERTY:

Q. Now, how would the concrete be affected by vibration from a loss-of-coolant accident blowdown in the suppression pool?

MR. CULP: Your Honor, I'd like to object to that question.

The contention reads that the pedestal concrete may be weakened by the heat from a power excursion accident or loss-of-coolant accident.

And I think again, he's getting a little bit beyond the scope of the contention.

He's talking about vibration. I think the contention is directed towards heat and how the heat applies to the concrete.

(Bench conference.)

MR. DOHERTY: It appears in a LOCA that there is both heat and vibration.

And one is not going to go on without the other.

And it seems to me that the effect on the pedestal really can't be considered, just by taking heat alone, as if this were in a test tube, that some consideration has to be given to the entire conditions of a loss-of-coolant accident.

JUDGE WOLFE: Your contention, however, is

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directed to weakening by heat and original thermal damage to the pedestal.

There's nothing in there as to vibration, is there?

(Bench conference.)

MR. DOHERTY: Yes, that's correct.

My answer to your question is yes.

JUDGE WOLFE: Objection sustained.

JUDGE LINENBERGER: Mr. Doherty, I think this might be a place to inquire, however, whether you and the witness may be using the word "pedestal" in different ways.

It is my impression that what you're calling a pedestal is the concrete structure, and that what the witness is calling a pedestal is the concentric steel ring structure.

Now, perhaps I'm wrong. Perhaps we can clarify this.

Sir, what -- I'm asking the witness here, what do you mean by the word "pedestal"?

THE WITNESS: A pedestal consists of the structural steel concentric rings and the stiffeners. And it is filled with concrete, which is a non-load bearing member.

The part that does the work (if you will) is the steel structure.

JUDGE LINENBERGER: Okay. Just so long as we understand how these words are being used, let m) bow out here.

MR. DOHERTY: No further questions, Your Honor.

JUDGE WOLFE: Is there redirect, Mr. Culp?

MR. CULP: No redirect.

MR. DOHERTY: I'm sorry, I didn't hear you, counsel.

MR. CULP: There's no redirect.

MR. DOHERTY: That's what I thought you said.

(Bench conference.)

BOARD EXAMINATION

BY JUDGE LINENBERGER:

Q. Mr. Simpadyan, you have indicated on page three of your testimony that one purpose of the concrete that fills the concentric steel structure is to provide mass, such that the dynamic response of the pedestal structure will more nearly match the response of the pressure vessel to vibrational forces; is that correct?

A. It will provide a structure that simulates the pedestal assumed by GE in their design of the vessel.

And the pedestal has to be compatible with the RPV that supports.

Q Well, yes, it has to be compatible. But compatability is a rather imprecise term in some respects.

Now what do you mean when you say the pedestal has to be compatible? Incompatability to me might mean dissimilar middles causing corrosion. And that's not what you mean.

What is compatability here?

A. When subjected to dynamic loading, if a vessel is supported on a structure, the frequency of the structure that supports the vessel affects the design of the vessel itself.

And the vessel is designed to certain -- to a frequency ... a certain range of frequencies.

You would like to get a pedestal that would be compatible, such that when the vessel sits on it, the loads are not exceeded, in addition to -- what ... you know, GE originally designed the vessel for.

Q All right.

For this purpose, namely, to optimize the -- if you will, dynamic coupling between the reactor vessel and the pedestal, could one have poured lead in there instead of concrete?

A. Lead has a different density than concrete does. So it could not be.

Q. Okay.

Now, in order for the concrete to provide the proper dynamic response, isn't it necessary that the concentric steel shells be rather closely in contact with the concrete?

In other words, if there were, say, an eighth of an inch gap between the concrete and the shell, would or would not that defeat the purpose of the dynamic response objective?

A. The purpose here is the mass of the concrete. We're not trying to say that we have a structure where the concrete and the steel would act as a composite structure.

By the mass being there, it is a property that matches what GE had. It's not the only property.

Q. Well, help me here now. Let me understand something.

I hear what you're saying, but I don't hear you answering my question. If I want to bend a piece of copper tubing and keep it from kinking, I fill it with sand; and I can make a pretty good bend, and it won't kink.

On the other hand, if the sand is not tightly packed, and, in fact, if there are voids in the sand and I try to make a bend, it will serve no purpose whatsoever. The tubing won't kink.

So the fact that the filling is not in contact with the wall of the tubing here defeats my purpose. Now, here I'm trying to understand: If the concrete were poured, such that it is not in contact with the steel shells inside it and outside it, does that defeat the purpose of its dynamic response characteristics?

A. The response would probably be different, but I wouldn't be able to tell you whether it defeats or not, because as it presently stands, EBASCO provides the proper structure that we've designed, as far as the pedestal is concerned.

And GE verifies that their vessel is still adequate to meet the load.

So it wouldn't make that difference.

Q. Are you saying that you can testify from your own analyses that it doesn't make that difference, or as far as you know, GE has never complained about it?

A. I couldn't say that. All I'm saying is that EBASCO provides the responses ... both the design that we had to GE, and they verified their vessel for the structure that we had.

Q. Now, when you say EBASCO provided the

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responses, I would infer from the context of this discussion that those responses are not something that you personally calculate? Is that correct?

A. Not -- They come out of the dynamic analyses of the reactor program that this performs.

?

Q. Okay. I'm sure we're making more out of this than it deserves.

But from your comments, I get the impression -- oversimplified -- that the concrete sitting within the pedestal rings does indeed act somewhat like a ballast, as Mr. Doherty said at the beginning, and might well prevent the whole reactor vessel structure from tipping over, due to some asymmetric forces.

But I really don't understand, if the concrete is not in contact with the steel shells of the pedestal, how it offers this dynamic response -- serves this dynamic response purpose.

There was a question about whether or not water in the concrete might be driven out by virtue of some sort of power plant behavior that would result in the temperature of the pedestal being raised.

And I'm not -- I believe you said that it really didn't make much difference whether the waters were driven out or not. Is that correct?

A. That is correct, because we do not rely on the strength of the concrete to carry the loads.

Q. All right.

You don't rely on the strength of it. So, if, perchance, the rate of heating should be relatively fast, such that the rate of steam generation (assuming that it can take place in the concrete) should be relatively fast, such that this would cause the concrete to fracture and to rubble within the two rings, presumably, as you view it, that would not defeat the purpose of the concrete. Is that correct?

A. That is correct.

Whether it's in that state or in any other state would be accounted for in our design.

Q. It sounds to me then as though you could accomplish the same purpose by -- instead of putting in concrete, just throwing in rocks or aggregate, if it were about the same density as concrete.

Would you think that would be a reasonable conclusion to reach from what you said?

A. You might say that.

Q. Okay.

JUDGE LINENBERGER: I have no more questions.

JUDGE WOLFE: Is there cross -- I'm sorry, go ahead.

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BOARD EXAMINATION

BY JUDGE CHEATUM:

Q. I'm somewhat puzzled by the terminology that you used in that sentence that Judge Linenberger was referring to. That's a typical engineer's sentence. If you're not an engineer, you would have no idea what was being said, and I'm not an engineer.

When you put down frequency envelope for which the reactor is designed, I'd like an explanation as to what a frequency envelope is.

And then further, how that relates to the frequency envelope or the frequency characteristic of the reactor.

When you say "frequency," what do you mean?

A. The reactor vessel itself has a set of natural frequencies, depending on what mode of vibration you are at.

And the natural frequency of the reactor vessel for the first few modes is specified.

Q. The first few what?

A. Mode.

Q. Modes? Of what?

A. Of --

Q. Operation or what?

A. No.

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Under dynamic loads you get a different type of response of the vessel. And you get a frequency. The natural frequency of the vessel will not change.

Q. And -- for example, what might the natural frequency be?

A. I wouldn't know what the number would be.

Q. Is it vibrations per second or what?

A. Frequency is vibrations per second.

Q. Well, good. Okay.

And this concrete in this shell is added, in order to provide mass that will correspond or give vibration frequencies corresponding to the vibration frequencies that the vessel is designed for? Is that the case?

A. By having the mass, or not having the mass, you would get different frequencies of the pedestal.

Q. Yes.

A. If you had the mass, you would get some frequency. If you didn't have the mass, you would get another -- different frequency of the pedestal.

And the mass was put in there so that you have the structure -- the pedestal structure similar to what GE had originally

And GE used some generic pedestal. And they put an RPV on that pedestal and applied seismic loads and analyzed their RPV and designed it.

So EBASCO, in designing their pedestal, thought it would be prudent to make their design as close to GE as possible.

And since GE had the concrete in there, EBASCO had the concrete in there. And that's how the pedestal was designed, because that determines what response the RPV has.

If you didn't have the mass of the fill concrete in your pedestal, you would get a different response of the RPV because you have, in a sense, two structures, if you think of the RPV has a structure.

You would have the pedestal and the RPV. And if you applied a dynamic load to the pedestal, which had fill concrete in it, the steel structure with fill concrete in it and a pedestal sitting on top of it would have certain characteristics ... a certain dynamic response.

Q Thank you very much. I now understand what you mean by "frequency envelope."

Thank you.

JUDGE WOLFE: Cross-examination, Mr. Sohinki, on Board questions.

MR. SOHINKI: I have none.

JUDGE WOLFE: Mr. Doherty.

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bm

MR. DOHERTY: Just one, I guess.

RECROSS-EXAMINATION

BY MR. DOHERTY:

Q In order to avoid the kind of problem of lack of contact between the concrete and the rings that Judge Linenberger mentioned a minute ago, would you also need to have contact between the concrete and the metal ring at the top, which you've spoken of earlier -- the ring between the two circles?

A. The concrete between the topmost stiffener and the top of the vessel for all practical purposes is a very small amount.

And even if it were not there, it would not make that much of a difference ... if that's what you're referring to.

MR. DOHERTY: I think that's it. Thank you.

JUDGE WOLFE: Is there redirect, Mr. Culp?

MR. CULP: No, Your Honor.

JUDGE WOLFE: All right. Is the witness to be permanently excused?

MR. CULP: Yes.

JUDGE WOLFE: The witness is permanently excused.

(The witness was excused.)

JUDGE WOLFE: We will have a 15-minute recess.
(A short recess was taken.)

JUDGE WOLFE: All right, Mr. Sohinki. Call your witness.

MR. SOHINKI: Yes.

I would call to the stand Dr. Sai P. Chan.

JUDGE WOLFE: Would you remain standing, Doctor, and raise your right hand.

Whereupon,

SAI P. CHAN

was called as a witness herein and, having been first duly sworn, was examined and testified as follows:

JUDGE WOLFE: Please be seated.

DIRECT EXAMINATION

BY MR. SOHINKI:

Q. Dr. Chan, do you have before you a seven-page document entitled "NRC Staff Supplemental Testimony of Sai P. Chan Relative to Containment Buckling and Reactor Pedestal," together with a two-page attachment entitled "Professional Qualifications of Sai P. Chan, Structural Engineering Branch, Division of Engineering"?

A. Yes, sir.

Q. Did you prepare those documents?

A. Yes, sir.

Q. And do you have any additions or corrections to make to those documents at this time?

A. No, I don't.

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Q. And is everything contained in those documents true and accurate, to the best of your knowledge, information and belief?

A. That's correct.

Q. And do you adopt everything contained in those documents as your testimony in this proceeding?

A. Yes, sir.

MR. SOHINKI: Mr. Chairman, I would move that the document previously identified by Dr. Chan be incorporated into the record as if read and accepted as testimony on behalf of the Regulatory Staff.

JUDGE WOLFE: Voir dire or objections?

MR. COPELAND: None, Your Honor.

JUDGE WOLFE: Mr. Doherty.

MR. DOHERTY: I have some voir dire, sir.

JUDGE WOLFE: All right.

VOIR DIRE

BY MR. DOHERTY:

Q. Dr. Chan, on the pages that are called "Professional Qualifications" -- Do you have that in front of you now?

A. Yes, sir.

Q. Fine. Okay.

You state at the top, "I am responsible for the evaluation of seismic analysis and design of structures,

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systems and components of nuclear facilities assigned to the Branch."

Have you been doing any work on the Allens Creek Nuclear Plant?

A. Yes, sir.

Q. All right.

Have you ever testified before an Atomic Safety and Licensing Board before?

A. No.

Q. All right.

Down further on that page, you have discussed two things that I wanted to know what they were. One is anisotropic structure. What is an anisotropic structure?

A. Let me, first, explain what is isotropic. Isotropic refers to the material of the structure that it displaces.

The same kind of properties -- material properties in every direction. For example, the modulus of elasticity ... it is the same if we look at it this way or that way.

Now, this kind of thing is particularly applicable to the so-called laminated structures or fiber-reinforced composite materials, where you have more reinforcements and less reinforcement in the other direction.

So in that case, it is different. Let me give you an example. Wood ... it has different properties for ... along with the grain of wood, than the transverse direction of the wood.

So wood itself is an anisotropic material.

But steel is isotropic, because it displaces the material properties in every direction.

Q. Okay, thank you.

What is a monocoque shell?

A. It is a term used frequently in the aerospace industry, which means unstiffened ... uniform thickness, unstiffened. That's monocoque.

Like an egg shell ... is monocoque.

Q. I guess I can remember it that way. Okay.

JUDGE CHEATUM: He has had experience as a professor, you can see that.

MR. DOHERTY: Yes, and I'm glad, too.

BY MR. DOHERTY:

Q. Now, at the top of page two of your qualifications, you speak about participating in developing criteria for seismic design. Have you developed any Regulatory Guides?

A. I helped in developing the Regulatory Guides. For example, 160, which refer to the design response factor of -- for the ground motions.

Q. Okay.

A. And also 161 on the damping values of the structures.

Q. Did you participate in the --

MR. DOHERTY: All right. I have no further questions, Your Honor.

JUDGE WOLFE: Any objection to the incorporation of the testimony?

(No response.)

JUDGE WOLFE: Absent objection, the supplemental testimony of Dr. Chan relative to containment buckling and reactor pedestal, as well as his professional qualifications, are incorporated into the record as if read.

(See attached pages.)

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04/20/81

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
HOUSTON LIGHTING & POWER COMPANY	)	Docket Nos. 50-466
	)	
(Allens Creek Nuclear Generating Station, Unit 1)	)	

NRC STAFF SUPPLEMENTAL TESTIMONY OF SAI P. CHAN
RELATIVE TO CONTAINMENT BUCKLING AND REACTOR PEDESTAL

[Doherty Contentions 9 and 27]

Q. Please state your name and position with the NRC.

A. My name is Sai P. Chan. I am employed at the U.S. Nuclear Regulatory Commission as a Senior Structural Engineer in the Structure Engineering Branch.

Q. Have you prepared a statement of educational and professional qualifications?

A. Yes. It is attached to this testimony.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to respond to Doherty Contentions 9 and 27 which state as follows:

Doherty Contention 9

That Intervenor's health and safety interests are inadequately protected because Applicant's steel containment shell is not strong enough by design to resist dynamic and static loads which may plausibly occur in the life time of the atomic plant.

Doherty Contention 27

> The concrete in the pedestal beneath the ACNGS reactor may be sufficiently weakened by heat from a design basis accident to compromise the safety of the plant after its subsequent return to operation.

Q. With respect to Doherty Contention 9, buckling of the steel containment, has that issue been identified as an "unresolved safety issue"?

A. No. This contention refers to the "Task B-5" listed in Table C.2 "List of Technical Activities," in "Safety Evaluation Report related to Construction of Allens Creek Nuclear Generating Station, Unit 1," Supplement No. 2, NUREG-0515, March 1979. The issue is listed as a Category B generic technical activity which is defined as: "Those generic technical activities judged by the staff to be important in assuring the continued health and safety of the public but for which early resolution is not required or for which the staff perceives a lesser safety, safeguards or environmental significance than category A matters." Table C-1, NUREG-0515.

Q. What is the generic concern to be addressed by Task B-5?

A. The most recent statement of the concern by the NRC Staff is the statement in "Generic Task Problem Descriptions, Category B, C and D Tasks, "NUREG-0471, June 1978. That statement is:

> Buckling Behavior of Steel Containments - The structural design of a steel containment vessel subjected to unsymmetrical dynamic loadings may be governed by the instability of the shell. For this type of loading, the current design verification methods, analytical techniques, and the acceptance criteria may not be as comprehensive as they should be. Section III of the ASME Code does not provide detailed guidance on the treatment of buckling of steel containment vessels for such loading

conditions. Regulatory Guide 1.57 recommends a minimum factor of safety of two against buckling for the worst loading condition provided a detailed rigorous analysis, considering inelastic behavior, is performed. On the other hand, the 1977 Summer Addenda of the ASME Code permits three alternate methods, but requires a factor of safety between 2.0 and 3.0 against buckling depending upon the applicable service limits. NUREG-0471, p. B-7.

Q. What are the objectives of Task B-5?

A. As stated in NUREG-0471 the task has the following specific objectives:

1. To review and assess the assumptions and methodology presently used in the buckling analysis of steel containment shells,

2. To establish general standard design and acceptance criteria for the dynamic/static stability of steel containment shells, particularly for steel containments subjected to unsymmetrical internal or external dynamic loads,

3. To evaluate the computer programs presently used in the buckling analysis and design of steel containment shells by developing benchmark problems to verify these programs, and

4. To perform selective detailed reviews of typical containment designs to assess the effect that any new licensing requirements may have on different types of containments.

Q. Have any new licensing requirements been established?

A. No. As stated on page C-4 of NUREG-0515, Task Action Plans have not been approved by the Technical Activities Steering Committee for Category B, C and D Tasks.

Q. Has such approval been made since NUREG-0515 was published in March, 1979?

A. No.

Q. Seventeen "Unresolved Safety Issues" are listed on page C-13 of NUREG-0515. Has that list been updated?

A. Yes. The Commission has approved four new "Unresolved Safety Issues" (Letter S. J. Chilk to W. J. Dircks, Subject: SECY-80-325 - Special Report to Congress Identifying "Unresolved Safety Issues (Commission Action Item), dated December 22, 1980). Candidate issues considered by the Commission originated from concerns identified in NUREG-0660, "NRC Action Plan as a Result of the TMI-2 Accident;" ACRS recommendations; abnormal occurrence reports and other operating experience. Task B-5 continues as a Category B Task and is not classified as an "Unresolved Safety Issue."

Q. Has any new information been developed during consideration of this contention that was not previously known to the Staff, and which sheds new light on the categorization of the generic concern.

A. No new information has been provided by the Intervenor or developed by the Staff.

Q. Does the Allens Creek application meet the Commission's present requirements?

A. Yes. As stated in Section 3.8.1 "Steel Containment" of NUREG-0515, the Applicant has utilized Regulatory Guide 1.57, "Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components," as the basis for the buckling criteria for the steel containment. The Commission accepts regulatory guide positions as one way of meeting its requirements.

Q. With the above noted concern with respect to containment buckling, why is it practical to proceed with construction?

A. Again, as indicated in Section 3.8.1 of NUREG-0515, we do not anticipate that the end product of this program will result in significant design changes, but rather will produce a clear and precise set of requirements for future licensing actions and that if anticipated results are not realized, design modification during construction are feasible.

Q. Why is it acceptable to proceed with construction of ACNGS and other plants if the resolution of this matter could later result in changed requirements for future licensing actions?

A. The Staff does not regard the buckling of the steel containment issue as being so critical as to warrant immediate resolution. The rationale for such a licensing approach is as follows:

1. Buckling of shells and plates has been the subject of numerous studies. Each study is usually limited to a shell of specific geometrical configuration and loading. Generally the results of such a study are at best applicable only to the particular shell configuration under the particular loading. However, the use of Regulatory Guide 1.57 related criteria is expected to be adequate and to provide ample margin of safety.

2. Stiffeners are used in the Allens Creek steel containment, and it is generally believed that the use of stiffeners will reduce the sensitivity of buckling to the shell geometrical imperfections, especially with a large shell structure as a steel containment. Use of the stiffeners, therefore, further minimizes the likelihood of buckling.

3. The steel containment of Allens Creek is designed for the loads which may give rise to its buckling. The conservatism associated with the definition of the loads is believed to compensate the uncertainty related to the buckling concern.

4. In case the prospective research program concludes that strengthening of the containment is required, it can be accomplished by welding additional stiffeners to the containment without undue difficulty even after the plant is put into operation.

Based on the foregoing, the Staff concludes that even though buckling of the containment is classified as a generic safety issue, the licensing actions and measures taken by the Applicant and reviewed by the Staff provide reasonable assurance that the health and safety of the public will be protected.

Q. Turning now to Doherty Contention 27, weakening of the pedestal concrete, can you briefly describe the purpose and characteristics of the reactor pedestal?

A. The reactor pedestal provides support for the reactor vessel by means of a support skirt anchored to the reactor pedestal and welded to the vessel bottom head. The reactor pedestal also supplies support for the reactor biological shield wall. The pedestal basically consists of two concentric steel cylinders with the annular space between filled with concrete.

Q. Is the strength of the concrete considered in the load bearing design of the pedestal?

A. No. The basic material of the pedestal is structural steel and, therefore, the strength of the pedestal depends on the steel. The concrete is non-load bearing and, accordingly, the contribution to the pedestal strength of the concrete is not considered in the design. The fill concrete is used to provide additional biological shielding. In reality, however, the concrete will also add strength to the pedestal.

Q. During postulated power excursion or loss-of-coolant accident conditions, what is the maximum temperature the reactor pedestal is designed to withstand?

A. The maximum temperature to which the pedestal will be subjected during these accidents is about 330°F. At this temperature, there is some loss of steel strength, but this has been taken into consideration in the design. Therefore, the structural integrity of the pedestal will be maintained under the postulated accident conditions.

Q. What would happen to the concrete under the postulated accident conditions?

A. The temperature of 330°F will not significantly affect the added strength of the concrete because the concrete is confined and sealed by the steel cylindrical box. This temperature will result in practically no loss-of-concrete moisture and, therefore, its inherent strength should be maintained.

Q. What is your conclusion with respect to this contention?

A. As noted above, postulated accident conditions should not result in any weakening of the reactor pedestal and, in particular, the pedestal concrete. In any event, since the pedestal concrete is not considered in the design of the pedestal strength, any weakening or cracking of the concrete will not create any safety hazard.

PROFESSIONAL QUALIFICATIONS
OF
SAI P. CHAN
STRUCTURAL ENGINEERING BRANCH
DIVISION OF ENGINEERING

I am a senior structural engineer in the Structural Engineering Branch of the Division of Engineering. I am responsible for the evaluation of seismic analysis and design of structures, systems and components of nuclear facilities assigned to the Branch.

I received a B.S. Degree in civil engineering with honor from Lingnan University, China, in 1943. I received the degree of Master of Science from the University of Illinois, Urbana, Illinois in 1950 and the degree of Ph.D (Structural Engineering) from the same institution in 1953.

I taught undergraduate students at the National Chiao-tung University, Shanghai, China from September 1943 to August 1947. From October 1947 to August 1949 I studied at the University of Paris, France under a scholarship sponsored by the Nationalist Chinese Government and worked as an architectural engineer in the Atelier Le Corbusier, Paris, France. During the years 1951 and 1952, I worked as Research Assistant at the University of Illinois where I developed numerical methods for dynamic analysis of structures.

Since 1953 I have served in the structural engineering area including research, development, design and analysis for the construction, aerospace and power industries. My experience in structural methodology and stress analysis includes development of computer programs and numerical methods for dynamic analysis of framed and shell structures; analysis of composite, laminated and anisotropic structures; structural optimization and nonlinearities; postbuckling and dynamic behavior of stiffened and monocoque shells. I also taught at the University of Denver part-time for two years in Theory of Elasticity and Theory of Plates and Shells.

My experience in seismic design and ground shock problems involves earthquake design of a fossil-fuel power plant in California; mining structures and facilities; launch towers and silos for the Titan missiles; ground shock studies for military structures; seismic design and analysis of containment structures and auxiliary buildings of nuclear power plants.

I joined the U.S. Atomic Energy Commission (now Nuclear Regulatory Commission) in 1972. As a member of the Structural Engineering Branch, Division of Engineering, I have participated in developing criteria for seismic design and instrumentation for nuclear power plants, performed evaluations of technical reports concerning structural dynamics and reviewed numerous nuclear power plants in the area of seismic and structural design.

I am a member of the American Society of Civil Engineers, Earthquake Engineering Research Institute, and the American Institute of Aeronautics and Astronautics. I am registered as Professional Engineer in the states of Colorado and Georgia. I have published technical papers in the Journal of Royal Aeronautical Society and Aircraft Engineering, and several research reports for the Lockhead-Georgia Research Laboratory.

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MR. SOHINKI: The witness is available for cross-examination, Mr. Chairman.

JUDGE WOLFE: Mr. Copeland.

MR. COPELAND: No questions, Your Honor.

JUDGE WOLFE: Mr. Doherty.

CROSS-EXAMINATION

BY MR. DOHERTY:

Q. Dr. Chan, did you hear the testimony this morning of Mr. Mokhtarian?

A. Yes, sir.

Q. Was there anything that he testified to this morning that you disagreed with?

A. In general, I tend to agree with what he said.

But if you pinpoint to some specific issue -- or problem, then I may have a different opinion. For example, the definition of "buckling," for example.

I may not agree entirely on his explanation, but I hate to dispute word by word, unless I or you specifically mention what point do I have different opinion and so forth, because in Mr. -- his testimony, a lot of points has been touched; and I cannot address -- in general say I don't agree or disagree.

Q. I see.

All right. Now, we'll look at your testimony then. I guess you must have it there.

A. Yes.

Q. Now, you discussed on page three the objectives of Task B-5. I was wondering in part three there what programs are being evaluated at this time.

A. This is our objective proposed in the Task B-5. We do not single out any specific computer programs presently used in buckling analysis and design.

I would also like to point out that the computer program is just a tool to do the calculation and the analysis or to do the calculating work of a certain theory.

And in this it's pretty hard ɔ single out or to specify what computer programs. And in the industry a lot of computer programs are proprietary. And it is not easy to get out.

And also, even those in public domain, we still have to investigate what that computer program is going to do.

Q. Well --

A. My answer is we do not have specific computer programs right now.

Q. I see.

Now, you say then that the programs are not identified?

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A. Not yet identified.

Q. Now in those four objectives there, has the Commission or has the Staff begun any of those four objectives?

A. We have in our branch ... sort of in-house work ... to prepare for this kind of work.

But since this past action, plans have not been approved by the technical activities ... as I answer in the next question.

But the preparatory work, yes.

Q. Turning then to page five, please, you state in your first answer: "we do not anticipate that the end product of this program will.result in significant design changes." Why is that, please?

A. According to our present staff position on the question of buckling, our position has not been changed, because the new concern of this problem is mainly on the clarification and also on the position of the analysis -- the buckling analysis.

In that way, the end product of this program will give us more information, will clarify a lot of vague terms, vague description of methods, and also give us more precision to the -- a better understanding of the buckling program. And in that case we feel that the design changes, because of a better understanding of the problem in getting into more precise prediction of calculation. And we don't believe it will give any design changes.

Q. Now, in that same answer, you mention design modification at the end -- design modification during construction are feasible.

What modifications would these be, Dr. Chan?

A. For example, in this study program -- or research program we found out that it is more desirable to strengthen up the shell a little bit. And in that case, we may add stiffness to the shell ... to make it more stiff.

So this is the kind of modification we have in mind, to modify the structure so that it will increase the required margin of safety ... if this is the thought -- the kind of things we're talking about.

Q. Would those stiffeners be kinds of rings around the containment shell? Would that be one kind you have in mind?

A. Either way. Ring or longitudinal ... whenever it's necessary.

Q. Okay.

Is it your understanding that the Allens Creek shell does not touch any of the concrete building around

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it?

A. The containment shell, that's right.

Q. It does not touch the shield?

A. It does not touch the shield. It is independent by itself.

Q. Have you ever heard of a containment shell for a nuclear plant that buckled in a ... you know, that ever buckled in a way that was of concern?

A. I'd like to understand the question.

Q. Yes.

A. What are the concerns of buckling? Do you mean hoop buckling, or longitudinal buckling, or what?

Q. Longitudinal.

A. Longitudinal buckling. No, I haven't heard of anything.

Let me emphasize one point. The buckling action only occurs at the area where there is a membrane compressive stressed. In the tension we don't have any problem with buckling.

Buckling actually is a stability problem. In most cases if the containment is under external pressure, then most likely if it buckles, it will buckle in the hoop buckling ... in the circumferential.

And that ... I don't think anything would happen because we just have no such kind of environment

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to produce this kind of external pressure loading on that structure.

And then talking about longitudinal buckling -- and also I cannot think of any longitudinal loading ... would cause alarm of that kind of problem.

Q Is this type of unsupported shell ever used in any other industry or construction?

MR. SOHINKI: Objection, Mr. Chairman. I don't see the relevance of this to the contention -- or to this plant.

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MR. DOHERTY: A moment ago I asked him if this had ever happened in a nuclear plant. He said no.

THE WITNESS: I haven't heard of it.

MR. DOHERTY: He hadn't heard of it.

And what I'm trying to get at is -- maybe I should ask the question more directly by has it ever happened with any other type of building structure like it.

MR. SOHINKI: Mr. Chairman, I still object to the question. We're talking about different structures with different design characteristics. We're concerned with the Allens Creek containment and whether that will withstand buckling loads.

(Bench conference.)

MR. DOHERTY: Well, the question -- I think under that consideration ... a reasonable question evaporates totally.

Counsel would have it that we couldn't gain from any experience except a shell that precisely emulated the Allens Creek shell, and that doesn't strike me as a very good inquiry.

I should have a little leeway there.

MR. SOHINKI: I was simply suggesting that it's appropriate to inquire into the methodology which the Applicant is using and whether that's acceptable to the

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Staff for this particular facility. But we're certainly not here to discuss a methodology for withstanding buckling loads for any other kind of facilities.

JUDGE CHEATUM: May I make a comment?

I have a question. If Mr. Doherty hadn't asked it, I was going to ask it. And that is --

(Bench conference.)

JUDGE LINENBERGER: With respect to this question and your objection, Mr. Sohinki, in the first place the question was premised by the constraint that it applied to similar kinds of structures used in other applications than nuclear.

And it seems to me that the question tends to elicit some insight into the experience of the industry in dealing with structures like this and helps to find out is there anything unique about nuclear here or are these kinds of things done all of the time -- in ... I don't know ... oil tanks or water tanks or tank cars or whatever.

So in that context, I personally seem to feel that the question has relevance.

So my recommendation to the Chairman would be that we hear the answer.

MR. SOHINKI: If the question is limited to structure similar to that that we're dealing with here,

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I don't have any objection to the question.

JUDGE WOLFE: Well, it's on that basis ... And if that is the question, it's on that basis that I overrule the objection ... if there was one.

Doctor.

THE WITNESS: Would you please repeat in your words what the question is?

BY MR. DOHERTY:

Q. Do you know of any shells similar to the one to be used at Allens Creek that have ever buckled in any industry or any place?

A. You mean similar structure --

Q. Yes, uh-huh. That's correct.

A. -- in configuration?

Q. Yes.

A. (Shakes head, "No.")

JUDGE WOLFE: Answer yes or no. Your shaking your head doesn't get to the reporter. Yes or no.

THE WITNESS: No.

JUDGE WOLFE: All right.

THE WITNESS: Sorry.

BY MR. DOHERTY:

Q. Now, down further you speak ... at the bottom of page five about ... okay ... about geometrical imperfections.

How dces the Staff analyze the reports of the Applicant with regard to that?

A. Which report are you referring to?

Q. The PSAR.

A. The PSAR, as I recall, did not address the effect of geometrical imperfections. They rather suggest a method in general ... on how to design to resist buckling.

Q. Did they commit to the design?

MR. COPELAND: Your Honor, I suggest that the PSAR speaks for itself. I don't see any reason to ask that of this witness.

MR. DOHERTY: Well, I think I want to know if the witness believes they've committed to that design.

JUDGE WOLFE: I'll allow the question.

Do you know, Doctor?

THE WITNESS: (No immediate response.)

JUDGE WOLFE: Did you hear the question? You may answer it.

THE WITNESS: He asked whether in the PSAR the Applicant has committed to design and take care of this geometrical imperfection. Is that your --

BY MR. DOHERTY:

Q. Yes. Or anyplace did they commit? It would not have to be in the PSAR.

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MR. COPELAND: Well, I don't understand why we're doing this, because we had a witness in here this morning who was designing the containment. He explained how he is going to design it. And he said right here on the witness stand that he was the one who was going to do it.

I don't understand why we're asking through this witness things that are already on the record.

MR. SOHINKI: I'll join in that objection on the additional grounds that testimony this morning clearly was -- as to the preliminary design of the containment -- that it still had some work to be done on it.

JUDGE WOLFE: Yes. And that was a different witness.

I have overruled the objection. Answer the question, Doctor.

THE WITNESS: The method itself should take care of this geometrical imperfection.

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BY DOHERTY:

Q. Is it your understanding that the Applicant will use that method?

A. Yes.

Q. Okay.

Now, you state at the top of Page 6, "The steel containment of Allens Creek is designed for the loads which may give rise to its buckling."

Is one of those loads an explosion of hydrogen within the containment?

A. I would not think that explosion would be the load that would give rise to its buckling, because the explosion is a sudden increase of internal pressure of the containment. And, internal pressure usually gave the containment tension in all directions.

And, therefore, I don't think there is any possibility of getting buckling problems because of the explosion.

Q. Would an explosion give an asymmetric loading?

A. Yes.

An asymmetrical loading.

Yes.

But, it is very doubtful that you can find compression in the containment, because of that even with that asymmetrical loading from explosion.

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Q. Okay.

Now, could you get compression from -- from blowdown from a safety relief valve?

Couldn't you get compression as a result from that?

A. Again, I would like to clarify that in order to have buckling, the compression should be membrane stress compression.

It is not the bending type of compression just like you spin a piece of paper you have te-sion on one side, compression on --

I don't mean that. I mean, this kind, overall membrane compression. That would give you buckling.

Otherwise, this is bending It is entirely different process.

MR. SOHINKI: Mr. Chairman, may I just caution the witness that some of the examples he is giving will not get into the record because you are not explaining it verbally.

BY MR. DOHERTY:

Q. Can you think of any way a compression load might be impinged on the containment?

A. You mean compressive strength?

Q. Yes, sir.

I believe I do.

A. Earthquake for example.

It is possible because when the ground moves the structure do respond to the ground motion, and then there is so-call inertia load that would bend horizontally.

It is just like cantilevered beam, so that one side of the containment was subjected to compression. The other side to tension.

And, that is the possibility.

And, also, that is the buckling that we always concerned the so-called asymmetrical loading resistance.

MR. DOHERTY: Mr. Chairman, may I approach the witness?

JUDGE WOLFE: Yes.

(Mr. Doherty hands witness document.)

BY MR. DOHERTY:

Q. I want to ask you if you agree or disagree with the statement in this document, called NU-REG CR-1219, "The Analysis of the Three-Mile Island Accident and Alternative Sequences" prepared by Bechtel-Columbus Labs.

JUDGE WOLFE: Dated?

MR. DOHERTY: All right.

A stamp date of February 11, 1980, on the document.

MR. SOHINKI: Mr. Chairman, could we find out if the witness has seen this document before.

If he is familiar with it?

BY MR. DOHERTY:

Q. Have you ever seen Nu Reg CR-1219?

A. No.

MR. DOHERTY: All right.

I will withdraw that question.

BY MR. DOHERTY:

Q. You also spoke on Page 6, in the part marked Part 4, would any of this -- In Part 4 you state that if ". the prospective research program concludes that strengthening of the containment is required, it can be accomplised by welding additional stiffeners to the containment. . ."

Does this include meridianal stiffeners?

A. Yes, sir.

Meridian as well as circumferential.

Q. I see.

Now, would it be possible to construct a second shell?

MR. COPELAND: Objection, Your Honor. There's no --

MR. DOHERTY: Well, I think I needed a little more time --

MR. COPELAND: It seems to me that calls for pure speculation --

MR. DOHERTY: I was interrupted.

JUDGE WOLFE: Had you finished your question?

MR. DOHERTY: No, sir.

MR. COPELAND: I'm sorry.

I thought you had.

BY MR. DOHERTY:

Q Can you -- Could a second shell be installed to strengthen the containment if the research program concluded it was so needed?

A I don't understand what do you mean by the second shell.

Q Well by that I mean: ne shell literally over the other.

A You mean double the thickness?

Q No.

Not double the thickness.

Two shells with a space between each shell.

MR. SOHINKI: I'll object to that question on the grounds that there's no showing that additional stiffeners won't do the job.

MR. COPELAND: It calls for pure speculation. I join in the objection.

I think we're wasting time pursuing something like that.

(Bench Conference.)

JUDGE WOLFE: I'll sustain that.

We're dealing only with the containment shell as proposed, not as to what might be proposed in addition.

Objection sustained.

MR. DOHERTY: All right.

I have no further questions on Number 9.

JUDGE WOLFE: Proceed and complete with 27, and we can come back, unless you -- Which do you prefer, Mr. Sohinki?

MR. SOHINKI: I'd just as soon Mr. Doherty complete his examination on both contentions.

JUDGE WOLFE: Oh. All right.

MR. COPELAND: I don't have any questions.

JUDGE WOLFE: You had --

MR. COPELAND. I assumed we were on both. I didn't realize we were bifurcating.

JUDGE WOLFE: No. Proceed with 27.

MR. DOHERTY: No. The questions are nicely divided, so --

JUDGE WOLFE: Proceed with 27, Mr. Doherty.

MR. DOHERTY: Okay.

I have very few questions on this.

I think, perhaps, none.

BY MR. DOHERTY:

Q On Page 7, the answer in the middle of the page.

There's a figure given of maximum temperature for a power excursion of loss of coolant accident to which the pedestal would be subjected.

Who calculated that?

Was that calculated by the Staff?

A. This number is taken out from the PSAR as the design temperature for the dry well, and the Staff has also, independently, estimated that this number is in the right range of design temperature.

(Pause.)

Q. Now, in the next question and answer, you state, ". . .the concrete is confined and sealed by the steel cylindrical box."

A. Yes.

Q. Did you today hear a commitment that that be true?

A. They said that they have some -- as I understand, they have some openings.

It is not entirely tight.

MR. DOHERTY: All right.

I have no further questions.

Thank you, Dr. Chan.

THE WITNESS: Okay.

JUDGE WOLFE: Redirect, Mr. Solinki?

MR. SOHINKI: We have no questions, Mr. Chairman.

JUDGE WOLFE: Any questions?

JUDGE CHEATUM: I have one question, Dr. Chan.

BOARD EXAMINATION

BY JUDGE CHEATUM:

Q. It is a general thing.

I was wondering how it came about that buckling of the steel containment became an issue.

You have explained it to some extent in your opening explanation about this Task B-5 Task or whatever it was.

Could you add to that as to how this became an issue?

A. I will try to explain to you.

Buckling is a phenomena of instability.

What I mean, stability is the capacity of the structure of restoring in its original position or condition after the load is relieved.

If the load sustains, that creates the compression -- compressive stress in the member.

Then, if we keep on increasing the load, there will be the breaking point to make that structure unstable.

Now, if we put a ball in a dish which contains; and the ball no matter what you pour in it, it will go back to the center.

So, that is stable.

But, if we overturn the dish the ball may be temporarily in an equilibrium. Or, in the balance position. But, it is not stable. It can roll down -- trigger a little bit of force and it will roll down.

And, if it isn't lying on a flat table, that is the critical condition. It is in between stable and unstable. That is the critical condition.

The phenomenon of buckling, also, I take for example, a bar. If we applied a load on it.

Where the load is small, it is stable. But, when we keep on increasing it for a certain configuration, a geometrical configuration of this bar, it may be unstable. A long, thin column, it is very easy to buckle even though they have the same cross-section. If it is short, it won't buckle so easy.

But, in other words, suppose we put the load on a short bar. It won't buckle.

But, if we increase the length of the bar without changing the load, it will buckle.

Q. I understand that. You've made that very clear. But you've also --

A. So, wherever --

Q. Oh, I'm sorry.

A. Excuse me.

Go ahead.

Q. But, you've also indicated that only one force that you illustrated to Mr. Doherty in answer to his question as to what events might occur which would cause buckling, you mentioned earthquake.

A. Yes.

Q. An earthquake situation might result in buckling. Compression on one side. Extension of the other or slouching on the other.

A. That's right.

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Q Is the general concern about earthquakes and their affects on nuclear plants, containment structures and other structures in nuclear plants.

Is this one of the areas where you felt that you needed a little more confidence in evaluating the resistance in relation to design, with respect to buckling.

You see what I mean?

Is this sort of the origin of the concern --

A. That's right.

Q -- all of the possibilities that would bring about buckling.

A. Yes.

The possibilities.

Q Yes, I know.

A. As long as there is compressive stress --

Q But, you've had no failures so far --

A. That's right.

But, the possibility is different --

Q Right.

A. Because even though with the earthquake, that compression stress may not be high enough to cause buckling.

Q All right.

Okay. I think that answers my question.

JUDGE CHEATUM: Thank you.

BY JUDGE LINENBERGER:

Q. Dr. Chan, with respect to the Staff's Action Plan and Task B-5, which you indicated has not yet been approved, assuming that it were approved, does the Staff have an estimate of how long it would take to complete the analyses indicated in your presentation here.

In other words, if Task B-5 could be begun immediately, how long would it take to complete it.

Or can you estimate that? Do you have an estimate for that?

A. I'm sorry, I am not in a position to answer you this question because I'm not responsible --

Q. Okay.

A. -- for this Task.

Q. On Page 4 of your testimony, about in the middle of the page, there is a statement that, "Task B-5 continues as a Category B Task and is not classified as an "Unresolved Safety Issue."

A. Yes, sir.

Q. On Page 6, just above the middle of the page, there is a statement that the Staff considers the ". . .buckling of the containment is classified as a generic safety issue. . .".

A. Yes.

Q. Now, I don't think there is necessarily a

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contradiction there. But, if containment buckling is a generic safety issue, then I'm interested in the rationale that allows one to conclude that Task B-5 does not constitute an unresolved safety issue.

A. Task B-5 is categorized, I think, Category B which is -- let me state it to the definition of Catagory B -- Catagory B of the Generic Safety Issues.

So, there is no contradiction on that.

The only thing is that Category B is the kind of generic issue that we don't need an early resolution.

Q. And, this is primarily because in the case, specifically of containment buckling, because it is relatively straight forward to go in later and so something if a need for that something is indicated?

A. That's right.

It's to our knowledge, it eliminates some uncertainty, and it clarifies a lot of late points.

(Bench Conference.)

Q. All right.

Let me just stick with that for a moment.

Containment buckling is classified as a generic safety issue, is that -- that's correct.

Task B-5, I think has perhaps its sole motivation, perhaps there are other motivations; but it

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seems to me it has its sole motivation derived from the possible buckling problem and you're saying that Task B-5 is not a high priority Task.

And, I'm assuming that the reason you're saying that is because Task B-5, when it is completed, indicates a deficiency of some sort in the analyses, plants that might potentially have a buckling problem can be strengthened if you will, by later applying stiffeners.

Is that --

A. That's correct.

Q. -- a correct statement?

All right.

Now, the problem I have here is that for understandable reasons, you don't know the schedule for completion of Task B-5. Probably not the schedule for approval of funding for Task B-5 --

A. No. I do not.

Q. -- therefore, in essence, what I see that we have here is an unresolved, generic safety issue associated with the possibility of containment buckling that may exist in already completed plants or plants that are being built for perhaps quite some years before the accomplishment of Task B-5 comes along and assures the Staff that, "Well, everything is or may not be all right with these plants."

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So, I say to myself, "Doesn't this cause some concern that while we're waiting to gain this additional confidence and precision out of the accomplishment of Task B-5, we may have some plants sitting around operating that are on the verge of being susceptible to buckling if the next earthquake is a little bit bigger than anticipated.

So, that -- I wonder why that isn't a problem that concerns the Staff.

Or a consideration that concerns the Staff.

Can you answer that or comment on it?

A. (No immediate response.)

Q. It may be ten years before Task B-5 is completed.

There may be a plant going into operation this year that has a containment like this.

So, it will ten years before the Staff has the confidence -- Now, these are my words. This is a supposition, but it may be ten years before the Staff knows that the plant that is going into operation this year does or does not possibly have a buckling problem.

There it sits for ten years operating. Isn't that kind of situation putting the public in some potential risk?

A. The way I feel is: Before the Task B-5 is completed, the containment or the shells designed by the present code or criteria will still stand. It won't buckle.

What is going to change is the margin of safety will change because we understand better the problem.

Q Fine.

Now, I understand that.

So, that then comes back then to cause me to ask the question: If you have confidence that the containments standing now, and during the period between now and the completion of Task B-5 won't buckle, why is containment buckling classified then as an generic -- as an unresolved generic safety problem?

A. Because the possibility of buckling still exists as long as there is a membrane compressive stress existing in this shell.

MR. SOHINKI: Judge Linenberger, can I -- I hesitate to interrupt; but I think he may be confusing terms.

I think you just asked whether it was an unresolved generic issue; and that gets into a conflict between the two terms and I'm not sure he is understanding what you are trying to say.

JUDGE LINENBERGER: Okay.

I did that purposely to see what kind of a

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response I might get.

But, peace.

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BY JUDGE LINENBERGER:

Q. On page five there is an item one just below the middle of the page ... or a paragraph one just below the middle of the page. And the last sentence of that paragraph one states that the "use of Regulatory Guide 1.57 related criteria is expected to be adequate and to provide ample margin of safety."

Now, what is the basis for the expectation of adequacy?

A. Let me take out Reg Guide 1.57.

Q. Sure.

(Pause.)

A. I specifically point at -- refer to the Regulatory Guide 1.57, Page 3, Article (e), small "e". That should be identified as B.1(e).

It mentions that the design limits of NE 3131.1 of the Code, which refers to the ASME Boiler and Pressure Vessel Code, Section 3, are specified for this loading combination.

However, if a detailed analysis is performed, Note 7 to the Regulatory Decision set forth in this Guide applies.

The factor of two, between the critical buckling stress and applied stress, as specified in Note 7 is based on generally applied margins used where

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the shell buckling is a design consideration.

So this referred to specifically the Reg Guide 1.57-related criteria, that is, that use of the factor of safety two is adequate.

Q. Okay. That's the basis for that?

A. Yes, sir.

Q. All right, sir.

Now at the top of Page 6, that Item 3 I have the impression says something a little different from what I thought I heard this morning from Mr. Mokhtarian.

Let me explain and maybe the problem I have with it -- or the difference I think I see.

The paragraph states that "The steel containment ... is designed for the loads which may give rise to its buckling."

But -- and now I'm putting my interpretation here. The containment design for loads which may give rise to buckling, but because of conservatism in the specification of loads, buckling is not likely to occur.

Now is that what paragraph three says, the way I rephrased it?

A. (No immediate response.)

Q. It's the conservatism in the specification -- I use the word "specification." This uses the word "definition."

Conservatism in the definition of loads that makes it unlikely that buckling will occur.

A. That's correct.

Q. Okay.

This morning Mr. Mokhtarian talked about some safety factors associated with the analysis of critical buckling stresses or loads. And those were, as I understood, his characterization of the safety factors -- the purpose of those safety factors was to accomplish the following.

Given a load or a stress specified by the Applicant, based on nuclear behavior of the plant, the containment designer, taking that load or stress as a given input, makes an analysis of what the vessel should look like ... thickness, stiffeners, whatever ... and to assure himself that the buckling analysis that he makes that leads to the ultimate vessel design is conservative, he puts in these safety factors of 2.75, if you're in the elastic range, and down to 2.0 if you're in the inelastic range.

So I got the impression from Mr. Mokhtarian's discussion that it was the safety factors in the buckling analysis that made it unlikely ... a low probability that buckling would occur, rather than conservatism in the Nuclear Plant Behavior Specifications for Load Designations that the Applicant would come forth with, that would give rise to conservatism.

Now, are you and he saying two different things here? Or have I misunderstood one of you? Or can you understand me?

A. I believe that I may have a different definition of factor of safety than Mr. Mokhtarian mentioned this morning.

But --

Q. You see, what bothers me here is: Your Paragraph 3 seems to be saying that the Staff is relying on the Applicant to come forward with conservatism with respect to the result of a nuclear event, such as the peak value of the containment pressure pulse.

And if there is conservatism there, then you avoid buckling.

A. The conservatism associated with the definition of the loads, that means -- I just mentioned that the load which may give rise to buckling more likely is seismic load ... an earthquake load.

And that earthquake load, when we define that load, it already has some kind of conservatism in it. For example, the G value of the -- I mean the acceleration .. ground motion acceleration, G value ... itself is a conservatism there.

But we do not count on that kind of conservatism.

But if we do, it is believed to compensate the uncertainty related to the buckling concern.

Now, what are the uncertainities of the buckling concern? We know pretty well the concern of uniform stress buckling, like in the cylindrical shell ... are the stresses of it distributed uniformly?

This is the buckling stress we usually mention. But the uncertainty for the earthquake type of compression, it only happens on maybe half of the shell.

The other is intangent. So we are using the stress calculated for the partial distribution of the shell and apply it to the all-round uniformly distributed load.

And this involves some kind of uncertainty. But we feel that that uncertainty is also on the conservative side, too.

So no matter what the uncertainty related to ... this conservatism is believed to compensate even if that is an adverse effect.

Q All right, fine.

Let's go to the next subject now, the containment pedestal.

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Your prefiled testimony is certainly consistent with Mr. Simpadyan's insofar as establishing that the concrete itself has no load bearing function with respect to the support of the pressure vessel.

You've indicated that the concrete ring between the -- within the annulus of the two pedestal rings -- both of you agree -- provides some additional biological shielding.

A. Yes.

Q. Now, Mr. Simpadyan indicated that the concrete that we're talking about served another function, and I'll probably phrase this improperly.

But, in essence, it served the function of achieving a sort of dynamic or vibratory matching of the base of the pressure vessel to the pressure vessel itself, insofar as its response to vibratory loads are concerned.

Now, I don't see that you mention this, and I wonder if you feel that this is an important role for the concrete.

A. I did not mention this concern that Mr. Simpadyan mentioned ... to talk about, because at first I do not quite understand what he means until this afternoon he mentioned that that is the requirement, or they have to match the GE specification of frequency range.

Now, GE made one -- they designed their reactor vessel, according to a certain measured frequency of the system -- reactor system ... that that reactor and its supporting pedestal on a thick mat -- concrete mat, which assumes a fixed base.

So the natural frequency of the system, that is, the reactor vessel coupled with the pedestal -- that may be expressed by GE that it is desirable to keep it within the designed natural frequency.

And to fill up that with concrete is to add the mass to the supporting system.

Now, since it is not a structural component in the pedestal, it does not increase the stiffness. At least we don't count on that ... the stiffness.

The natural frequencies of the system is a function of two things. One is the mass. The second is the stiffness.

Usually, it's M over K ... square root, or something like that. I cannot remember that formula correctly.

But mass of the pedestal is a way to change or to make the natural frequency of the coupled system to a certain range.

And I feel maybe, if I understand Mr. Simpadyan correctly, I think this is what he means.

Q Well, I guess the question I was asking you is -- I mean, I, too, think that's what he means. I agree with you.

But the question I was asking you is: Do you personally, on the basis of your own understanding of the dynamics of laboratory analysis, feel that this extra mass in the pedestal plays an important role -- that it is indeed important to add mass at that point?

A. It is desirable, because it adds the stability of the system.

Q Would you say it increases the inertia of the system?

A. That's right.

Q All right.

That consideration led me to one more; namely, if the concrete were free to -- were not tightly constrained within the pedestal, such that it was loose, suppose you threw in some lead balls that weighed as much as the concrete but didn't take up all of the volume, and then an earthquake started the system, and the lead balls were free to bounce around and move, would this serve the same purpose as a tightly bound load of concrete that could not shift under vibratory loads?

In other words, I'm trying to understand how important is the monolithic integrity of the concrete in this dynamic response analysis. Is this important at all?

A. If concrete is used as the filler, it really doesn't matter. It is only the mass.

Q. Only the mass?

A. All right, fine.

Q. On Page 7, near the top of the page is a question that asks what is the maximum temperature the reactor pedestal is designed to withstand.

And my impression is that the answer is not responsive to the question. The answer /s -- talks about what temperature the pedestal will experience.

But the question was what temperature is it designed to withstand.

Now, I don't know how different the two answers are, but I would suspect that the pedestal is designed to withstand a considerably higher temperature than it actually experiences.

Do you happen to know what temperature it is designed to withstand?

A. I just mentioned while ago the design temperature ... 330° --

Q. Right. But I'm sure that's not the temperature that the pedestal is designed to withstand.

In other words, there will be no yielding --

there will be no deformation of the pedestal at that temperature.

I suspect that the pedestal could stand a temperature twice that high, without the yield strength of the material being reached. I would guess that. I don't know.

So all you're saying is that it's just safe at that temperature?

A. Safe.

Q. All right.

A. It could stand higher temperatures --

Q. I would think so.

A -- because according to the ASME Code, I guess, the change of steel -- strength of steel is very little for temperatures below 700 or 600.

So 330 is really ...

Q. Okay, fine.

A. -- not a concern.

Q. And the final point: There has been some discussion about whether moisture will or will not be able to get out of the concrete.

Since the concrete is not load bearing, since it's basically the gross weight that's important and since the amount of moisture free to leave is probably small, does it really make any difference whether any moisture gets out of the concrete in this situation?

A. If I talk about the strength of concrete, we know that the property of concrete is it gains strength with time.

And it's because -- During this slow curing process, it just gains strength. And it dries up -- some of the moisture by curing.

But if they lost too much moisture, then the concrete becomes brittle. If you subject to -- well, put a real high temperature to the concrete, then it dries up excessive moisture from the concrete. And then the concrete may become brittle, and it's easy to crack.

Q. What difference does that make if all you're depending on is the weight of it?

A. No ... no change ... not much change --

Q. Except there may be a little weight lost if the moisture comes out, but --

A. Well, if some condensate water sneak into it ... so we don't really lose any weight either.

Q. But if it cracks up ... so far as you're relying on it for support and you're only relying on it for weight, in terms of the dynamic response. So really is it almost immaterial whether --

A. Immaterial.

JUDGE LINENBERGER: Okay, thank you. That's

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all of the questions I have, Judge Wolfe.

JUDGE WOLFE: Is there cross on Board questions, Mr. Copeland?

MR. COPELAND: No, sir.

JUDGE WOLFE: Mr. Doherty?

RECROSS-EXAMINATION

BY MR. DOHERTY:

Q. What's the year of Regulatory Guide 1.57, Dr. Chan?

A. I guess it is 1973, June 1973.

MR. DOHERTY: No further questions, Your Honor.

JUDGE WOLFE: Is there redirect?

MR. SOHINKI: I just had perhaps one or two questions, Mr. Chairman.

REDIRECT EXAMINATION

BY MR. SOHINKI:

Q. Dr. Chan, you were discussing the assumption of the uniform load to compensate for uncertainities in buckling analyses.

A. Yes.

Q. Is that methodology -- the assumption of a uniform load, is that the methodology that's going to be used by the Applicant?

A. Yes.

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Q And on a scale from least conservative to most conservative methodology, where would you place that?

A That is the most conservative of the three alternative methods mentioned by the ASME Code -- the latest one, 1977 addendum.

MR. SOHINKI: No further questions, Mr. Chairman.

JUDGE WOLFE: Is the witness to be permanently excused?

MR. SOHINKI: Yes, sir.

JUDGE WOLFE: The witness is permanently excused.

(The witness was excused.)

JUDGE WOLFE: We'll recess until 9:00 a.m.

(Whereupon, at 5:30 p.m. the hearing was recessed to reconvene at 9:00 a.m., Tuesday, May 19, 1981, in the same place.)

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This is to certify that the attached proceedings before the

NUCLEAR REGULATORY COMMISSION

in the matter of: HOUSTON LIGHTING & POWER COMPANY

DATE of proceedings: May 18, 1981

DOCKET Number: 50-466 CP

PLACE of proceedings: Houston, Texas

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

MARY L. BAGBY

Official Reporter (Typed)

Mary L. Bagby

Official Reporter (Signature)