

RAS 4541

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Private Fuel Storage, LLC

Docket Number: 72-22-ISFSI; ASLBP No. 97-732-02-ISFSI

Location: Salt Lake City, Utah

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UNITED STATES OF AMERICA
 NUCLEAR REGULATORY COMMISSION

)	
In the Matter of:)	
PRIVATE FUEL STORAGE, LLC,)	Docket No. 72-22
(Independent Spent Fuel)	ASLBP No.
Storage Installation))	97-732-02-ISFSI
)	

U. S. Nuclear Regulatory Commission
 Sheraton Hotel, Wasatch Room
 Salt Lake City, Utah 84114

On June 4, 2002 the above-entitled matter came
 on for hearing, pursuant to notice, before:

MICHAEL C. FARRAR, CHAIRMAN
 Administrative Judge
 U. S. Nuclear Regulatory Commission

DR. JERRY R. KLINE
 Administrative Judge
 Atomic Safety & Licensing Board Panel

DR. PETER S. LAM
 Administrative Judge
 Atomic Safety & Licensing Board Panel

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I N D E X

E X A M I N A T I O N

Witness Panel: Krishna Singh and Alan I. Soler

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No.	MRKD/ADMTD
APPLICANT'S EXHIBITS	
86A Modified beyond-design-basis report	9563/
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225 Additional Cask Analyses for the PFSF, Holtec Report No. HI-2022878	9604/
226 Multi-cask Seismic Response at the PFS ISFSI, Holtec Report No. HI-97-1631	9619/9690
221 (Marked previously)	/9690
92 (Marked previously)	/9691
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STATE'S EXHIBITS	
197 Information from Max DeLong to John Vincent	9733/9781
198 Letter to Kris P. Singh from Mark S. Delligatti	9765/9781
199 Document "Predicting the Structural Response of Free-standing Spent Fuel Storage Casks Under Seismic Events	9771/9788

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1 June 4, 2002

9:02 a.m.

2 P R O C E E D I N G S

3 JUDGE FARRAR: It looks like we're all
4 set to go. Any preliminary matters?

5 (No response.)

6 JUDGE FARRAR: Then we're ready to start
7 the PFS rebuttal witnesses.

8 MR. GAUKLER: Yes, we are.

9 JUDGE FARRAR: Okay. I see Dr. Singh
10 and Dr. Soler there.

11 MR. GAUKLER: Yes.

12 JUDGE FARRAR: You'll recall being sworn
13 earlier in the case, so if you'll consider
14 yourselves still under oath.

15 DR. SOLER: Yes, Your Honor.

16 DR. SINGH: We do.

17 KRISHNA P. SINGH

18 and

19 ALAN I. SOLER,

20 called as rebuttal witnesses,
21 having been previously duly sworn to tell the
22 truth, were examined and testified as follows:

23 DIRECT EXAMINATION

24 BY MR. GAUKLER:

25 Q. Before we get started with the rebuttal,
26 Dr. Singh and Dr. Soler, do you have any changes
27 that you wish to make in your previously prefiled
28 testimony?

29 DR. SOLER: Yes, we do.

30 MR. GAUKLER: And let us hand out copies
31 of what changes have been made so they can see it.

32 MR. SOPER: Your Honor, I'm a little
33 confused at the process here. If this is the
34 direct testimony, direct prefiled testimony which
35 has already been introduced, sworn to and after
36 changes have been made, I object to a second round
37 of doing the same. They've also been

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1 cross-examined on their sworn testimony.

2 JUDGE FARRAR: Let's hold the objection
3 for a moment, let Mr. Gaukler present these changes
4 and the reasons for them, and then we'll hear your
5 objection.

6 Q. (By Mr. Gaukler) Dr. Soler, would you
7 please describe the changes?

8 DR. SOLER: In Question 1 -- in the
9 answer to Question 144, and specifically on page
10 82, the number 33 hertz should be changed to 22.6
11 hertz. The number 40,100 -- 40,130,000 pounds per
12 inch should be changed to 18,864,480 pounds per
13 inch in two places on that page in that response.
14 And the number .009 should be changed to .019 and,
15 if possible, add the word "total" for clarification
16 before the word "vertical" in the fifth line from
17 the bottom of the answer.

18 Q. And would you please tell me the reasons
19 for these changes?

20 DR. SOLER: The reasons for these
21 changes is to reflect an inconsistency in our
22 report which was determined from ongoing analyses
23 on this and other projects. We put in input for 34
24 contact elements but actually put in a spring
25 constant input for only 16 elements. And while the

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1 analyses and the results remain the same, in order
2 to provide the correct information for the record
3 and on the report, we felt it required us to inform
4 the Board of this change.

5 Q. So these are -- were the input
6 parameters for the simulations that you ran --

7 DR. SOLER: For the, I believe --

8 Q. -- last year?

9 DR. SOLER: -- 11 simulations that were
10 in the beyond design basis report.

11 MR. GAUKLER: Your Honor, those are the
12 reasons for the corrections, and I think we should
13 put them into the record so we have a complete
14 record.

15 MR. SOPER: May I voir dire?

16 MR. GAUKLER: And we also have made
17 changes to the beyond design basis report to
18 reflect the same corrections, which was PFS
19 Exhibit 87, which I think was handed out at the
20 same time.

21 JUDGE FARRAR: That was previously
22 admitted, and now you have changes to that?

23 MR. GAUKLER: I don't know if that was
24 admitted or not. That may have been held up
25 pending the State's objections. I forget exactly

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1 whether or not that was admitted, but it certainly
2 was handed out and discussed.

3 JUDGE FARRAR: Okay.

4 MR. GAUKLER: If I could hand that
5 out --

6 JUDGE FARRAR: It looks like it was not
7 admitted. Let's hand out the new version.

8 MR. GAUKLER: Let's mark this, just for
9 purposes of the record, as PFS Exhibit -- I'll have
10 the right number in a second.

11 JUDGE FARRAR: If you've not put that
12 number on there already, should we do 87A --

13 MR. GAUKLER: That's fine.

14 JUDGE FARRAR: -- so there will be some
15 connection?

16 MR. GAUKLER: Excuse me. It's 86A, it
17 should be.

18 JUDGE FARRAR: 86A.

19 (APPLICANT EXHIBIT-86A WAS MARKED.)

20 (A discussion was held off the record.)

21 JUDGE FARRAR: Mr. Gaukler, unlike the
22 corrected testimony handed out a moment ago which
23 just had the front page and pages 81 and 82 where
24 the corrections are, is this the entire report?

25 MR. GAUKLER: Yes, it is, and it shows

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1 revision bars in the right-hand column, I believe,
2 where revisions were made. And I'll have Dr. Soler
3 briefly describe what these are as well, for the
4 record.

5 JUDGE FARRAR: All right.

6 Q. (By Mr. Gaukler) Dr. Soler, would you
7 briefly describe the changes to the report? And I
8 believe there was one additional run you did make
9 in this connection as well. Would you please
10 describe that for the Board and the record?

11 DR. SOLER: Yes. The report was updated
12 to reflect the correct number of contact points.
13 Throughout the report you will find where used to
14 be a number 34 is now a number 16.

15 The -- an appendix was added which
16 really contains, I believe, one of the State's
17 exhibits where we provided a complete set of input
18 data for each run. We took the opportunity to
19 incorporate that into the report as an appendix so
20 that it goes with the report instead of a separate
21 document, and we made the necessary corrections to
22 that.

23 And, finally, we produced an additional
24 dynamic simulation. We reran Case 1 with the
25 parameters that we had intended to use in the first

1 place, namely, 40 million total stiffness, and an
2 appropriate damping that goes with that. And we
3 produced a Case 12, and we showed that, in fact,
4 the first 11 simulations were giving conservative
5 results, somewhat larger results than had they been
6 run with 40 million stiffness.

7 And if I can, just for the record, read
8 the comparisons. These are in the report. For the
9 case where the stiffness is only roughly 18
10 million, the net displacement at the top of the
11 cask was 3.7 inches. When the -- when the
12 stiffness was raised to 40 million, the
13 displacement dropped to 3.2 inches. The maximum
14 angle of rotation for the -- what I'll call the
15 less stiff case .916 degrees. For the additional
16 run, that same angle drops to .792 degrees.

17 The -- of course, the text of the report
18 in various places was updated to reflect the actual
19 inputs to the, in this case, now 12 simulations.

20 Q. Where were you reading those numbers
21 from with respect to --

22 DR. SOLER: Those numbers were coming
23 from a table in Section 9, in particular on page
24 21, of the report.

25 JUDGE FARRAR: Dr. Soler, I thought in

1 your description you just gave you went back to the
2 40 million, but your correction and testimony
3 indicates you used to be at 40 million and now
4 you're at 18 million? Did I misunderstand that.

5 DR. SOLER: A little bit, Your Honor.

6 JUDGE FARRAR: Did I misunderstand it or
7 did you misstate it or both?

8 DR. SOLER: I'm not sure, so let me
9 restate it again.

10 JUDGE FARRAR: Okay.

11 DR. SOLER: The original analyses that
12 were shown as movies in earlier testimony where we
13 had stated in the report they reflected stiffness
14 of 40 million, in reality we have now found they
15 reflected a stiffness of 18 million, all of those
16 11 simulations. Therefore, the text of the report
17 needed to be corrected to reflect the true data.
18 In order to show that if you had used 40 million as
19 we originally intended, that we would have gotten
20 even less displacement, we ran an additional case.

21 JUDGE FARRAR: So you're saying
22 40 million is the better number to have used, and
23 you -- and you mistakenly used 18?

24 DR. SOLER: That would be an appropriate
25 way to put it, yes.

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1 JUDGE FARRAR: So you're correcting your
2 testimony to show that you used 18, so that's how
3 we can understand the animations from before?

4 DR. SOLER: Correct.

5 JUDGE FARRAR: But now your report uses
6 the 40 million and shows that, had you used that,
7 that would have been more conservative?

8 DR. SOLER: Well, our report stands as
9 it did before. But the text has changed to
10 basically say that the first 11 runs are done with
11 a stiffness of 18 million, but we have added in
12 this revision a 12th run for a sensitivity
13 comparison, if you will, for -- and it's only the
14 12th run that uses 40 million. So the report
15 stands as an 18 million stiffness report, if you
16 will.

17 JUDGE FARRAR: Okay. Mr. Soper, before
18 you start your --

19 MR. GAUKLER: Your Honor, I just wanted
20 to clarify.

21 Q. You did -- the sensitivity stayed with
22 Case 1, right?

23 DR. SOLER: Yes, for the --

24 MR. GAUKLER: And Case 1 it change the
25 18 million to the 40 million stiffness --

1 DR. SOLER: Yes, if you will read
2 through the changes in the report, you will find
3 that previously Case 1 was with the 2K earthquake,
4 and then there were 10 additional cases. We have
5 now added a Case 12 which is the same as Case 1
6 except with a stiffness -- a total stiffness
7 increased to 40 million.

8 JUDGE FARRAR: All right. Mr. Soper,
9 before you start your voir dire, give me a minute
10 with my colleagues.

11 (The Board confers off the record.)

12 JUDGE FARRAR: Go ahead, Mr. Soper.

13

14 VOIR DIRE EXAMINATION

15 BY MR. SOPER:

16 Q. Dr. Soler, the changes to your testimony
17 are in a sentence that reads, In our latest
18 analysis for the beyond design basis 10,000-year
19 return period earthquake, we used an equally valid
20 rationale for the choice of contact stiffness;
21 namely, for a simple vertical vibration of the
22 cask, we set the stiffness so that it was
23 consistent with the assumption that the lowest
24 frequency of vibration was 33 hertz.

25 Now, that was your original testimony;

1 was that right?

2 DR. SOLER: Correct.

3 Q. Was that ever true, sir?

4 Dr. Singh, I could hear you here, but I
5 don't think the reporter got it .

6 DR. SINGH: It's essentially true.

7 Q. You did set it so that it was consistent
8 with the lowest vibration at 33 hertz?

9 DR. SINGH: No, no. That's not --

10 Q. Was it ever true? Was 33 hertz ever
11 correct in your testimony?

12 DR. SINGH: 33 hertz is a derived
13 number. 33 hertz will become approximately 22
14 hertz.

15 Q. Let me ask Dr. Soler.

16 DR. SINGH: Okay.

17 DR. SOLER: It was our intention to set
18 it at 33 hertz.

19 Q. And you did not; is that true?

20 DR. SOLER: That is true, we did not.

21 Q. Okay. And let me ask you another
22 question. Did -- this report that's been marked as
23 86A, does that use the figure 33 hertz in it?

24 DR. SOLER: Now or --

25 Q. Originally.

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1 DR. SOLER: Originally it had 33 hertz
2 in it. Now it has 33 hertz and 24 -- 22.6 hertz.

3 Q. It originally represented that it was
4 consistent with the assumption that the lowest
5 frequency vibration was 33 hertz, just like --

6 DR. SOLER: That is correct.

7 Q. -- just like your testimony was
8 originally?

9 DR. SOLER: That is correct.

10 Q. And that was incorrect originally?

11 DR. SOLER: You could say that, yes.

12 Q. And that's in spite of the fact that
13 this document represents that it had been subjected
14 to review, verification and approval according to
15 the process set forth in the Holtec quality
16 assistance procedures manual. The report went
17 through that process, did it not?

18 DR. SOLER: It did.

19 Q. And, nevertheless, it was incorrect; is
20 that correct?

21 DR. SOLER: That is correct.

22 Q. And it was incorrect even though -- in
23 order to gain acceptance as a safety significant
24 document in the company's quality assurance system,
25 the document was required to undergo a prescribed

1 review and concurrence process, and it was
2 incorrect in spite of that; is that right?

3 DR. SOLER: That is correct. Both the
4 author and the reviewer missed this point.
5 However, let me add that as part of our QA process,
6 in ongoing work, if we suspect that there is a
7 potential problem because of some new reviews we do
8 on either that project or another project, we are
9 required to go back and investigate other projects
10 which may have the same problem by -- and that is
11 what we do because that -- our QA program is, I'll
12 say, a living thing. No document is ever put to
13 rest and --

14 Q. In spite of its initial review and
15 approval, it may subsequently be found to be wrong,
16 and you would change it in that event?

17 DR. SOLER: If it was found, there would
18 be a number of processes. If it was found to be in
19 error in a conservative manner, the process might
20 simply be to document the conservativeness of the
21 actual result and, depending on the circumstances,
22 simply go on with life. In other situations,
23 generally we would update the report to reflect the
24 changes and resubmit it as a new revision. And
25 that's what we've done here.

1 Q. And your testimony is also changed in
2 the respect that -- the sentence reading, This
3 requirement yielded a vertical stiffness value of
4 40,130,000 pounds per inch, that statement was
5 never true, was it?

6 DR. SOLER: Well, that statement is tied
7 to the 33, so if one changes, so does the other.

8 Q. Could you answer my question, please?

9 MR. GAUKLER: I think he did.

10 JUDGE FARRAR: No, he didn't.

11 DR. SOLER: Well, I thought I did, but I
12 will answer it with a yes if you desire.

13 I mean maybe you better --

14 MR. SOPER: Ms. Court Reporter, would
15 you read my question, please?

16 DR. SOLER: Maybe you better read back
17 the question.

18 (The question was read as follows:

19 "Question: And your testimony is also
20 changed in the respect that -- the sentence
21 reading, This requirement yielded a vertical
22 stiffness value of 40,130,000 pounds per inch, that
23 statement was never true, was it?")

24 DR. SOLER: Now, let me think whether --
25 never true. Yes, that statement was never true.

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1 Q. (By Mr. Soper) Thank you.

2 DR. SINGH: Can I add to the question
3 you asked?

4 Q. Well, I think that Mr. Gaukler will
5 probably ask you a question he wants you to answer,
6 Dr. Singh.

7 DR. SINGH: Okay.

8 Q. Dr. Soler, who did the QA review on the
9 Exhibit 86A?

10 DR. SOLER: Are you asking the name of
11 the reviewer?

12 Q. Yes, sir.

13 DR. SOLER: Dr. John Zhai.

14 Q. Anybody else?

15 DR. SOLER: No.

16 Q. I don't see his initials appearing here.
17 Am I missing that?

18 DR. SOLER: No. The initials appear --
19 the actual signature appears in our database. It
20 does not appear on the page of the report.

21 Q. Is he the only reviewer on this?

22 DR. SOLER: Technically, yes.

23 Q. How about non-technically?

24 DR. SOLER: There is a project manager
25 who signs off mainly on the -- I guess the

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1 readability of the report and that everything that
2 was required to be put in there in terms of topics
3 is in there. And then, of course, quality
4 assurance signs off to basically ensure that we
5 have put in a pointer to all the computer files and
6 that every page number is numbered, housekeeping
7 items like that. But mainly the technical work is
8 reviewed by the author and the reviewer -- and the
9 technical reviewer.

10 Q. Now, in the -- as I understand, the
11 final change to your testimony is the sentence that
12 reads, This different value, however, also met the
13 test of, quote, no visible penetration, unquote, as
14 formulated in the ANSYS guideline manual, for it
15 yielded an interpenetration D equals 360,000 pounds
16 per -- and originally you had 40,130,000 pounds per
17 inch equals 0.0 --

18 DR. SOLER: 9.

19 Q. What was the original, 0. --

20 DR. SOLER: 009.

21 Q. .09 --

22 DR. SOLER: No, no, .009.

23 Q. -- .009 inches, excuse me, a value
24 sufficiently low to be deemed acceptable.

25 And, of course, that number that

1 appeared there originally, the 40,130,000, was
2 incorrect at all times; isn't that true?

3 DR. SOLER: That is true.

4 Q. And you've changed that number to
5 18,864,480; is that right?

6 DR. SOLER: That's correct.

7 Q. A little less than one-half of the
8 initial number?

9 DR. SOLER: That's correct.

10 Q. And, yet, your statement in other
11 respects, that is, a value sufficiently low to be
12 deemed to be acceptable, is unchanged. In other
13 words, with the new number you make the same claim;
14 is that right?

15 DR. SOLER: Yes, although I would say
16 not as strongly as I would like it to be.

17 Q. Was this analysis done by ANSYS?

18 DR. SOLER: No.

19 Q. I don't understand your reference to the
20 ANSYS --

21 DR. SOLER: It was simply a reference
22 because ANSYS gives guidelines on how to pick a
23 contact stiffness if -- if you are picking one or
24 calculating one, whatever you're doing, so I
25 referenced that guideline, even though I was using

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1 a different program.

2 MR. SOPER: Now, Your Honor, with
3 respect to these changes, I would object to them
4 for the following reason: Like every other witness
5 in this proceeding, they swear to testify under
6 oath. They're cross-examined on that testimony.
7 Where inconsistencies or inaccuracies appear, they
8 appear, and they get explained to the best of the
9 witness's ability on the record. And the witness
10 that's not satisfied with how he did in cross-
11 examination or finds that he made an error does not
12 get to go back to ground one and change their
13 testimony from the start to what they preferred it
14 would have been.

15 Now, we've covered the explanations
16 here, the errors that have been made. They're on
17 the record. We understand what they are. But that
18 doesn't entitle these witnesses to a new prefiled
19 testimony. I object on that grounds.

20 MR. GAUKLER: Your Honor, I'd like to
21 say, first of all, I think under NRC rules and
22 requirements we're supposed to correct an error
23 that you identify under the McGuire Doctrine. We
24 identified this mistake. We just identified it
25 over the past week -- weekend, and we corrected it

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1 promptly. And we think the record ought to be
2 clear exactly what the parameters are with respect
3 to the analysis that was done. And the results
4 were changed of the analysis, and, also, as
5 Dr. Soler and Dr. Singh point out, that, in fact,
6 this is a situation where the results are more
7 conservative than we had intended to show had we
8 used the original parameters we intended to use.

9 DR. SOLER: Could I correct that? The
10 results of the report did not change.

11 DR. SINGH: The solution, if it had been
12 run with the intended spring constant of
13 40 million, would have produced a smaller
14 displacement, less kinematic response from the
15 casks.

16 DR. SOLER: But the important thing is
17 no results that were presented before in the movies
18 or discussed as results have changed.

19 JUDGE FARRAR: Does the Staff have an
20 opinion on this?

21 MR. O'NEILL: I don't have any
22 objections to the extent that these represent
23 corrections that would serve to improve the
24 accuracy of the record.

25 I guess, you know, my concern is can you

1 say that the general conclusions that are based on
2 the specific values used haven't been altered?

3 DR. SINGH: That is emphatically
4 correct.

5 MR. O'NEILL: And I would have -- I know
6 you did a sensitivity comparison with the 12th run.

7 DR. SOLER: Yes.

8 MR. O'NEILL: Could you comment on the
9 applicability of the conclusions of that run to the
10 other runs?

11 JUDGE FARRAR: No, let's leave that for
12 later. Let's keep talking about what we're talking
13 about.

14 MR. O'NEILL: Okay.

15 JUDGE LAM: I'd like to hear more from
16 the Staff about what Applicant counsel had
17 mentioned about the McGuire Doctrine. Do you have
18 anything to add to that?

19 MS. MARCO: I believe that what the
20 McGuire Doctrine says is that if information that
21 is potentially relevant or material to an issue in
22 the proceeding is -- is no longer valid or there's
23 a change, that that has to be brought before the
24 Board in some form of notification. I understand
25 that this is the Applicant's attempt to cure that

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1 deficiency and make that right.

2 JUDGE FARRAR: And how do you square
3 that with the contentions rule, late filed
4 contentions rule and any number of other doctrines
5 which preclude intervenors from having a similar
6 chance to correct their or amend their positions.

7 MS. MARCO: Well, as I understand it,
8 this contention has already come in.

9 JUDGE FARRAR: I'm not talking about the
10 legal niceties. I'm talking about an overall
11 philosophy of when you get a chance to change your
12 position.

13 MS. MARCO: Well, as I understand it --

14 JUDGE FARRAR: And something in the --

15 MS. MARCO: Right.

16 JUDGE FARRAR: -- and something in the
17 Fifth Amendment that I don't have right handy, but
18 I think you all know what I'm talking about.

19 MS. MARCO: But if new information comes
20 in such as -- any kind of new information, that
21 they could change their position.

22 JUDGE FARRAR: Well, I can remember
23 personally in the limited time I've been in this
24 case at least three times being told by people on
25 the left side of the room that I was duty bound to

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1 reject new material the State had because it ran
2 afoul of some Commission policy.

3 MS. MARCO: For timeliness, right, but I
4 think here that you have a matter of -- as I heard,
5 it came in over the weekend that they discovered
6 it, and it's being brought to you at this time.

7 MR. SOPER: Well -- oh, I'm sorry,
8 Your Honor.

9 MR. GAUKLER: If I could just add,
10 Your Honor --

11 JUDGE FARRAR: No, no. I'll call on you
12 when I want you.

13 Back in the first opinion we wrote in
14 December on seismic, we commented in Footnote 34 on
15 page 35 the Applicant had amended its application
16 at least 23 times. We'd previously indicated in
17 Footnote 30 that we didn't criticize the Applicant
18 for doing that, but, in fact, we're looking for any
19 project that's finished to be as safe as it can be.
20 And, of course, the Applicant gets credit for -- or
21 the Applicant should be encouraged to amend its
22 application or, I suppose like here, to make
23 corrections to make sure that we have a -- I think
24 we said here, Indeed, PFS should be given credit
25 for seemingly doing its utmost to analyze and

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1 support all aspects of its project on a continuing
2 basis.

3 Then we had the sentence which is the
4 one that's troubling me now. At the same time
5 those opposing the project must, in fairness, be
6 afforded some modicum of similar leeway to adjust
7 their approaches as their knowledge base, too,
8 increases over time.

9 Mr. Gaukler, you referred yesterday to
10 other people, and we particularly focused at that
11 point on the judges of the United States Courts of
12 Appeal. I need you and the Staff to tell me once
13 again why it's permissible to allow, over the
14 State's objection, what you want to do here, which,
15 Mr. Gaukler, may be unexceptional in the terms you
16 put it. They found a mistake. And they have to
17 correct it, and they're duty bound to correct it.
18 But we're duty bound to make sure everybody in this
19 room gets treated fairly and equitably and equally,
20 and I'm having a lot of problem right now with
21 things like this in light of the rulings we've made
22 at your urging against the State at various points
23 earlier in this case.

24 MR. GAUKLER: First of all, in terms of
25 the evidentiary record, that I believe that both

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1 parties would be duty bound to bring to the Board's
2 attention a mistake that they identified in some
3 analysis or some type of evaluation they put before
4 the Board. I think that would apply equally to
5 both parties.

6 JUDGE FARRAR: However, a mistake versus
7 a rethinking of what they're doing.

8 MR. GAUKLER: Excuse me, Your Honor?

9 JUDGE FARRAR: A mistake versus a
10 rethinking.

11 MR. GAUKLER: Yes, that's correct.

12 JUDGE FARRAR: Let me say it clearly.
13 Everyone has a duty to bring mistakes to the
14 Board's attention --

15 MR. GAUKLER: And that's what we've done
16 here. We've identified a mistake, and we've
17 brought it to the correction (sic) of the Board --
18 to the --

19 JUDGE FARRAR: You've identified a
20 mistake, and you've done an additional run. And I
21 remember in the in limine motions the State had an
22 additional theory, and you all convinced us that it
23 was too late for the State to introduce it.

24 MR. GAUKLER: The additional run is only
25 necessary, Your Honor -- we did it to show the

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1 sensitivity of what we had intended. Also, it ties
2 into the rebuttal of what we are going to have with
3 respect to Dr. Khan, so in that sense it will be
4 tied in to the overall record. So that additional
5 run is only necessary for this -- correcting the
6 mistake, and whether or not that should be
7 admitted, we'll leave that to the question of
8 rebuttal because it does tie in to that as well.

9 But I think both parties, any party
10 would have the obligation to bring to the Board's
11 attention a mistake in the evaluation or analysis
12 that they've done, and that's what we've done here.
13 We haven't changed -- it hasn't changed a
14 conclusion. It doesn't change the methodology or
15 anything like that. It just is making sure the
16 record is clear and complete.

17 In terms of -- in terms of new
18 information, to the extent there is ever new
19 information -- if we had come forward with new
20 information, the State would always have the
21 opportunity, no matter when, to have new
22 information to come in with a new contention. And
23 the issue with respect to the things that we've
24 already dealt with the State in the past is when
25 did they come in to make a new contention based

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1 upon when they had the information. So we were
2 judging and applying the Commission's rules with
3 respect to lately filed. We had made arguments in
4 terms of they had come in too late to make their
5 adjustment, not that if they had identified
6 something that they couldn't have not have made a
7 new contention.

8 So I think -- first of all, I think it's
9 two different things, Your Honor, that we're
10 dealing with here. One is just a mistake that any
11 party would have an obligation to correct, and
12 that's what we've -- that's what we're attempting
13 to do here, Your Honor.

14 JUDGE FARRAR: Does the Staff have any
15 additional thoughts along this line?

16 MS. MARCO: Well, I recall that the
17 Staff also has made correction in this proceeding.
18 Not necessarily with respect to this contention,
19 but in an earlier environmental matter we made a
20 correction to the EIS that's the same -- I see it
21 as you see an error, and you have a duty to correct
22 that error, as opposed to your bringing forward new
23 information, a new topic, a new issue that hasn't
24 been subject to comments in terms of a late-filed
25 contention.

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1 MR. SOPER: Could I be heard briefly
2 before you decide, Your Honor?

3 JUDGE FARRAR: Oh, you'll be heard at
4 length before we decide.

5 This may or may not be relevant, but
6 this comes on the heels of the aircraft -- the
7 additional aircraft reports. And that wasn't a
8 mistake, and yet we've permitted this. Now we've
9 given the State the opportunity to have time to
10 analyze those, but at some point the moving target
11 the Commission licensing proceedings have always
12 been, and for good and sufficient reason have
13 always been, creates at least an appearance of
14 unevenhandedness. And it's a concern. Do you have
15 anything to add to that?

16 MR. GAUKLER: Just, for example,
17 Your Honor, the other day the State brought in the
18 graph -- State Exhibit 195 which showed, you know,
19 what their evaluation -- thinking, evolvement of
20 their thinking. And that was proper rebuttal or
21 proper redirect or however you want to characterize
22 it, and we didn't object to it because we felt that
23 was proper evolution of their thinking and
24 presenting new evidence on that. The same way that
25 we're going to present some rebuttal today with

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1 some new analysis --

2 JUDGE FARRAR: Are you referring to
3 yesterday's --

4 MR. GAUKLER: Exhibit 195, the graph,
5 yeah.

6 Today we're going to have some
7 evaluations which we've given to the State ahead of
8 time so they've had time to look at it, responding
9 to Dr. Khan's analysis, which I think is proper
10 rebuttal. So this is all, you know, part of the
11 process of rebuttal and surrebuttal as may be
12 appropriate.

13 So I don't -- you know, if everybody has
14 an opportunity to evaluate, look at and respond to
15 the information in the process of -- the hearing
16 process, then I think it's appropriate.

17 And I think -- again, I think, as I
18 said, going back to the basic issue here, whoever
19 would identify the mistake in their evaluation or
20 exhibit or whatever the case may be I think would
21 have an obligation to correct it so you have a
22 full, complete and accurate record. That's one of
23 the themes you see throughout the Commission case
24 law, the need for a full and complete record. And
25 that's one of the themes we feel we can say with

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1 respect to rebuttal evidence, for example, to allow
2 rebuttal evidence to assure a full and complete
3 record, accurate record, and that is part of this
4 process.

5 JUDGE FARRAR: Suppose at this time of
6 the argument on the in limine motions on seismic,
7 the State, instead of presenting its theory about
8 the interaction between the various pads, as an
9 additional theory had presented it as a mistake in
10 their previous thinking. Would that have made it
11 admissible?

12 MR. GAUKLER: I think -- well, in that
13 case there was nothing that they had put in the
14 record that was affirmatively incorrect that they
15 needed to correct, which is the case -- we've got a
16 number in the record that was incorrect, and --

17 JUDGE FARRAR: And, Mr. Gaukler, as you
18 can tell, this argument is not about whether you
19 had a duty to correct this number.

20 MR. GAUKLER: Okay.

21 JUDGE FARRAR: Obviously, you had to
22 come forward with that. The argument is about
23 whether allowing you to make a change which may
24 affect the way in which your case was presented is
25 evenhanded in terms of other rulings we've made.

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1 Mr. Soper, why don't you --

2 MR. GAUKLER: I just want to say there's
3 no substantive change in the way we're presenting
4 our case, no additional new theory or anything like
5 that. We -- no other result's different, okay? We
6 have the simulations. They stand for what they
7 represent, and we've corrected the input parameters
8 to show what they represent. The conclusion, as
9 you heard Dr. Singh and Dr. Soler say, is the same.
10 The analysis methodology is the same. So I don't
11 see the -- you know, a change that -- that
12 obviously Your Honor's concerned with. But I don't
13 see that type of change here.

14 JUDGE FARRAR: I want to hear from the
15 State.

16 MR. SOPER: I agree, Your Honor, that
17 there's no question that information that's no
18 longer true cannot be asserted under oath, and the
19 witnesses or attorneys have a duty not to put forth
20 information that they know is untrue. It's a
21 different issue. How you do that is you simply
22 testify that this is untrue and my testimony is now
23 something else. I can no longer maintain this
24 testimony, it's no longer true.

25 You don't, however, after you originally

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1 testified to that information, with fanfare, with
2 the fact that it's been through our company's
3 quality assurance project -- or process, pages
4 describing that and how airtight this information
5 is and the reviewers have reviewed it and
6 procedures for changing it, when it's found out not
7 to be true, let's go back and change everything so
8 now we have a new document that says it's been
9 through a review process and we have our testimony
10 changed. Where we swore to it under oath, now we
11 change that. The fact is they missed it. And it
12 affects the credibility and the quality of their
13 work, and it ought to be reflected in the record.

14 Now, sure, they come forth, and they
15 say, There was a mistake in our work. Well, it's
16 very interesting. And it ought to be -- and
17 they're doing the right thing by doing that. On
18 the other hand, we ought to know that, a reviewer
19 ought to know that. Everyone who looks at this
20 proceeding ought to know that mistakes are possible
21 even in a document that says we have a quality
22 assurance program, this is a safety analysis
23 document, it's subject to this, it's subject to
24 that. We have to know that, despite those
25 assurances, mistakes can be made.

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1 Nothing entitles them to go back to
2 square one just because they revealed a mistake and
3 say, We're going to change things so as to appear
4 that we didn't make a mistake. They're not
5 entitled to that, in the State's view.

6 JUDGE FARRAR: But if we grant their
7 motion to make these changes, the record will, in
8 fact, reflect what you just said you wanted it to
9 reflect.

10 MR. SOPER: I think the record already
11 reflects, without the granting of a motion to
12 change their prefiled testimony, that they made a
13 mistake in their prefiled testimony, which they're
14 testifying to. That's on the record. They ought
15 not to be able to change their prefiled testimony
16 any more than indicating that it was incorrect. I
17 mean why is that a better process to do it?

18 JUDGE FARRAR: Okay. To that extent,
19 though, your objection is only one of form. You
20 would prefer that they had stood up here and,
21 rather than hand out these documents, they would
22 have said, We have something we want to bring to
23 your attention, we made a mistake, here's the
24 mistake and so forth.

25 MR. SOPER: And I think that that's what

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1 they have done on questioning.

2 JUDGE FARRAR: I guess, in their
3 counsel's defense, we have tended to want to have
4 corrections, for example, in prefiled testimony,
5 appear on -- on the documents so that it is -- it's
6 clear. So I can't -- we can't fault counsel for
7 presenting -- for -- even though this may be of a
8 slightly different character, we can't fault
9 counsel for having presented it this way.

10 MR. SOPER: And that -- it's not my
11 purpose to fault Mr. Gaukler. But the example you
12 give, Your Honor, is the prefiled testimony is
13 reviewed by the witnesses prior to them testifying,
14 raising their hand and subscribing to it and
15 saying, Yes, I'll swear to it provided we make
16 these changes. They've had that opportunity, and
17 we're past that now. So why would we go back to
18 that procedure? I'm not faulting Mr. Gaukler, I
19 think that maybe this is a similar situation, we
20 ought to do it the same, but on analysis, it's not.

21 MR. GAUKLER: Your Honor, just to make
22 the point, I think that all the stuff that
23 Mr. Soper's referring to goes to weight and how you
24 interpret it in terms of the record, and he's made
25 his points on cross-examination. And I think the

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1 record ought to have the documents in corrected.
2 And he has already made his points on
3 cross-examination, and it's all part of the record.

4 JUDGE FARRAR: Does the Staff have
5 anything?

6 MS. MARCO: Yes. I might add,
7 Your Honor, that even though the changes were made
8 to the prefiled testimony, I almost see this as a
9 new exhibit that just shows that there were errors
10 there rather than if it was a change to the
11 prefiled testimony itself.

12 MR. SOPER: Well, that would be okay if
13 this is offered for not a correction, in other
14 words, this doesn't relate back so as of day one
15 now our testimony has been, always has been this,
16 if this is an exhibit that says, here are changes
17 in our -- not changes, here are errors in our
18 prefiled testimony, we made these mistakes and
19 we're bringing them to the panel's attention.

20 MS. MARCO: That was always my
21 understanding of what Mr. Gaukler was doing.

22 (The Board confers off the record.)

23 JUDGE FARRAR: Let me ask the reporter
24 how we marked these two documents, first the
25 testimony and then the report.

1 (A discussion was held off the record.)

2 JUDGE FARRAR: Then let's mark the
3 testimony as PFS Exhibit 86B.

4 (APPLICANT EXHIBIT-86B WAS MARKED.)

5 MR. SOPER: I have only addressed the
6 State's objection to changing the prefiled
7 testimony in answers to Question 144. Concerning
8 the separate document which has been marked as
9 Exhibit 86A, the State has a number of objections.
10 Number one, it's a modification of a previous
11 Exhibit 86, of course, which the State had an
12 objection to and which was not admitted, being
13 held. And, additionally -- the transcript at page
14 5972 and 73, April 30th, is the reference to that.
15 Additionally, they've now incorporated into 86A a
16 document which has been previously marked as
17 Exhibit OO, PFS Exhibit OO.

18 MR. GAUKLER: I think that is incorrect.
19 I think that it incorporates what was State
20 Exhibit 187 or 186 which had been previously
21 admitted.

22 MR. SOPER: No, I don't think it has.
23 You mean the runs, the backup information on the
24 runs? No, it hasn't been admitted.

25 MR. GAUKLER: It was admitted. I think

1 the record will show it was. I'll look.

2 But, anyway, it does incorporate that
3 186 or 187, State Exhibit 186 or 187.

4 JUDGE FARRAR: State?

5 MR. GAUKLER: Yeah. The State
6 introduced it so it ended up being a State exhibit.

7 MR. SOPER: I would say it's not
8 introduced. I don't know how it's marked. It
9 might have been marked for -- this is a document
10 that Dr. Soler and/or Dr. Singh had produced which
11 showed their version of the input data on the
12 basis -- on various video simulations. We were
13 given an opportunity to review it to see if it
14 answered our concerns.

15 JUDGE FARRAR: Wait. What was PFS
16 Exhibit 86?

17 MR. GAUKLER: PFS Exhibit 86 was the
18 beyond design basis report.

19 JUDGE FARRAR: Looks just like what I
20 have here, 86A --

21 MR. GAUKLER: Yes.

22 JUDGE FARRAR: -- except for the
23 changes?

24 MR. GAUKLER: Exception for the changes
25 and the addition of that one appendix with the

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1 input parameters. If you recall, the State desired
2 the input parameters for the various cases. We
3 then provided the State a document that had input
4 parameters and the results for the 11 cases. It
5 was in the course of examination Ms. Nakahara
6 introduced or had that document marked with the
7 inputs and the results --

8 JUDGE FARRAR: And you think that was
9 State what?

10 MR. GAUKLER: I don't have the exact
11 number.

12 MR. SOPER: It was not either offered or
13 accepted into evidence. We're sure of that. We
14 have --

15 JUDGE FARRAR: Okay. Well, we can -- it
16 was during a time we had no law clerk here, so our
17 log is deficient.

18 MR. SOPER: Okay. It now appears as F-1
19 through F-15 in this 186A as an appendix or
20 attachment or something.

21 MR. GAUKLER: The record will show what
22 it shows. I believe that was admitted, but we can
23 go back and look at the record.

24 JUDGE FARRAR: But this -- okay. So
25 this Appendix F in 86A is --

1 MR. GAUKLER: Is the input data --

2 JUDGE FARRAR: That was --

3 MR. GAUKLER: -- and results that we
4 provided to the State which was subsequently at
5 least identified and, I believe, admitted, but the
6 record will reflect whatever it is.

7 JUDGE FARRAR: Right. I recall seeing
8 that.

9 All right. Mr. Soper, we'll resolve the
10 matter of whether it was admitted or not, but
11 however that comes out, we're in the midst of an
12 argument.

13 MR. SOPER: And it was in addition to
14 the fact that -- both 86, the original 86 and the
15 exhibit that appears as F-1 through F-15, in the
16 State's recollection, neither have been admitted
17 and both have been objected to by the State.

18 In addition to that fact, now there is
19 another -- an additional run included --

20 JUDGE FARRAR: Now, you objected to the
21 original 86 on the ground that you didn't have the
22 data, and so did we -- is my recollection correct
23 that we deferred ruling on it while you could get
24 the additional data and look at it?

25 MR. SOPER: And we haven't been heard on

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1 that since that was done.

2 JUDGE FARRAR: Right. Okay.

3 MR. SOPER: In addition to those
4 concerns, the document marked as 86A now contains
5 an additional run which we haven't had an
6 opportunity to review. And our problem is as you
7 have noted earlier in this case, Your Honor, and
8 that is at some point prior to the end the target
9 has to stop moving. And here we are at this date,
10 about ready to see yet another simulation, another
11 run by means of modifying a document we've talked
12 about earlier, incorporating all these changes and
13 a new run, and here we are starting from ground
14 zero as to yet another issue.

15 It's too late for that, and that is the
16 State's objection.

17 MR. GAUKLER: Your Honor, I would --

18 JUDGE FARRAR: Wait a minute.

19 (The Board confers off the record.)

20 JUDGE FARRAR: Mr. Soper, have you
21 concluded your argument about the proposed
22 Exhibit 86A?

23 MR. SOPER: I have, except that we have
24 found that the -- what's attached as F-1 through 15
25 was Exhibit 179 admitted at page 7598 --

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1 JUDGE FARRAR: Say that again. Exhibit
2 what?

3 MR. SOPER: State Exhibit 179. And then
4 Mr. Gaukler's correct, that was admitted. I
5 apologize. I wasn't here on that day.

6 JUDGE FARRAR: What transcript page?

7 MR. SOPER: The transcript page is 7598,
8 May 9.

9 Other than that, that's the end of
10 our --

11 JUDGE FARRAR: Okay. Mr. Gaukler?

12 MR. GAUKLER: I was just going to say,
13 in terms of the additional run, it's not necessary
14 to the correction that we've made. I think we will
15 tie in to our rebuttal testimony, so I would say
16 leave that issue until after we have presented our
17 rebuttal testimony with respect to Dr. Khan. I say
18 we leave that issue alone until we have a complete
19 picture at that point in time in terms of the
20 argument by the State.

21 JUDGE FARRAR: Staff?

22 MS. MARCO: The Staff agrees that we'll
23 listen to the rebuttal. I think that's an
24 appropriate way.

25 JUDGE FARRAR: There is concern been

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1 expressed from time to time in some quarters about
2 the length of Board proceedings. Speaking for
3 myself, I would hope that those who express those
4 concerns would always take care, when they express
5 those concerns, to include the moving target factor
6 as one of the reasons why Board proceedings take
7 longer than some people would like them to take.

8 Having said that, we're going to decline
9 to admit Exhibit 86A because it has the additional
10 run in it. If you want to submit a revised version
11 at some point that includes just the material that
12 has to be corrected, you're free to do so.

13 86B we will admit, and I think we need
14 not say any more. The record is clear that this is
15 not a correction as of April 1st of the original
16 testimony but, rather, is more the nature of what
17 Mr. Soper characterized, an admission today that
18 the original testimony was incorrect.

19 (APPLICANT EXHIBIT-86B WAS ADMITTED.)

20 JUDGE FARRAR: So on that basis, we will
21 proceed.

22 MR. GAUKLER: Your Honor, do you want to
23 take a break before we start now? It's almost
24 10:00 (sic).

25 JUDGE FARRAR: Why don't we do that.

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1 It's 10:15. Let's come back at 10:30.

2 (A recess was taken.)

3 JUDGE FARRAR: All right. Mr. Gaukler,
4 I think everyone's back, and we'll start the actual
5 rebuttal.

6 MR. GAUKLER: Yes, Your Honor, just one
7 quick question in terms of what we were talking
8 about.

9
10 DIRECT EXAMINATION (Continued)

11 BY MR. GAUKLER:

12 Q. Dr. Singh, in terms of the mistake
13 earlier that we've been talking about, would you
14 please describe the context of that as well as its
15 significance?

16 DR. SINGH: Yes, I'll be glad to do so.
17 The quality assurance program at our company, I
18 just want everyone to understand, entitles every
19 nuclear worker to raise questions on any work that
20 the company does, that if he were and the preparer
21 and everyone else -- every colleague of these
22 folks, they are all under 10 CFR 21 regulations to
23 report any variation that they find in the work
24 that's been approved within the company quality
25 assurance system.

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1 Please understand that there are levels
2 of errors, errors in methodology, errors that
3 change conclusions, errors that in any way will
4 affect the equipment, those significant errors.
5 They -- I can inform you in the past 15 years, we
6 have produced over 2500 reports. We have never had
7 one. We have never had an error where the
8 methodology or the conclusions have come out
9 erroneous. There have been, on occasions, rarely,
10 errors noticed on insubstantial, insignificant
11 matters which do not change -- and I define them as
12 those that do not change conclusions.

13 This is one of those. We would, whether
14 we were in court proceedings or not, immediately
15 report such an error in a report -- in a report
16 produced by us before to our client. That's what
17 we have done here.

18 But I want to reassure you that there
19 is -- our quality assurance process has served us
20 well over the past 15 years. We have never had to
21 go back and report a fundamental error either in
22 the methodology or in the major conclusions. We
23 have made reportings to the NRC under 10 CFR 21 on
24 errors, for example, in commercial computer codes,
25 but under no conditions, in no case thus far in 15,

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1 16 years of this nuclear program that we have in
2 place at Holtec International, have we ever had to
3 report or did we ever find any error of any
4 significance.

5 Thank you.

6 JUDGE FARRAR: Mr. Gaukler, let me
7 interrupt and just indicate on behalf of the Board
8 that nothing in that argument among counsel in
9 questioning the Board was meant to criticize your
10 bringing forward to the Board and to the parties
11 the mistake. That was clearly your duty to do,
12 which -- which you did. So there was no criticism
13 at all. I don't think anyone would have taken it
14 that way, but I want to make sure that you know
15 that none of that had to do with criticism of you
16 for coming forward.

17 DR. SINGH: Thank you, Your Honor.

18 Q. (By Mr. Gaukler) I can turn to the
19 rebuttal now.

20 Dr. Soler, in answer to Question 16 in
21 Dr. Khan's testimony, he states that he determined,
22 as a result of his analysis that cask movements
23 predicted by mathematical models are highly
24 sensitive to the assumed contact stiffness between
25 the cask and the pad. And some of his analyses in

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1 his Table 3 shows cask displacements in some
2 instances of 30 feet or more.

3 Have you evaluated whether these are
4 valid results for the input parameters that he
5 used?

6 DR. SOLER: I have evaluated that table
7 and have come to certain conclusions.

8 Q. And what did you do in evaluating that
9 table?

10 DR. SOLER: I simulated the exact
11 problem that Dr. Khan and Altran did, with the
12 exception that I assumed a rigid cask. I subjected
13 that cask to the same input parameters that
14 Dr. Khan had used, the same number of contact
15 points with the pad that he had used and, of
16 course, the same seismic inputs. I then ran the
17 simulations on VisualNastran, which is a program
18 that can simulate large orientation changes if they
19 do occur.

20 Q. And why did you believe it was
21 appropriate to simulate it on VisualNastran as
22 opposed to DYNAMO or SAP itself?

23 DR. SOLER: First of all, both DYNAMO
24 and SAP cannot give reliable answers when large
25 rotations are involved. They may give answers, but

1 you cannot consider them reliable without
2 evaluation. In my opinion, a solution using a
3 small deflection program, whether the parameters
4 that are input are realistic or not, begs the
5 issue. The fact is that in my 40 years of
6 experience, if I were to receive a report which
7 predicted that something moved 40 feet to an
8 earthquake input, I would question the results. I
9 do not -- am not a user of SAP 2000, so I can't
10 comment on exactly -- to any degree of certainty
11 what the problem is, but it's my firm opinion that
12 the results leading to these large excursions as
13 predicted by SAP 2000 are erroneous.

14 Q. Have you documented your evaluation?

15 DR. SOLER: Yes, I have.

16 MR. GAUKLER: I'd like to have marked as
17 PFS Exhibit 225 a document.

18 (APPLICANT EXHIBIT-225 WAS MARKED.)

19 Q. (By Mr. Gaukler) I've handed out a
20 report entitled "Additional Cask Analyses for the
21 PFSF," Holtec Report No. HI-2022878.

22 Dr. Soler, is this the report in which
23 you documented your results?

24 DR. SOLER: Yes. This -- this
25 particular analysis was a part of that report.

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1 This report was issued to address all of the
2 concerns that we'll be dealing with in rebuttal.

3 Q. And how did you go about preparing this
4 report?

5 DR. SOLER: I'm not sure I understand
6 your --

7 Q. Did you prepare the report?

8 DR. SOLER: Yes, I prepared the report
9 as a technical report for Holtec.

10 Q. Would you please summarize your
11 evaluations of Dr. Khan's model that you did in the
12 context of this report here?

13 DR. SOLER: Based on the results that
14 are in this report and the evaluations we did and
15 the simulations we ran, we conclude that even with
16 the unrealistic contact parameters and
17 unrealistic -- unrealistic value of contact
18 stiffness and unrealistic value for contact
19 damping, even using those values and subjecting
20 this to the 2K earthquake, the casks remain stable
21 and upright and the maximum excursions are in the
22 order of inches, not feet.

23 Q. Are the reports of your evaluation
24 listed in the report where? I believe 24 and 25,
25 is that correct, pages 24 and 25?

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1 DR. SOLER: Yes. My evaluation is in
2 Section 8.1.2, Evaluation, and the results of the
3 simulation are presented in a table.

4 Q. And you have on page 25 two sets of
5 results, correct?

6 DR. SOLER: That is correct.

7 Q. And would you describe the first set of
8 results?

9 DR. SOLER: The first set of results
10 takes a cylindrical object weighing 360,000 pounds
11 with the correct dimensions of the HI-STORM cask,
12 puts it on a pad, uses a contact stiffness of
13 125,000 pounds per inch at each of 8 contact
14 points.

15 Q. And that gives a total contact of --

16 DR. SOLER: That gives a total of 1
17 million pounds per inch vertical stiffness for the
18 cask.

19 Q. And that's the same as Dr. Khan used in
20 some of his runs on Table 3 of his report where he
21 got in the range of 30 feet?

22 DR. SOLER: That is correct. He used in
23 a number of cases 1 million pounds per inch total
24 vertical stiffness and 1-percent damping.

25 Q. And he used 1-percent damping here in

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1 this case as well?

2 DR. SOLER: Yes.

3 Q. Do you have a simulation that you can
4 show the Board of the results of this analysis?

5 DR. SOLER: Yes, I do.

6 Q. Would you please show the Board that?

7 DR. SOLER: Let me, before I -- let me,
8 before I run it -- let me, as it's running, try to
9 make --

10 JUDGE FARRAR: Before you run it, I
11 think when you did the --

12 DR. SOLER: Wait. Let me stop it here.

13 Okay.

14 JUDGE FARRAR: When you did the previous
15 simulation, didn't we get a computer disk as an
16 exhibit?

17 MR. GAUKLER: Yes.

18 DR. SOLER: Yes.

19 MR. GAUKLER: I would be proposing to
20 put this all on a compact disk, and we just haven't
21 had time to do that yet. That's my intent, to do
22 that and submit that as a separate exhibit.

23 MR. SOPER: The State will have -- this
24 hasn't been offered or marked or anything else, but
25 the State will have an objection to this as well as

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1 to this document that's marked as 225. So I don't
2 know if --

3 JUDGE FARRAR: My immediate concern is
4 not with a substantive objection but with the
5 development of -- of the record, that usually we
6 would have a disk that they would be running.

7 Is there any chance -- how do we assure
8 that what is now shown us will, in fact, be the
9 same -- whether or not it's objectionable
10 substantively, will, in fact, be the same as the
11 disk we get this afternoon or tomorrow or next
12 month?

13 MR. GAUKLER: I can let Dr. Soler
14 address that.

15 DR. SOLER: Given that I presume that
16 there are facilities in Salt Lake City for
17 producing a CD, I will do anything necessary. It's
18 convenient, the simulations are here. I will
19 transfer them to a CD with whatever witnesses need
20 to be provided as I do it, and that would guarantee
21 the integrity.

22 JUDGE FARRAR: Is there -- there may not
23 be a problem here, but I thought it would be better
24 to deal with it now before they run it. And,
25 again, this is not questioning the witness's

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1 personal integrity, but just how do you assure that
2 the record ends up with what, in fact, is about to
3 be shown?

4 MR. GAUKLER: We can submit a piece of
5 paper with a declaration with Dr. Soler's signature
6 if that would be appropriate for Your Honor and the
7 State, or if the State wants to be present when we
8 actually do the process, we have no problem with
9 that. Either way, I think that we've worked with
10 the State on things like this before in terms of
11 procedure and process. We would be able to work
12 that out.

13 JUDGE FARRAR: Then let's assume that
14 can be done properly.

15 Mr. Soper, any --

16 MR. SOPER: I understand the problem,
17 Your Honor, but I don't -- I agree with you. I see
18 no guarantee that what's about to be shown will be
19 included in the record or furnished to the State.
20 We haven't received any such disk.

21 MR. GAUKLER: They have received a draft
22 of the disk which we did provide them. There are
23 some changes to it, but we did provide them a
24 draft.

25 JUDGE FARRAR: The draft being a disk

1 that they could run or --

2 MR. GAUKLER: Both.

3 DR. SOLER: Yes. The answer to that
4 question is yes. But it was --

5 MR. GAUKLER: It was a draft. It has
6 changes --

7 JUDGE FARRAR: When I hear a draft --
8 remember how old I am. When I hear draft, I think
9 piece of paper. You're talking a draft disk?

10 MR. GAUKLER: And draft report as well.

11 JUDGE FARRAR: Okay.

12 MR. SOPER: I understand that we have a
13 draft of something different than what's about to
14 be shown --

15 MR. GAUKLER: That's not the same.

16 MR. SOPER: -- that we got on Friday.

17 JUDGE FARRAR: Well, let's move ahead,
18 and we'll -- we're aware of the possible problem,
19 and we'll find a way to resolve it.

20 DR. SOLER: Let me just add something.
21 The individual files which you're looking at now,
22 the directory listing, each one could probably be
23 transmitted directly by e-mail. But the sum total
24 of them together I think would overpower most
25 e-mail systems, and so I'd want to prepare a CD in

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1 some manner.

2 JUDGE FARRAR: All right. Let's move
3 ahead.

4 DR. SOLER: All right. Now, this
5 simulation I haven't started yet. I point your
6 attention, before I start it -- and I don't know if
7 everyone can see it -- to these little circles
8 located at 8 points around the sphere.
9 VisualNastran will not let you crudely model
10 contact between two surfaces. Therefore, to model
11 with only 8 points, I had to first tell the system
12 to let the cask penetrate the pad and then manually
13 add little hard points at the appropriate points
14 around the periphery which were rigidly attached to
15 the cask and actually made the contact. So this is
16 how I simulated the Altran analysis.

17 And you have to look closely, but if you
18 remember the parameters of 1 million pounds per
19 inch, the natural frequency of a cask weighing
20 360,000 pounds and a 1-million-pound-per-inch
21 stiffness works out to a natural frequency of about
22 5.2 hertz, which is pretty close in the region of
23 the peak power point of the earthquake.

24 Now, you may not see it, but you -- if
25 you look closely, you will be able to see that

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1 there is a bouncing to the cask as well as a
2 rocking and precession. If you study the CD, you
3 can see it, but I can't guarantee that you'll
4 necessarily see it here. Kind of focus on the base
5 of the cask. There's a little bounce there, and I
6 surmise that's at about 5 hertz. But the cask
7 begins to tilt.

8 Now, this -- because of the exigencies
9 of time, it's not real time. This is about four
10 times longer than 30 seconds. So it moves a lot
11 faster in real life.

12 Q. (By Mr. Gaukler) And the simulation
13 that you showed last time at the hearing, they were
14 in real time?

15 DR. SOLER: Yes. I compressed the
16 simulations last time so that they were all 30
17 seconds. Because of where I am and where the
18 program is that does the compression, I had to work
19 with this in basically the time that it comes out
20 of the system. So this total simulation is 1
21 minute and 23 seconds of physical time, but it
22 represents 30 seconds of earthquake time.

23 There, it's done.

24 Now --

25 JUDGE FARRAR: Hold on just a second.

1 (The Board confers off the record.)

2 JUDGE FARRAR: Go ahead.

3 Q. (By Mr. Gaukler) Would you briefly
4 describe the second analysis you did testing
5 Dr. Khan's thesis and show the simulation for that
6 as well?

7 DR. SOLER: Okay. Bearing in mind that
8 the purpose of these two simulations is not
9 necessarily to present information other than to
10 demonstrate that, in my opinion, the SAP 2000
11 results are in error, that's the sole purpose of
12 these demonstrations. So the -- the key
13 information is the fact that it predicted results
14 in the order of inches, not feet, as far as the
15 responses are concerned.

16 So we ran a second simulation which we
17 did not attempt to match 8 contact points. We
18 simply said we have a thousand -- a million pounds
19 per inch total stiffness, 1 percent of critical
20 damping, and we're going to run what has been our
21 standard simulation model in all of the simulations
22 we've shown. Again, the 2K earthquake is used, and
23 in this case the particular model I chose to run
24 was the one that had 8 casks on it. So let me pick
25 that one out.

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1 So this is essentially the same model,
2 except it has multiple contact points and all 8
3 casks are involved in the simulation. Again, the
4 pad is being driven. There's no soil structure
5 interaction in this case to conform with the Altran
6 solution.

7 Q. And, again, this is a 1-percent damping?

8 DR. SOLER: 1-percent damping and
9 1-million-pounds-per-inch total stiffness.

10 Q. And, again, this is extended time or
11 real time?

12 DR. SOLER: This is extended -- this is
13 extended time, but it doesn't go all the way to 30
14 seconds because I wanted to go just past the peak
15 power point and not spend the time generating it
16 all out to 30 seconds when things come to rest. So
17 this is actually 56 seconds of real time, which is
18 about 20 seconds, in this case, of the actual
19 earthquake time.

20 Q. Based on your evaluations that you've
21 run, what is your conclusion concerning the
22 validity of Dr. Khan's SAP 2000 results in table 3?

23 DR. SOLER: I believe that the results
24 that give these very large errors -- pardon me,
25 these very large displacements are in error. I --

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1 as I said before, I cannot precisely pin down what
2 the error is. I have my opinions, but they're just
3 opinions because I am not a regular user of SAP.

4 Q. Now, when Dr. Khan was asked on
5 cross-examination whether the large displacements
6 that occurred in his program could be the result of
7 his computer program blowing up in terms of giving
8 a result that makes no sense, he claimed that was
9 not the case because SAP 2000 did not stop working.
10 Do you believe that you can only get -- do you
11 agree with Dr. Khan in that respect?

12 DR. SOLER: No.

13 MR. SOPER: Let me object. That
14 mischaracterizes his testimony.

15 MR. GAUKLER: I don't believe it does.

16 Q. But is the fact -- I'll rephrase the
17 question so we don't need the objection,
18 Your Honor.

19 JUDGE FARRAR: Yes, do that, please.

20 Q. (By Mr. Gaukler) Does the fact that the
21 computer program did not stop running mean that the
22 program did not blow up in terms of giving
23 unrealistic results?

24 DR. SOLER: You better say that again.
25 I'm not sure whether I should answer yes or NO.

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1 Q. Okay. Does the fact that SAP 2000
2 continued to run without stopping in the computer
3 runs that Dr. Khan did signify or show that the
4 computer didn't blow up in terms of giving
5 unreasonable results -- the program blew up in
6 terms of giving unreasonable results?

7 DR. SOLER: The fact that the computer
8 ran -- the computer ran to completion and gave
9 results does not reflect whether it blew up or not.
10 You must always examine the results in the light of
11 reality.

12 For a small deflection program that,
13 say, starts from a position 000 and ends up at 050
14 feet, 2 feet, that is a very large deflection and
15 beyond the scope of the computer program. The
16 computer program is a dumb animal. It just goes
17 and computes whatever it's given in terms of input
18 data, and it computes according to a certain
19 formula. And it does not ask itself whether a
20 number is realistic or not.

21 Now, some -- some programs will be
22 written so that if the displacement gets too large,
23 then the program will automatically stop and maybe
24 print out some error that says -- some message that
25 says, Your displacement is too large, please

1 examine your results.

2 In my own experience, you can get a
3 number, 50 feet, you could get a number 10 to the
4 32nd power. It depends on your program. I will be
5 the first to admit that it's a little more obvious
6 when the computer gives you 10 to the 32nd power as
7 a displacement than it is if it gives you 50 feet.
8 But if you recognize -- if it's a small deflection
9 program, you must question your results.

10 Q. Dr. Singh, in his testimony Dr. Khan has
11 made the point that you should choose contact
12 stiffness to correspond to cask frequencies that
13 fall in the amplified spectral range of the input
14 spectra. In essence, the way I understand that is
15 you should choose a contact stiffness such that the
16 cask or pad would naturally vibrate in accordance
17 with the natural frequency of the amplified spectra
18 of the earthquake. Do you agree with this approach
19 asserted by Dr. Khan?

20 DR. SINGH: No, I don't. I consider it
21 to disfigure the problem, and it will lead to
22 erroneous conclusions and results.

23 Q. Why do you think that is a misstatement
24 of the problem? First of all, do you consider
25 contact stiffness to be a function of the

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1 earthquake input, or is it a property of the
2 materials and bodies involved?

3 DR. SOLER: Contact stiffness is not a
4 parameter. It has nothing, and I repeat, it has
5 nothing to do with the earthquake. It's an
6 intrinsic property of the bodies that are subjected
7 to the earthquake. In this case it's a property of
8 the interface, the property of the interface being
9 the cask and the pad.

10 The contact stiffness and its conclusion
11 is standard part of applied mechanics, solid
12 mechanics. There are thousands of papers, I've
13 read hundreds of them over the years, that solve a
14 variety of contact stress problems.

15 The use of contact stiffness to predict
16 the response of structures goes back -- I'll give
17 you a calendar date -- 1881. Heinrich Hertz
18 developed the Hertzian theory of contact that was
19 published in 1881 in Germany, and since then there
20 have been thousands of papers. There are books.
21 The procedure to calculate contact stiffness is
22 well established. It is not a science of the 21st
23 century, it is not a science of the 20th century.
24 It goes back a long time.

25 The property of the interface can be

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1 calculated accurately and then used in a finite
2 element program such as VisualNastran or any other
3 program to predict the response of the structure.
4 There is no need to speculate, there is no need to
5 make it a parameter, and there is certainly no need
6 to use absolutely absurd values for the interface
7 we have here such as a million pounds per inch.

8 MR. GAUKLER: I'd like to hand out and
9 have marked as PFS 226 an excerpt from a Holtec
10 calculation, "Multi-cask Seismic Response at the
11 PFS ISFSI," Holtec Report No. HI-97-1631. It shows
12 the dates of the report, the second page does,
13 being May 1997.

14 JUDGE FARRAR: And you want this marked
15 as?

16 MR. GAUKLER: PFS Exhibit 226.

17 (APPLICANT EXHIBIT-226 WAS MARKED.)

18 JUDGE FARRAR: Okay. The reporter's
19 marked it.

20 Mr. Gaukler, before you inquire about
21 this, let me ask the -- Dr. Singh a question about
22 his last comment.

23 I thought a previous witness told me
24 that contact stiffness was a mathematical construct
25 that we couldn't really visualize in the real

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1 world, but that's not what you've just said.

2 DR. SINGH: Yeah. The previous witness
3 has given you, Your Honor, a -- factually vacuous
4 and technically inaccurate information.

5 JUDGE FARRAR: It might have been one of
6 your witnesses, but I can't remember.

7 MR. GAUKLER: I was going to say --

8 JUDGE FARRAR: I, you know, was trying
9 to visualize -- in fact, I looked it up in the
10 transcript yesterday, and, in fact, that was what
11 the witness told me, that it was a mathematical
12 construct to describe something that we couldn't
13 really see in the physical world.

14 DR. SINGH: That's not true at all.

15 The --

16 Q. (By Mr. Gaukler) Is there --

17 DR. SINGH: Let me -- let me explain.
18 The -- when two bodies in any manner interact with
19 each other, typically it's a dynamic situation. It
20 could be a static condition. Where a cask is on a
21 pad, there is a contact stress. The interfacial
22 stress is called contact stress. The area that is
23 loaded, it's called contact patch. The amount by
24 which the two bodies approach each other is known
25 as approach. And there are formulas, equations,

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1 papers, textbooks -- I at least have -- at Holtec
2 we must have 25 books that provide the information
3 on how to calculate the approach, how to calculate
4 the contact patch, how to calculate the stress
5 distribution in the contact patch.

6 The entire problem of two bodies in
7 contact has been studied in great depth for a long,
8 long time. Actually, when I heard that -- I was in
9 the audience yesterday, and when I heard that, I
10 was -- I was appalled.

11 JUDGE FARRAR: Well, I was not referring
12 so much to yesterday as some weeks ago when the
13 term was first used, and I think it was one of your
14 witnesses that I asked about that.

15 So this is, then, in layman's
16 language -- well, let's take a simple example, my
17 fist on a pillow. Is that -- is that the
18 phenomenon we are talking about, that I push my
19 first down and it goes into the pillow? And, now,
20 we're talking about obviously not an effect of that
21 magnitude, but here's the cask sitting on the pad,
22 and the cask is the fist trying to force itself
23 into the pad? Is that --

24 DR. SINGH: Exactly. The fist in the
25 pillow is perhaps a good analogy. The force, the

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1 weight of your fist or the force that you
2 deliberately apply and the displacement of the
3 fist, if the elastic properties of the pillow are
4 known, then an engineer who is familiar with theory
5 of contact can calculate it for you. It is not a
6 mysterious quantity. It is not a mathematical
7 construct. It is not abstract at all. It is
8 something that can be calculated with accuracy.
9 And if one does not have an analytical solution,
10 one can use a finite element program to calculate
11 the -- the stiffness of the interface.

12 It is -- the point I want to make with
13 absolute clarity is that the interface between the
14 cask and the pad, it's -- the stiffness of an
15 interface is calculable to the level of accuracy
16 ones you used to.

17 JUDGE FARRAR: Go ahead, Mr. Gaukler.

18 Q. (By Mr. Gaukler) In terms of -- the
19 stiffness that Holtec used with this DYNAMO run
20 used a stiffness of 454 million pounds per inch,
21 and can you tell us how you arrived at that
22 stiffness value?

23 DR. SINGH: Yes. Here is actually a
24 good case of how contact stiffness is calculated.
25 The procedure used --

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1 Q. Referring to PFS Exhibit 226?

2 DR. SINGH: I am referring to PFS
3 Exhibit 226, Holtec Report HI-971631, and I'm
4 referring specifically to Appendix C.

5 In this calculation -- it's a good
6 example. This particular calculation uses --
7 treats the pad as an elastic half-space which is a
8 simplification. A half-space, by the way, is the
9 scientific term to denote -- for example, the
10 ground would be half-space. In other words, it
11 does not extend up, but it does extend down. Half
12 of the space is taken. That's half-space.

13 The solution here is a half-space
14 solution taken from a book written by Timoshenko
15 and Goodier. Timoshenko, by the way, is considered
16 father of solid mechanics in this country. He
17 passed away about 20 years ago. This book was
18 published in the '30s, I believe, or the '20s even.
19 It goes back a long time. Bousinesq solution,
20 B-o-u-s-i-n-e-s-q, Bousinesq solution extended to a
21 rigid punch. You're treating the cask as a rigid
22 punch. There's a simple formula in the Timoshenko
23 and Goodier theory of elasticity, and the formula
24 is applied here. This spring constant calculated
25 here -- because the pad is thin, but it's assumed

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1 to be a half-space, therefore, the spring constant
2 calculated is a lower bound on the actual spring
3 constant.

4 That is typical procedure that one would
5 use if one does not wish to use a detailed finite
6 element program, and there are many, many other
7 models available in the literature.

8 JUDGE FARRAR: And the number you got is
9 what?

10 DR. SOLER: Is 454 million pounds per
11 inch total for the cask.

12 JUDGE FARRAR: Okay. Now, tell me what
13 that means. It would take what to do what?

14 DR. SINGH: You want to say?

15 DR. SOLER: Yeah.

16 If you imagined that you could penetrate
17 the concrete to whatever extent that you wanted to,
18 if you took that cask and put enough material in it
19 to bring its weight up to 454 million pounds, it
20 would deflect into the concrete 1 inch.

21 Q. (By Mr. Gaukler) And you stated that
22 was a conservative lower bound for the contact
23 stiffness?

24 DR. SINGH: Yes. It's a conservative
25 lower bound because the pad is assumed to extend to

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1 infinity downwards. That's why it's treated as a
2 half-space in this particular solution. It's an
3 approximate solution, but it is a conservative
4 solution in the sense that it gives a lower bound
5 value.

6 Q. And so the actual contact stiffness
7 would be greater than 454 million pounds per inch;
8 is that correct?

9 DR. SINGH: It would be somewhat
10 greater, yes.

11 MR. GAUKLER: I'd like to hand out
12 additional copies of what was marked yesterday as
13 Exhibit 221. This has been already marked as an
14 exhibit, so the reporter doesn't need any, so I'm
15 handing out courtesy copies.

16 Q. I've handed out what has been marked
17 previously as PFS 221, which are some excerpts from
18 the ANSYS training manual, and does ANSYS provide
19 general guidance on the calculation of contact
20 stiffness that is in accordance with the
21 methodology you've just described?

22 DR. SINGH: Yes, sir.

23 Q. And could you briefly point out where
24 that is and --

25 DR. SINGH: Well, this document has --

1 you can go to page 3-6, and I will simply read the
2 sentence that's germane to our statement here. It
3 says, For bulky solids, the hertz contact stiffness
4 often provides an appropriate basis for the penalty
5 stiffness. This stiffness can be estimated from
6 the element side and Young's modulus. And it goes
7 on to provide some guidance to the user. This is
8 the same document that yesterday was discussed as
9 the -- as the ANSYS training manual.

10 Q. And ANSYS provides -- we also were
11 discussing yesterday, I believe, PFS Exhibit SS,
12 which is other guidance from the ANSYS manual, and
13 ANSYS provides general guidance for the estimation
14 of contact stiffness for purposes of numerical
15 analysis?

16 DR. SINGH: Yes.

17 Q. The -- you read from the PFS
18 Exhibit 221. You referred to penalty stiffness in
19 that first sentence. What does that mean?

20 DR. SINGH: That's the stiffness at the
21 interface. It's this document that you just passed
22 out. How do you characterize it so I can refer to
23 it?

24 Q. That's PFS Exhibit SS?

25 DR. SINGH: PFS Exhibit SS defines -- in

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1 this document talks about contact stiffness in a
2 simplified way and basically explains that you --
3 you can get approximate values of contact stiffness
4 by assuming a fictitious penetration and then
5 calculating the forces that will be necessary to
6 support that penetration and then dividing the
7 force by the penetration to get the contact
8 stiffness. It also explains that you -- if you use
9 the correct -- if you have two stiff surfaces such
10 as a cask and a pad, your stiffness may be very
11 large and you may use a smaller value to get
12 convergence, but, of course, then your solution is
13 not as accurate.

14 Q. And yesterday when I showed this
15 exhibit, PFS Exhibit SS, to State's witness,
16 Dr. Khan, he suggested that this guidance in PFS
17 Exhibit SS from ANSYS was limited to penetration
18 problems? Is that correct?

19 DR. SINGH: No, that's not -- that's an
20 incorrect statement by the State's witness.

21 Q. And how would you describe this
22 guidance?

23 DR. SINGH: I describe this guidance as
24 providing information to the user on how to model
25 an interface between two bodies if its physical

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1 problem involves the interface.

2 Q. And the State's witness also described
3 the training manual and this guidance as applying
4 only with respect to static analysis as opposed to
5 dynamic analysis. Is that correct?

6 DR. SINGH: No, that's not correct at
7 all. The -- the contact stiffness of solid bodies
8 are not changed in any significant manner by
9 whether the event is dynamic or static. As a
10 matter of fact, there is a large body of technical
11 literature on modeling impact between bodies using
12 Hertzian contact as the -- as the basis for
13 simulating the -- the stiffness between the
14 impacting bodies. Dr. Soler has run the case, I
15 guess --

16 DR. SOLER: Well, not run it, but I'm
17 aware and I can describe one case in the classical
18 literature that was performed by -- in Timoshenko's
19 book.

20 Q. Would you please do that, Dr. Soler?

21 DR. SOLER: In the discourse of deriving
22 Hertzian contact theory, you eventually end up with
23 a relation between the approach and the penetration
24 of, in this case, two spheres of unequal size.
25 Timoshenko then went ahead to apply that to the

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1 problem of two spheres moving toward one another,
2 impacting one another and then separating. The way
3 he did that was to take the contact stiffness that
4 he had calculated from the static Hertzian problem
5 and then apply that as a stiff spring, if you will,
6 to his dynamic problem. And he evolved the
7 solution for the total depth of penetration and the
8 total time at which the two bodies were in contact,
9 all in terms of this static Hertzian contact
10 solution. And he showed there that for that
11 particular geometry that the relationship was
12 proportional to the approach raised to the 1 1/2
13 power. But that was -- that was an outcome of his
14 solution, not an assumption for his solution.

15 DR. SINGH: Simulating the interface
16 between the bodies using Hertzian contact mechanics
17 is the standard state of the art. There are
18 numerous technical papers, books where this
19 procedure is described.

20 DR. SOLER: And let me add one thing --

21 MR. SOPER: Excuse me. Can we proceed
22 by question and answer here instead of narrative?
23 I don't even know what the witnesses are about to
24 speak to here.

25 MR. GAUKLER: I don't understand the

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1 objection.

2 MR. SOPER: The objection is this is an
3 examination and ought to proceed by question and
4 answer where a question is put and then the
5 opportunity to evaluate the question for objections
6 is made and so forth. A narrative is something
7 contrary to that.

8 JUDGE FARRAR: It's a matter of degree.
9 We don't -- we tend to let witnesses give expansive
10 answers, but I have to agree with Mr. Soper that
11 we're beginning to get more of a back-and-forth
12 lecture maybe related to the question and maybe
13 not. So his point is somewhat well taken, but I'm
14 not sure I know what to do with it.

15 MR. GAUKLER: These are complex --

16 MR. SOPER: I know if there's a question
17 pending, but maybe we start there. And if there's
18 a question there -- let's see if there is. My
19 understanding is it was answered and then people
20 moved on to make speeches.

21 JUDGE FARRAR: Let's move on with
22 another question.

23 MR. GAUKLER: May I have the last
24 question and answer read back, please?

25 JUDGE FARRAR: No. You may have the

1 last question read.

2 MR. GAUKLER: Fine.

3 (The question was read as follows:

4 "Question: Would you please do that,
5 Dr. Soler?")

6 MR. GAUKLER: Thank you. That answers
7 my question.

8 Q. So that I can summarize very briefly, in
9 solving the dynamic problem, they used the contact
10 stiffness in the same way that you've calculated
11 for your analysis here, is that correct, for the
12 DYNAMO analysis?

13 DR. SINGH: Yes. The approach that we
14 used is an appropriate approach.

15 Q. Okay. The -- I'd like to go on, and
16 Dr. Khan has suggested that -- as we said, that you
17 ought to set the contact stiffness at the frequency
18 of the amplified region of the response spectra.
19 Dr. Soler, I think you addressed this somewhat in
20 the report that's been marked as PFS Exhibit 225,
21 and can you tell me whether or not Dr. Khan's
22 suggestion of setting the contact stiffness to
23 accord with the amplified region of the response
24 spectra produces a realistic physical result or
25 not? And I'd like to have you refer to, I think,

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1 the beginning of Section 8 of your report.

2 DR. SOLER: Yes. If you --

3 JUDGE FARRAR: Which report?

4 MR. GAUKLER: This is Section 8 of PFS
5 Exhibit 225.

6 DR. SOLER: Natural frequency, which has
7 been defined by a number of witnesses during the
8 course of this presentation, is basically 1 over 2
9 pi times the square root of K, the stiffness,
10 divided by the mass. The static deflection of a
11 body resting on a surface is defined as the weight
12 divided by the stiffness. Between those two
13 formulas, if you substitute for the stiffness, you
14 can then write a very simple relationship between
15 the static deflection of a body and its natural
16 frequency. Now --

17 Q. Now, that's what you've done on page 21?

18 DR. SOLER: Correct.

19 Q. And if I look at that formula, first
20 formula, f equals 1 divided by 2 pi times the
21 square root of Kg divided by W, that is the same
22 formula we were talking about yesterday with
23 Dr. Khan, is it not, which is --

24 DR. SOLER: That is correct.

25 Q. -- f equals 1 over 2 pi times the square

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1 root of K over M, correct?

2 DR. SOLER: That is correct because W
3 over g is M.

4 Now --

5 Q. Go ahead, then, please.

6 DR. SOLER: Now, the relationship that
7 you evolve from that means that if you have a body
8 resting on a surface and you can measure its static
9 deflection, you immediately know what its natural
10 frequency is insofar as oscillations in the
11 direction parallel to that static deflection. It's
12 sometimes, depending on the surface, a little
13 difficult to determine what that deflection is, but
14 in theory you can take a ruler, measure the
15 displacement and, without further calculation other
16 than to substitute into this formula, determine the
17 natural frequency of the system.

18 If you go to the next page of the
19 report, which is page 22, that relationship has
20 been plotted, and the nature of the relationship is
21 that on a log-log scale, it becomes a straight
22 line. So this, then, avoids the necessity to do
23 any calculation. You can look at this relationship
24 of saying if I know the static deflection, I can
25 calculate what the lowest natural frequency of this

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1 object will be in a simple oscillation, or,
2 conversely, if I wish to choose a natural frequency
3 or I know a natural frequency, that immediately
4 determines the static deflection.

5 In the terms that we're talking about
6 here where we're talking about artificially
7 adjusting a contact stiffness to be in tune with an
8 external excitation, what that really means is that
9 you're physically trying to change the character of
10 the surface that you're resting on, because once
11 you put the cask down on this surface, whatever
12 else you may or may not be able to determine
13 easily, the one thing you can see visually is that
14 it does not have a static deflection to the
15 magnitude alluded by Dr. Khan when he uses 1
16 million pounds per inch as a stiffness value.

17 Q. So, for example, he has suggested taking
18 a K equals 1,000 pounds per inch --

19 DR. SOLER: 1 million.

20 Q. -- 1 million pounds per inch, excuse me,
21 and that is much less than the contact stiffness
22 that you've calculated for the cask and pad here,
23 correct?

24 DR. SOLER: That is correct.

25 Q. And looking at the contact stiffness for

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1 the pad that you've -- that you've calculated for
2 the cask and pad here, what's the natural frequency
3 at which the cask would vibrate with respect to the
4 pad?

5 DR. SOLER: Now, are you -- are you
6 talking about the DYNAMO analysis --

7 Q. Yes, the 454 million.

8 DR. SOLER: I was afraid you were going
9 to ask that. Just give me a second here.

10 Well, I don't have a technical reviewer
11 here to ensure the correctness of my result, but I
12 calculate 111 hertz.

13 Q. So that would be the natural frequency
14 at which, given the contact stiffness that you've
15 calculated --

16 DR. SOLER: That that cask would
17 oscillate up and down. If -- if I -- let's put it
18 this way: If I had that contact as a linear spring
19 which could take tension and compression and if I
20 applied a -- by some external source, let's say, a
21 simple sine wave oscillation at 111 hertz, then I
22 would see that this cask would have amplified
23 vertical oscillations. How amplified would depend
24 on the damping.

25 Q. Dr. Singh, do you have anything to add

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1 to that explanation?

2 DR. SINGH: Yes. I think that the
3 fundamental point is the cask -- a HI-STORM on a
4 pad, even using the -- the simplified rigid punch
5 solution that we talked about earlier, rigid punch
6 solution that we talked about, on the half-space
7 solution that we talked about earlier, the
8 frequency is over 100 hertz. The typical
9 characteristic of a HI-STORM on a pad is that the
10 interface stiffness is so high that the -- if you
11 were to assume the cask connected to the pad, then
12 you have a frequency you can calculate, which is
13 what Dr. Soler just did. That frequency is in what
14 is known as the rigid range.

15 Now, rigid range is a term in structural
16 mechanics which simply means that the natural
17 frequency of the structure is outside of the
18 frequency content of the earthquake. The
19 earthquake consists of -- if you were to look at
20 the earthquake as a combination of sine waves, then
21 each sine wave has a certain frequency. The
22 content of the sine wave, the number of frequencies
23 that the earthquake is composed of, they invariably
24 lie -- in real earthquakes they lie below 33 hertz.
25 Most of the energy is below 25 hertz.

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1 Now, one can create an artificial time
2 history like Geomatrix has done for PFS where they
3 have populated the time history with -- with
4 frequencies well outside of 30 hertz, all the way
5 up to 100 hertz. Even then, even to that time
6 history, this particular cask/pad combination
7 presents a structure in the rigid range.

8 Now, to deliberately take it down,
9 reduce the stiffness to put it in the range of
10 amplified spectrum simply subverts the physical
11 problem. You will get answers which bear no
12 semblance to the reality.

13 Q. So what you're saying is if you set the
14 contact stiffness such that you will get a natural
15 frequency, say, of 5 hertz such as you get with the
16 1-million-pound-per-inch contact stiffness, you get
17 a result that does not accord with physical
18 reality?

19 DR. SINGH: That bears no semblance to
20 the way the structure will perform.

21 And also, incidentally, one cardinal
22 rule in doing structural dynamic analysis is that
23 your -- your initial conditions in the dynamics,
24 meaning the way they structure it before the
25 earthquake begins, should have a bare semblance to

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1 the reality. It should be compatible. Your model
2 should be compatible with the structure. Showing a
3 displacement of 3/8 of an inch with 1-million-pound
4 stiffness assumed clearly had wrong initial
5 condition. So this solution with 1 million pounds
6 per inch violates every rule in structure mechanics
7 and structural dynamics.

8 (The Board confers off the record.)

9 JUDGE FARRAR: Go ahead, Mr. Gaukler.

10 Q. (By Mr. Gaukler) So in -- for example,
11 in Question and Answer 28 of Dr. Khan's testimony,
12 he claims that a high contact stiffness makes the
13 vertical frequency of the cask too rigid and thus
14 artificially reduces the vertical displacement. I
15 take it you disagree with that and that exactly the
16 opposite is true, correct?

17 DR. SINGH: Well, I wouldn't -- I
18 wouldn't characterize it the way you did. I
19 would -- I would say that statement is -- bears no
20 relevance to the way one would do a structural
21 evaluation. You take the -- you take the stiffness
22 that you have. You do not juggle your stiffness to
23 reduce it deliberately to get an answer that you
24 know would be wrong, because if you reduce your
25 stiffness where it is really in the rigid range for

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1 the structure and take it down to a highly
2 magnified range in the response spectrum, you're
3 going to get inaccurate results.

4 So I really don't know -- I don't agree
5 with the way you characterized it, but at the same
6 time I guess we need to make sure that we
7 understand that the stiffness is not a parameter.
8 It's a value. It's a property. It should not be
9 played with to change -- to get the answer one
10 wants.

11 Q. Now, Dr. Khan also made a claim that
12 the -- you couldn't use the static deflection
13 parameter -- to consider the weight of a cask
14 acting over the surface was inadequate in terms of
15 evaluating contact stiffness -- strike that.

16 Now, in his prefiled direct testimony
17 and also in direct examination, Dr. Khan claims
18 that the appropriateness of a contact stiffness for
19 dynamic analysis could not be determined based on
20 static deflection considerations. Do you agree?

21 DR. SINGH: No.

22 DR. SOLER: Who are you asking?

23 Q. Dr. Soler.

24 DR. SOLER: No.

25 Q. And why not?

1 DR. SOLER: For precisely the reasons
2 that I think I've touched on. A dynamic stiffness,
3 if you want to define such a thing, is the result
4 of analyzing a problem. I believe in Dr. Khan's
5 own testimony he gave an example of that with
6 respect to the calculation of energy. He claimed
7 that the energy $1/2 KD$ squared could not be
8 calculated correctly until you had the right value
9 of D appropriate to the solution to the problem,
10 and with that I agree.

11 With a known value of stiffness, which
12 is a property -- contact stiffness, which is a
13 property of the two contacting bodies, you can then
14 solve a problem, determine the final deflection or
15 the dynamic deflection during the course of the
16 event of the body, and then, if you wish, at some
17 instant of time you are perfectly free to say at
18 that instant of time the deflection is X and the
19 total force causing that deflection is Y and then
20 define the ratio Y over X which will have the units
21 of pounds per inch. And if you wish to call that a
22 stiffness, that's fine, but it is a result of a
23 specified analysis, it is not an input parameter to
24 a problem.

25 MR. GAUKLER: In terms of -- I'd like to

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1 hand out what was previously marked as PFS Exhibit
2 94.

3 JUDGE LAM: Before you go any further,
4 Mr. Gaukler, let me ask Dr. Soler a clarifying
5 question.

6 Dr. Soler, I am puzzled by comparing
7 what I just heard from Dr. Singh and you showing me
8 how Timoshenko would have done it by computing the
9 contact stiffness to be 454 million pounds per
10 square inch on one hand -- this is something -- a
11 physical measurable quantity -- and, on the other
12 hand, I'm reading PFS Exhibit SS, this training
13 manual from ANSYS, telling me, well, contact
14 stiffness is really a figment of your imagination,
15 you should really pick and choose. On one hand you
16 are guided by convergence difficulty. On the on
17 the other hand, you want to select one that will
18 reflect a minimum deflection. Now, how am I to
19 reconcile these two pieces of information here?

20 DR. SOLER: Well, you have to remember
21 that the computer program, be it ANSYS or ABAQUS or
22 ADINA, the way they simulate the contact is you
23 first -- you have a number. Now, whether you
24 choose it by solving a hertz problem to get a
25 reasonable range or whether you just choose it high

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1 enough, you start with a stiffness.

2 Now, the way the computer program goes
3 through the solution is at each step in time it
4 will calculate -- obviously it won't predict any
5 stiffness -- any force at all at the surface unless
6 the two points, one on each surface, try to
7 penetrate each other so that the spring, if you
8 will, goes into compression. So at each instant in
9 time, the computer program at a contact point is
10 taking the stiffness that you input, taking the two
11 deflections that it has computed in the previous
12 time step and calculating a force. Or I guess a
13 better way to say it is taking the force that it
14 has calculated from equilibrium and using the
15 contact stiffness that was assumed, it calculates a
16 compression of the spring.

17 Now, because the two surfaces started
18 off at zero with no interpenetration, any
19 compression of this contact spring is going to be
20 visualized as an interpenetration, that the -- the
21 point on the cask is somehow going below the point
22 in the concrete because they both started off at
23 zero height, if you will, and now you've got some
24 penetration so a point on the cask has penetrated
25 the concrete.

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1 And all ANSYS is trying to say is that
2 your choice of stiffness has got to be high enough
3 so that that interpenetration that you see as
4 you're trying to do the problem is not a real
5 number, a real measurable number. So if you had
6 chosen the stiffness to be very high, then you
7 would see a very small number had you looked at the
8 interim solution in saying, at this instant of
9 time, what is the penetration.

10 So the ANSYS training manual is simply
11 saying calculate a stiffness, whether you use hertz
12 contact to calculate this stiffness or whether you
13 simply say to yourself, if I put this cask down on
14 the floor -- I don't expect to see it go more than,
15 oh, an eighth of an inch if I put it on mud. Maybe
16 I don't see anything if I put it on concrete. If I
17 put it on this rug, I suppose I'd be able to see a
18 measurable crush of the rug fibers. But whatever
19 number you start with, when you get the results,
20 you need to examine that, for instance, in a
21 dynamic problem where maybe the force gets
22 amplified, that you don't predict from the number
23 you've picked a penetration of, say, 1 inch.

24 For instance -- maybe this makes it a
25 little clearer -- if I have chosen this static

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1 stiffness to be 400 million pounds per inch and
2 then I subject my problem to a dynamic analysis, be
3 it an earthquake or a drop or any other dynamic
4 problem, and during the course of the conclusion I
5 examine the contact surface as a function of time.
6 And I say, What's happening to the cask? Is it
7 being shown that at, say, time equal to 5, because
8 the force has been so amplified, that I'm
9 predicting that this cask is penetrating the
10 concrete to a foot depth to be, let's say, absurd?
11 Do I have a realistic solution?

12 Well, I may have a solution that hasn't
13 blown up on me, but I have to ask myself, are these
14 two surfaces one in which I am really going to get
15 a foot of displacement from this solution? The
16 answer to that question would probably evolve to be
17 that most likely I would have crushing of the
18 concrete and gone beyond the bounds of my model.

19 But it is a fact of life that when you
20 assume this contact stiffness and use it in a
21 problem, you must examine the results as you get
22 through the entire domain and, if necessary, adjust
23 the stiffness to be even higher. If you're, in
24 fact, sure that 1 foot of penetration at some time
25 during this dynamic analysis is a fallacy of your

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1 choice of stiffness, it may not -- it most likely
2 is.

3 Now, all ANSYS is trying to bring out is
4 that you pay a penalty in solution time. That's
5 the price you pay for making these stiffnesses very
6 high. So they simply recognize your objective
7 should be to make them as low as possible to make
8 an efficient solution but still not to the point
9 where you begin to get absurd results.

10 JUDGE LAM: Thank you, Dr. Soler.

11 Q. (By Mr. Gaukler) Very briefly, in terms
12 of PFS Exhibit 94, Dr. Khan had made the claim that
13 the stiffness would change in the dynamic analysis
14 of the cask if the cask were to lift up partially,
15 or something like that. Have you taken that into
16 account in your analysis?

17 DR. SOLER: Yes, we have.

18 Q. And how have you done that?

19 DR. SOLER: If you look at this exhibit,
20 which it shows --

21 Q. That's PFS 94?

22 DR. SOLER: PFS 94.

23 -- it shows presumably a cask at two
24 stages during some kind of an analysis. At one
25 point in the analysis it's resting flush on the

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1 concrete, and it will have a certain total
2 stiffness that is equal to whatever the force is
3 vertically downward divided by whatever the spring
4 constant value you assume for the number of contact
5 elements times the number of contact elements.

6 At some later instant in time, due to
7 the forces that have been applied to it, it
8 acquires a tilted orientation where, for argument's
9 sake, only one point is in contact. At that point
10 in time there is a certain downward force acting on
11 that cask. The contact stiffness from one point,
12 let's say, is, you know, $1/10$ or $1/16$, depending on
13 the number of contact points, of the value when
14 it's flush.

15 So at these two instants of time, you
16 can calculate a number which is downward force
17 divided by current stiffness and get two different
18 values. And all of our solutions would give you
19 two different values if you choose to go in and
20 contact them.

21 But the underlying fact is the problem
22 starts with a certain fixed value assigned to each
23 one of those little springs, if you want to think
24 of them as springs, and that value doesn't change
25 as the solution goes on. The only thing that

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1 changes is the number of points that may be in
2 constant at a particular instant in time and the
3 vertical force that happens to be acting on the
4 cask at that particular time. If you -- if you
5 wish to compute force divided by current deflection
6 and plot stiffness as a function of time, dynamic
7 stiffness as a function of time, you can, but
8 that's a result, not an input.

9 Q. Now, in the cross-examination of
10 Dr. Khan, I asked him to look at your Question and
11 Answer 148 to 151 of your testimony, and that is
12 where you applied your model to a classical
13 solution that had been reported in the literature
14 and you showed how your model simulated the results
15 of the classical solution. And then you applied
16 Dr. Khan's model, and you said in your testimony
17 that his model did not simulate the results of the
18 solution.

19 Now, Dr. Khan testified that he believed
20 he would get the correct answer, I believe, if he
21 didn't use any -- that he would get the correct
22 answer with his methodology as well, or he would be
23 able to get the correct answer as well. Have you
24 reviewed his testimony that he provided on
25 cross-examination?

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1 DR. SOLER: Yes, I have.

2 Q. And do you agree with what Dr. Khan said
3 or not?

4 DR. SOLER: Yes and no, I guess, is the
5 best answer I can give, and I, of course, will have
6 to clarify that. I believe for this particular
7 classical problem that you can get an analytical
8 solution to the problem without introducing a
9 horizontal stiffness. I believe, in my review of
10 the testimony, that the real question that was
11 asked was could you get a numerical solution using
12 the methodology that you use with SAP 2000 to get
13 the correct solution.

14 Q. And how would you distinguish between a
15 numerical solution and analytical solution as you
16 just stated it in your answer?

17 DR. SOLER: The concept of friction is
18 really what I'll label stick/slip phenomena, in
19 that if you wanted to write a mathematical
20 presentation for the behavior at the horizontal
21 resistance at the contact surface and you wanted to
22 plot force versus deflection, what you would do is
23 you would plot a line that is basically -- well,
24 let me -- let me back off a little bit.

25 Q. First of all, why don't you just define

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1 for us the difference between an analytical
2 solution and a numerical solution.

3 DR. SOLER: Okay.

4 Q. That's all I was getting at.

5 DR. SOLER: An analytical solution is
6 one in which I would say I can work out the result
7 by using formulas on a piece of paper, get the
8 solution by hand and then, at most, use a
9 calculator to determine a numerical result.

10 A numerical solution is one which I
11 would characterize where I either write or use a
12 computer program because the solution or the
13 problem is so complex that I cannot solve it,
14 quote, by hand, unquote.

15 Q. Dr. Singh, would you like to add
16 anything to that?

17 DR. SINGH: Yeah. I guess let me put in
18 different words. The equations of motion are
19 second order differential equations. Newton's
20 equations of motion are second order differential
21 equations. You can directly integrate them using
22 classical calculus, and you get what is known as
23 the analytical solution. You can model it on a
24 computer program, and there you're not solving the
25 equation using classical calculus, you're solving

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1 it by integrating numerically in time what is known
2 as numerical quadrature. That's done by computers.

3 An analytical solution is all the world
4 had before computers came about. Of course,
5 solutions did exist, and those solutions were by
6 direct integration of the equations of motion.
7 That's what Alan is saying.

8 Q. And going back to -- now, with that
9 background, in what sense do you agree and disagree
10 with what Dr. Khan said in his cross-examination --

11 DR. SOLER: I --

12 Q. -- if you would describe that.

13 DR. SOLER: Okay. I agree that if you
14 get an analytical solution to that particular
15 problem, which was simple enough so I believe you
16 can, you would be able to do it without introducing
17 the concept of horizontal stiffness. If I restrict
18 myself to getting a numerical solution to that
19 problem, irregardless of whether I can do it
20 analytically, and I can use a computer program,
21 then I must introduce a horizontal stiffness to do
22 it because the computer algorithms cannot handle
23 jumps in displacement in zero time. You can't go
24 from nothing to a finite value in zero time. You
25 have to do it gradually, at least in a short time,

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1 which means introducing a -- a stiff spring there.
2 And the stiffer the better insofar as trying to
3 simulate the behavior of a vertical rise, a near
4 vertical rise in -- at the stick/slip surface.

5 Q. And so I take it that in your solution
6 you were reporting in your testimony you took a
7 horizontal stiffness -- in replicating what
8 Mr. Khan had done -- Dr. Khan had done, you took a
9 horizontal stiffness analogous to the horizontal
10 stiffness he used in his modeling?

11 DR. SOLER: Yes. It was obviously a
12 different value because we weren't working with the
13 masses associated with a cask. I think we were
14 working with a 10-pound block, if my memory serves
15 me correctly. But the methodology, the ratio
16 between the problem that Dr. Khan -- the
17 methodology that Dr. Khan used to choose his
18 particular stiffness was applied to that problem to
19 come up with an appropriate stiffness that was in
20 relationship to the other parameters of that
21 problem.

22 Q. And then you ran the solution of the
23 problem, and you could not replicate the classical
24 solution --

25 DR. SOLER: That is correct.

1 Q. -- using Dr. Khan's methodology?

2 DR. SOLER: That is correct.

3 Q. Since we've talked about horizontal
4 stiffness, I'd just like to hand out what's been
5 previously marked as PFS Exhibit 92.

6 JUDGE FARRAR: And since you've brought
7 up horizontal stiffness, now that I think back a
8 few minutes ago, it was horizontal stiffness that I
9 think some witness told us was a mathematical
10 construct. So when I asked you, Dr. Singh, some
11 time ago --

12 DR. SOLER: I'm glad of that because I
13 thought maybe he was alluding to me.

14 JUDGE FARRAR: -- it was horizontal
15 stiffness so --

16 DR. SINGH: That is, and in that
17 context, if you rephrase your question, Your Honor,
18 then my answer would be I'm in total agreement.

19 JUDGE FARRAR: Okay.

20 Mr. Gaukler, let's have the -- you don't
21 need this marked?

22 MR. GAUKLER: I don't need this marked.
23 It's already been marked.

24 JUDGE FARRAR: Okay. To accommodate the
25 reporter's different schedule today, we wanted to

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1 break around noon. If you have something we can do
2 quickly, we'll do it, or your choice, but I don't
3 want to go too much further than we are right now.

4 MR. GAUKLER: Why don't we just explain
5 this exhibit -- we can do that quickly -- and call
6 it quits?

7 JUDGE FARRAR: Okay.

8 MR. GAUKLER: I take it Your Honor is
9 suggesting we take a lunch break then?

10 JUDGE FARRAR: Yes.

11 Q. (By Mr. Gaukler) Briefly, using the
12 exhibit -- what's been marked as PFS Exhibit 92,
13 can you briefly explain why the use of a horizontal
14 stiffness, as done by Dr. Khan in his methodology,
15 of a hundred thousand pounds per inch is not
16 realistic?

17 DR. SOLER: Well, using the figure
18 exactly, the -- for the -- for the given weight of
19 the cask, the force that -- for a given choice of
20 horizontal stiffness, the deflection that you would
21 predict to move this object and cause it to slide,
22 you would have to move it 3/4 of an inch before you
23 would see relative sliding as sliding is defined
24 between the cask and the body.

25 Now, it is immaterial whether or not

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1 this force is applied statically, as by, say,
2 pushing against the cask, or dynamically, as if by
3 hitting the cask with a missile. With the
4 parameters that -- of a hundred thousand pounds per
5 inch, it would basically say that something moves
6 3/4 of an inch, but it isn't sliding, after
7 subjecting this cask to a sideward force, either
8 static or dynamically. And there's nothing there.
9 The cask is rigid. The concrete is rigid. The
10 sliding stiffness here is really -- and I guess
11 I'll use the term a "mathematical artifact" to try
12 to simulate a stick/slip phenomena, and a
13 stick/slip phenomena, you can only simulate it with
14 a high stiffness, not a low stiffness.

15 Q. You should use a higher horizontal
16 stiffness than what Dr. Khan used?

17 DR. SOLER: Right.

18 DR. SINGH: The ideal value of
19 horizontal stiffness is infinity, okay, because you
20 want the -- as Dr. Soler said, you want the cask or
21 any object, when you're modeling friction, to stick
22 or slip. That's what friction is.

23 Now, to model when the cask begins to
24 slip, you don't want to -- to corrupt the problem
25 by saying it will move by quarters of an inch --

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1 3/4 of an inch before it begins to slip. Clearly
2 it's physically inadmissible, and it clearly makes
3 the problem different from what the friction
4 supported structural problem is.

5 MR. GAUKLER: With that, it's a good
6 time to break, then.

7 JUDGE FARRAR: All right. Then it's
8 just after 12:00. Let's be back at 1:00.

9 MS. CHANCELLOR: Your Honor, can I find
10 out how much longer Mr. Gaukler has? I'm trying to
11 determine whether Dr. Arabasz needs to come today
12 or not, or should I just tell him not to come?

13 JUDGE FARRAR: What do you think,
14 Mr. Gaukler?

15 MR. GAUKLER: I guess I had expected to
16 be done this morning. But for the fact of the
17 recent discussions, I think I'm on track in terms
18 of what I originally intended. So -- what? -- I've
19 been going about an hour and a half. I probably
20 have another hour, hour and a half left.

21 JUDGE FARRAR: Then you'll want to --
22 does the Staff have much that they would do?

23 MR. O'NEILL: At this point maybe --
24 maybe a question or two, so I -- I need to confer
25 again.

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1 JUDGE FARRAR: Then you would -- you'll
2 have some?

3 MS. CHANCELLOR: Cross-examination, yes,
4 and there may be some rebuttal by Dr. Khan. It
5 looks like the full day.

6 JUDGE FARRAR: Well, I hate to lose him.
7 I mean he's only got to come down the hill, right?

8 MS. CHANCELLOR: Yes, but he's got to
9 change into a suit first.

10 JUDGE FARRAR: Well, why don't you tell
11 him show up without changing into his suit, and
12 we'll ban any cameras if they're here.

13 MS. CHANCELLOR: I'm not sure
14 Dr. Arabasz would do that, Your Honor.

15 JUDGE FARRAR: Why don't you get him
16 here. I hate to take the chance of losing any
17 time.

18 MS. CHANCELLOR: I'll keep him on
19 standby, if that's okay.

20 JUDGE FARRAR: Yes, and then you could
21 call him at 3:00 or 3:30 or something like that.

22 MS. CHANCELLOR: Right.

23 JUDGE FARRAR: Let's come back at five
24 after.

25 (Lunch recess was taken.)

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1 JUDGE FARRAR: Mr. Gaukler, if you're
2 ready to resume, we'll get started.

3 Q. (By Mr. Gaukler) Good afternoon,
4 Dr. Singh and Dr. Soler.

5 DR. SINGH: Good afternoon.

6 DR. SOLER: Good afternoon.

7 Q. Dr. Singh, I would like to turn to a new
8 topic, damping. You've heard a lot of discussion
9 about damping. First of all, is damping a real
10 value or a mathematical construct as far as your
11 evaluation is concerned?

12 DR. SINGH: Damping is a real fact in
13 life. Without damping, human civilization would be
14 impossible. Damping is essential.

15 Now, to quantify it, one uses
16 mathematical tools, if you call it mathematical
17 construct, when using mathematical tools to
18 quantify damping.

19 Q. And what kind of mathematical tools do
20 you use to quantify damping?

21 DR. SINGH: These would be numerical
22 codes that are equipped to predict response of, for
23 example, impacting bodies to give the value of
24 damping. Equivalent damping, I should say.

25 Q. Now, yesterday Dr. Khan had made

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1 reference to NRC Regulatory Guide 1.61 which I
2 think concerns structural damping. To what extent
3 is structural damping taken into account in your
4 model, number one; and number two, is that the type
5 of damping we're talking about when we talk about
6 the damping value that you use in your model?

7 DR. SINGH: Structural damping that
8 Dr. Khan mentioned, he referred to Reg Guide 1.61,
9 is really written, and structural damping really is
10 significant in linear structures, structures which
11 are anchored. Perhaps linear is a poor choice of
12 words. Anchored structures. Structural damping --
13 and by the way, a good many of the structures in
14 nuclear power plants are anchored. That particular
15 Reg Guide really deals with damping that the
16 structure applies internally to it by virtue of its
17 deformation under stress. That's why it's called
18 structural damping.

19 The principal mode of damping in a
20 freestanding structure is impact damping, damping
21 that arises from the fact that two surfaces, two
22 bodies may experience an impact force during a
23 dynamic event. Impact between the cask and the
24 pad, the damping that applies to the interface, the
25 appropriate term for that is impact damping.

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1 The appropriate damping between the fuel
2 assemblies which are inside the fuel basket and the
3 basket is impact damping. The damping because of
4 the basket interface with the enclosure vessel in
5 the MPC is impact damping. The damping because of
6 contact between the MPC and inside surface of
7 HI-STORM is impact damping.

8 There are copious locations of impact
9 damping in a freestanding cask. Structural damping
10 is a relatively insignificant player, the damping
11 variable, in a rigid structure such as a cask.

12 Q. And the damping that you use in your
13 model represents the impact damping between what
14 and what?

15 DR. SINGH: We have neglected impact
16 damping everywhere except between the cask and the
17 pad, again, for reasons of conservatism.

18 Q. Have you done evaluations as to what is
19 the appropriate impact damping to use between the
20 cask and the pad?

21 DR. SINGH: Yes, we have.

22 Q. And would you please briefly describe
23 those.

24 DR. SINGH: One can and we have
25 quantified damping between two bodies by accurately

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1 modeling the elastic and inelastic properties of
2 the two bodies undergoing impact. There are
3 suitable computational tools available to do that.
4 LS-DYNA, which we mentioned yesterday, is one such
5 computer program. One can and we have used that
6 program to quantify the extent of damping that
7 would exist between the interface between a cask
8 such as HI-STORM and a concrete pad. The values of
9 impact damping under an impact event such as
10 between a concrete pad and a cask are in the order
11 of 40 percent of critical or greater.

12 Q. So the damping that you use can be
13 calculated, and you have done calculations with
14 respect to that damping?

15 DR. SINGH: In the course of our work
16 that we do on these casks, and realize that our
17 people are doing this work all the time, the values
18 have been quantified by our people in the range of
19 40 percent or greater.

20 Q. Is there any, say, test data that it
21 would be relevant in terms of the amount of damping
22 that would be appropriate?

23 DR. SINGH: Yes. As a matter of fact,
24 NRC sponsored a series of impact experiments by
25 Lawrence Livermore Laboratory. They dropped on a

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1 simulated concrete pad casks made out of steel.
2 They call them billets, b-i-l-l-e-t-s. They were
3 typically I guess 20, 24 feet in diameter, certain
4 length, and they ran calibrated impact tests. In
5 other words, the billet was equipped with a
6 accelerometer -- accelerometers, I should say, and
7 the data, the behavior of the actual impact event
8 was fully characterized. NRC published those
9 documents through the laboratory -- the laboratory
10 wrote the documents and NRC published them. They
11 became available to the industry in around 1997, so
12 five years ago.

13 Now, those tests, the test data, I will
14 call it Lawrence Livermore studies for sake of
15 reference. The Lawrence Livermore studies test
16 data can be and was -- by the way, we used LS-DYNA
17 to correlate the test data with our version of the
18 program. That's how we benchmarked the program,
19 and NRC, incidentally, has reviewed it and accepted
20 it.

21 One can use test data of that sort to
22 quantify impact damping. One can, if you have a
23 benchmark program such as we do, essentially now
24 simulate impact of any two bodies and calculate
25 impact damping that will exist in that collision

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1 event.

2 Q. Dr. Khan has claimed that one should
3 consider damping values as low as 1 percent. Do
4 you consider damping values as low as 1 percent
5 reasonable or anywhere close to being realistic?

6 DR. SOLER: No.

7 Q. Have you done any evaluation in an
8 attempt to show why you believe 1 percent of
9 damping is unrealistically low?

10 DR. SOLER: Yes. I've done a numerical
11 experiment which happens to be reproducible very
12 easily in real life. I simulated the dropping of
13 three spheres, each starting off 18 inches above a
14 surface. One sphere is given a coefficient of
15 restitution equivalent to 40 percent damping, the
16 other, the next sphere equivalent to 5 percent
17 damping, and the third sphere a coefficient of
18 restitution equivalent to 1 percent damping.

19 Q. Could you briefly describe what
20 coefficient of restitution is? Just define that
21 term.

22 DR. SOLER: Coefficient of restitution,
23 and this is in the report that was just
24 submitted --

25 MR. GAUKLER: And I would point the

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1 Board to pages --

2 DR. SOLER: Pages 22 and 23 -- 23 I
3 think is fine.

4 MR. GAUKLER: 22 to 24.

5 DR. SOLER: 22 to 24. Basically,
6 without trying to extend this, the coefficient of
7 restitution in a normal impact as we're talking
8 here is defined as the ratio of the velocity of
9 separation to the velocity of approach, meaning
10 that if this is the surface, the sphere drops right
11 when it hits, it has a certain velocity, it bounces
12 back. And if you had the capability of measuring
13 those, the ratio of the hitting to the bouncing
14 back is the coefficient of restitution.

15 You can also solve the problem
16 analytically to show that the ratio of the initial
17 height to the height it comes back to is equal to
18 the square of the coefficient of restitution.

19 And then finally, you can solve the
20 entire problem as a mass spring damper system and
21 show that the coefficient of restitution is
22 independent of the stiffness and related only to
23 the percent of critical damping.

24 So if I talk a certain value of
25 coefficient of restitution, that is equivalent to a

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1 certain percentage of critical damping.

2 Q. With that background, would you go ahead
3 and show the simulation, narrate it as necessary?

4 DR. SOLER: This simulation simply will
5 show you by visual means what is and is not
6 realistic.

7 I will leave it -- it's very obvious
8 which one is 40 percent, and we'll assume the
9 obvious which one is 1 percent. This is not
10 real-time. The total duration of the event is
11 about 3 minutes and 50 seconds. What's more
12 relevant is if you count the number of bounces and
13 then ask yourself the question as to what is
14 reasonable and what is unreasonable for this
15 situation we're dealing with now.

16 Q. So I take it the red ball is the 40
17 percent?

18 DR. SOLER: The orange ball is 40, the
19 yellow is 5, and what's still moving is 1. And
20 we're only about a quarter of the way through the
21 total time of this event and the bouncing ball
22 hasn't stopped bouncing when I shut down the run.

23 Q. Now, you've calculated the number of
24 bounces that each ball does?

25 DR. SOLER: Yes.

1 Q. And that's in the report, correct?

2 DR. SOLER: Yes. Within halves of
3 bounces, for the 1 percent case it's going to be
4 roughly 73 bounces until it reaches I think 1
5 percent of its initial height. For the 40 percent
6 damping it's two bounces, and for the 5 percent
7 damping I believe it's 14 bounces before it
8 reaches -- I guess it's -- yeah, 1 percent of its
9 initial height. So if you start at 18 inches, in
10 two bounces the 40 percent damped sphere will be
11 down to .18 inch, and if you look at the sphere
12 that's still going, it will take 73 bounces before
13 it roughly reaches a three-eighths of an inch
14 height.

15 It's now about two thirds through the
16 simulation run. It will eventually, although not
17 in the lifetime of this movie, come to a halt. So
18 do you want me to continue or shut this down?

19 Q. Why don't you go ahead. You've also
20 done a simulation of kind of visually showing it
21 with casks.

22 DR. SOLER: Yeah. Now, to show you
23 that, of course at least in this computer program
24 the way the problem has been set up, it's
25 independent of the shape of the body. I have also

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1 repeated the simulation using casks. And before I
2 start that simulation, I would like to just show
3 this one picture which shows three casks, and they
4 are true to scale, each 18 inches above a surface.
5 And the little green cylinder over to the left
6 represents a human being of roughly five and a half
7 feet tall. I just show you that to give you the
8 scale of the real objects we're dealing with.

9 Having done that with the picture, I
10 will now basically run the simulation. This hasn't
11 been made into a movie. This is running directly
12 from the computer code. So the three plots on the
13 right represent the velocity of the center of the
14 cask, and from that you can count the bounces if
15 you're so inclined to do that.

16 This run is again not in real-time, but
17 the same -- the same result shows. I run this for
18 a total of, well, actually, almost about 17 seconds
19 now. If you look closely at this curve, that
20 curve, which you obviously can't see until you get
21 it up close, you will definitely see two bounces
22 and then there is a third bounce and then it comes
23 to rest for 40 percent damping. The curve on the
24 bottom is obviously showing what's going on with 1
25 percent damping.

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1 The distances you see here are different
2 from the sphere because I was able to bring the
3 sphere up closer to the focus without losing all
4 three pictures. But I thought it was worthwhile to
5 see the -- understand the scale of the real object
6 you're dealing with.

7 JUDGE LAM: Dr. Soler, do they weigh
8 360,000 pounds?

9 DR. SOLER: They do, but weight doesn't
10 come into the problem. You get the same result --
11 well, weight comes into the problem only because in
12 choosing the percent of critical damping, the
13 actual value for the damper is reflected in the
14 percentage of two times the square root of KM. So
15 to that extent the weight you're dropping enters
16 into the problem. But if I change the weight to a
17 hundred thousand or ten pounds or one pound and I
18 calculated 40 percent of critical damping, 5
19 percent of critical damping, and 1 percent of
20 critical damping, I would get the same responses in
21 the right-hand plot.

22 JUDGE LAM: Do you mean to demonstrate,
23 Dr. Soler, then, using Dr. Khan's model of 1
24 percent damping is 360,000-pound cask would bounce
25 73 times before coming to a rest?

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1 DR. SOLER: Well, it hasn't even come
2 to -- before it comes to 10 percent of its initial
3 height in this solution -- 1 percent. When it
4 becomes -- it will bounce 73 times, and then after
5 the 73rd bounce it will rise up to a height of .18
6 inches if it started at 18 inches.

7 Okay, this is done.

8 JUDGE FARRAR: You said a couple of
9 times this was not real-time. What's the length of
10 your animation versus how long it would take in
11 real life?

12 DR. SOLER: In this particular case
13 that's shown on the screen, I'd actually have to
14 time it. But the length of this animation in
15 real-time is 23 and a half seconds. I could
16 roughly run it over --

17 JUDGE FARRAR: Don't use the word
18 "real-time," because every time you use it I don't
19 know if you're talking real life or this -- I'd
20 like the animation versus real life.

21 DR. SOLER: In real life this event
22 takes 23 seconds.

23 JUDGE FARRAR: You mentioned earlier
24 when you were talking about critical damping
25 coefficient of restitution, and it measured the

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1 same thing, they're the inverse of each other?

2 DR. SOLER: No --

3 JUDGE FARRAR: Or inversely related to
4 each other?

5 DR. SOLER: They're related to each
6 other. The exact relationship, I'm not sure I have
7 it -- yes, I do. The exact relationship, if I can
8 find that equation --

9 MR. GAUKLER: Page 23?

10 DR. SOLER: It's page 24. If you'll
11 look, the first equation which says H sub n divided
12 by H equals -- well, that's the number of bounces.
13 So it's -- basically there is a relationship that
14 says that the coefficient of restitution is related
15 to the E raised to some constant times the percent
16 of critical damping. I mean, it's a mathematical
17 relationship. I would not call it inversely.

18 Q. (By Mr. Gaukler) It's a mathematical
19 relationship but you would not call it the inverse?

20 DR. SOLER: I mean, it's not like the
21 coefficient of restitution is 1 over the percent of
22 critical damping.

23 JUDGE FARRAR: But they move in opposite
24 directions.

25 DR. SINGH: They have a reciprocal

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1 relationship.

2 Q. (By Mr. Gaukler) Dr. Singh, in your
3 visual NASTRAN runs that you were doing for the
4 beyond design basis report, you used 40 percent
5 critical damping and those analyses, and for the
6 design basis DYNAMO runs you used 5 percent
7 critical damping. Can you tell me the reason why
8 you use 5 percent in one and 40 percent in the
9 other?

10 DR. SINGH: Yes. The percent of
11 critical damping is related to the severity of the
12 event. In other words, if you have a weak, rather
13 modest earthquake in which the structure is barely
14 moving, then the associated damping that nature
15 provides to the phenomenon is also small.

16 As the severity of the earthquake
17 increases and the structure of course responds to
18 the earthquake, the damping, impact damping
19 provided by the impact that occurs in the
20 earthquake is greater.

21 The NRC's documents recognize this also
22 in respect of structural damping. NRC has
23 operating basis earthquake and design basis
24 earthquake which I'm sure all of you have run into
25 in nuclear plant design. The damping permitted for

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1 the operating basis earthquake is less than that
2 for design basis earthquake, deliberately
3 recognizing the fact that the extent of damping is
4 directly related to the severity of the event.

5 We have used 5 percent again in the
6 spirit of conservatism in doing the early
7 evaluations with 1,000- and 2,000-year return
8 earthquakes. When we went to the extremely severe
9 earthquakes then it became meaningful, so we don't
10 have absurd modeling of the problem. We changed
11 the damping, impact damping to a more realistic and
12 yet conservative value, 40 percent.

13 Q. Dr. Singh and Dr. Soler, Dr. Khan in his
14 testimony in his cross-examination has claimed that
15 the cask stability analysis is highly sensitive to
16 changes in contact stiffness and changes in
17 damping. Have you done any evaluations to test the
18 sensitivity of the cask stability analysis to
19 changes in contact stiffness or damping?

20 DR. SOLER: Yes, we have.

21 Q. Would you please describe those,
22 Dr. Soler, and then show the appropriate
23 simulations that go with them. Start out with the
24 base case, I guess.

25 DR. SOLER: Yes. I will refer to page

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1 29 of the report just submitted, and that shows the
2 results from three simulations. The first result
3 is what we have been calling the 2K design-basis
4 earthquake which has been reported in the beyond
5 design basis scoping evaluation which was actually
6 done for roughly 18 million as a total stiffness
7 and 27-1/2 percent of critical damping. And one of
8 the runs that I'm going to show now is that same
9 run that has been redone for using a total
10 stiffness of 40 million at the base of the cask and
11 40 percent critical damping. So the first
12 simulation is one that's comparing 18 million
13 stiffness and 27-1/2 percent critical damping and
14 40 million stiffness and 40 percent critical
15 damping. In both cases we would claim that the
16 stiffnesses used are in the right range.

17 Q. Are you showing -- I'd like to direct
18 you to page 29 of 43.

19 DR. SOLER: Yes.

20 Q. Which case are you talking about?

21 DR. SOLER: That is what is labeled here
22 as Case 12 of referencing reference No. 3, which is
23 the report beyond design basis scoping analysis.

24 Q. And what is the stiffness of this case,
25 again?

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1 DR. SOLER: The stiffness for this case
2 is each cask-to-pad interface has a total of
3 approximately 40 million pounds per inch as a
4 vertical stiffness, and it has a percent of
5 critical damping of 40 percent.

6 Q. I thought you had mentioned something
7 else. I just wanted to make sure exactly what you
8 were saying here.

9 DR. SOLER: Now, let me go through the
10 three simulations and then I'll run them one at a
11 time.

12 The second case is one in which we
13 maintain a stiffness of approximately 40 million
14 pounds per inch between the cask -- between each
15 cask and the pad, but we lower the percent of
16 critical damping to 5 percent, which is a value
17 based on our dropped spheres here which we feel is
18 reasonable but very conservative.

19 The third case is a case where we
20 lowered the stiffness to five million pounds per
21 inch, approximately, but kept the damping as 40
22 percent of critical damping.

23 Now, the actual value for the damping
24 constant changes even though the percentage of
25 critical damping remains the same, because critical

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1 damping is a function of the stiffness.

2 So I have three simulations, all with
3 eight casks on the pad, all using the lower bound
4 soil properties, and all using the 2,000-year
5 return seismic event. And in one case there is a
6 change in both stiffness and damping, in the second
7 case there is a change in damping dramatically
8 downward, and in the third case there is a change
9 in stiffness dramatically downward.

10 So I'll start by running the first case.
11 All three of these were for 30-second earthquakes.
12 Now, this one will run longer than 30 seconds.

13 Q. This is not --

14 DR. SOLER: This is case one -- 40
15 million stiffness, 40 percent critical damping.

16 From the results here, I shut this one
17 down at roughly 25.3 seconds because all the motion
18 had essentially stopped.

19 Q. And 25.3 seconds, you're talking about
20 real --

21 DR. SOLER: That's the real-time.

22 Q. And what you saw here took longer than
23 that?

24 DR. SOLER: Yes, and I did not time it.

25 Now, the next case, which is case 2 --

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1 let me make sure I've got the right simulation
2 here. All right, this one is the second case where
3 the stiffness is still maintained at approximately
4 equal to 40 million pounds per inch, but the
5 damping is lowered to 5 percent. So this is still
6 stiff but with low damping. The total event time
7 that you're seeing here is one minute and 20
8 seconds.

9 Q. And the earthquake time?

10 DR. SOLER: The earthquake time is 30
11 seconds. Now, if you will refer back to the table
12 on this one, you'll notice that I have plotted two
13 casks, because it's quite obvious from viewing the
14 visual that the casks that I normally plotted
15 the -- and normally I mean in all the previous
16 simulations -- where I've normally tracked cask
17 number one, which is that one, the top center of
18 that cask, that point right up there, you could see
19 from these simulations that certain periods of time
20 these interior casks obviously seemed to be moving
21 much more than cask number one. So for this
22 simulation I did also went back and tracked a point
23 at the top center of that, and that value, the
24 maximums are also reported in this case for the two
25 casks, not just the one.

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1 Q. And that was cask five, the second cask?

2 DR. SOLER: It's cask five, according to
3 my numbering system, which is that guy right there
4 (indicating).

5 Finally, the third simulation is for a
6 low stiffness per cask, approximately just under
7 five million pounds per inch but back up to the 40
8 percent damping. This case is also going to be one
9 of a 30-second earthquake which takes a minute and
10 20 seconds to run in what I'll call hearing time.

11 Okay, and that completes the simulations
12 here.

13 Q. From these analyses that you've just
14 shown and the other analyses that you've done with
15 respect to the HI-STORM 100 at PFS, what
16 conclusions do you draw regarding Dr. Khan's claim
17 that the cask movements are highly sensitive to
18 contact stiffness and damping?

19 DR. SOLER: I would say in summary that
20 changing the parameters we're talking about
21 certainly causes some changes in a particular
22 result. But these changes that you might see by
23 varying damping or stiffness or both are in the
24 order of inches, not in the order of multiples of
25 feet as claimed by Dr. Khan.

1 Q. Dr. Singh?

2 DR. SINGH: Yes.

3 Q. I would like to go to the topic of
4 benchmarking. Just for background purposes, could
5 you just briefly summarize different methods by
6 which one could benchmark a computer model?

7 DR. SINGH: A computer model is
8 benchmarked by several means, can be benchmarked by
9 several means. One of them, of course, is to check
10 the model itself. I'm speaking to the model, not
11 the program, to perform the necessary compatibility
12 check, which is checking the initial conditions.
13 Initial conditions in this case would be, in the
14 case of the cask, dynamic analysis would be its
15 initial deflection before the earthquake begins,
16 checking the response of the system to equivalent
17 systems.

18 Now, we at Holtec, for example, have
19 thousands of runs that we have made over the past
20 15 odd years simulating freestanding structures.
21 We have a large body of data. We verify the model
22 of a new problem against the body of data and
23 results we have from the past. That's how models
24 are done. Of course, you make sure that your model
25 does not have characteristics or parameters that

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1 would be absurd for that physical problem.

2 In that context I'll mention, for
3 example, the spring. That represents friction. As
4 I said earlier today, the ideal value of the
5 friction spring is infinite. Any number that one
6 uses less than infinity is only to satisfy the
7 demands of the computer. One would check,
8 depending on the parameters used in the model,
9 check it against the ground rules of satisfying
10 initial conditions, satisfying the physics of the
11 problem, and so on.

12 Q. You mentioned that -- well, it's been
13 discussed that the DYNAMO code has been validated
14 and benchmarked, and the question came up yesterday
15 to what extent the validation benchmarking of that
16 DYNAMO code was -- the extent to which the
17 benchmarking and validation was limited to the
18 application for spent fuel storage racks or to what
19 extent that validation and benchmarking also
20 applied to cask stability analysis. Could you
21 please inform us about that?

22 DR. SINGH: All right. I can answer
23 that question. DYNAMO stands for dynamic motion.
24 It's an acronym for dynamic motion. It's a code to
25 analyze the dynamic response of structures.

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1 Now, it is true that the great bulk of
2 work that we do at Holtec is on freestanding fuel
3 racks and freestanding casks, and therefore the
4 great majority of the application of this program
5 is in casks and racks. However, the validation of
6 the program was done against a broad range of
7 dynamics problems, problems that will test out the
8 veracity of the computer program against some
9 challenging dynamic situations.

10 I have -- in front of me I have this
11 training manual, DYNAMO training manual sent to me
12 by Federal Express from the office yesterday. This
13 has in here in this book over a dozen cases, I
14 believe twelve of them, maybe some miscellaneous --

15 DR. SOLER: There may be more.

16 DR. SINGH: -- that simulate a wide
17 variety of problems. Some of them are rather
18 difficult to simulate problems on the computer,
19 problems of harmonic resonance, bifurcation, the
20 rather unique dynamic responses of nonlinear
21 structures. This program has been shown in this
22 manual, but it predicts, even though -- it's able
23 to simulate, even though it's rather arcane,
24 dynamic motion situations.

25 Q. So the validation process would be

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1 equally applicable for spent fuel racks and cask
2 stability analysis?

3 DR. SINGH: Yes, sir.

4 Q. Yesterday we discussed with Dr. Khan
5 IEEE standard 344-1987, and Dr. Khan claimed that
6 following that standard that testing, shake table
7 testing would be appropriate here. Do you agree
8 with Dr. Khan in that respect?

9 DR. SINGH: No. I think he's
10 misinformed.

11 Q. Would you please tell me why you
12 disagree? First of all, is IEEE standard 344
13 applicable here?

14 DR. SINGH: No, it is not.

15 Q. Why not?

16 DR. SINGH: IEEE is a document published
17 by the Institute of Electrical Engineers and it is
18 intended for the class of components which are,
19 number one, not very large, therefore they can be
20 put on a shake table; number two, an essential
21 characteristic is that during an earthquake, of
22 course, a structure is subject to stresses and
23 deformations. In some electrical equipment and in
24 some mechanical equipment as well, very small
25 deformations will negate the functionality of that

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1 equipment during the earthquake and sometimes after
2 the earthquake. For those cases where small
3 tolerances are important in the equipment, testing,
4 and that is where the focus of IEEE 344 is, testing
5 is recommended and an appropriate procedure.

6 The situation for a cask, HI-STORM, the
7 applicable document one should refer to is a public
8 document, it's NUREG 1536, that Dr. Khan referred
9 to yesterday. NUREG 1536 is the premier design
10 guidance document from the NRC. And that
11 document --

12 Q. Design guidance document from the NRC
13 for what?

14 DR. SINGH: For storage casks. And that
15 document does not invoke IEEE 344. So I do not
16 mean to speak for the NRC, but I would say that the
17 considered -- the opinion in the
18 regulatory/scientific energy is that IEEE 344 is
19 not applicable to casks.

20 Q. Wholly apart from the applicability of
21 IEEE standard 344, I have two questions with
22 respect to shake table testing which has been
23 discussed at various points. One, do you believe
24 it's necessary here, and number two, do you believe
25 it would be feasible to get meaningful data from a

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1 shake table test data. And would you please
2 address shake table testing in those two respects?

3 DR. SINGH: The first question, is it
4 necessary. The answer is absolutely no. The shake
5 table test would only confirm, if it could be done
6 successfully, would only confirm that Newton's laws
7 of equation are indeed valid today. Now, I could
8 imagine when Newton first proposed Newton's laws of
9 motion, that Robert Hooke, who opposed everything
10 Newton said, would have said, run a shake table to
11 prove to me that your equations of motion are
12 right. But today to ask a shake table test for a
13 problem which is well defined and is fully and
14 completely modeled by classical Newton's equations
15 of motion makes no sense. That is the answer to
16 your first question.

17 What was your second question?

18 Q. Second question was, to what extent do
19 you believe it would be feasible to obtain
20 meaningful data from a shake table test?

21 DR. SINGH: I assure you that a shake
22 table test will confer no new knowledge, no new
23 information, even if it were carried out, to this
24 problem. And the reason, the principal reason is
25 that a physical shake table test simulating the

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1 conditions of a cask on a pad is simply not
2 feasible. This statement is -- I say this in
3 absolute earnestness. Let me try to explain why I
4 say this.

5 Some time ago we were trying to do tests
6 just to compute, just to get the value of
7 coefficient of friction between two bodies, static
8 and dynamic. The static conditions and dynamic
9 conditions. I'm not going to go through the
10 detailed technical problems we faced, but let me
11 just summarize it for you.

12 We found that the so-called Coulomb
13 coefficient of friction, I'll spell it for you
14 later, Coulomb coefficient of friction, which is
15 neatly represented by stick and slip phenomenon,
16 when you read on the test you have friction
17 coefficient which is a function of velocity, it's a
18 function of the pressure under which the two
19 surfaces are subjected, it's a function of the
20 frequency at which these two surfaces are rubbing
21 against each other, and it's a function of the
22 duration for which the rubbing goes on.

23 The friction coefficient that we so
24 neatly simulate in a computer program, if you go to
25 run a test you have to contend with the fact that

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1 that coefficient is a variable with time, with
2 pressure; as a matter of fact, it's changing all
3 the time.

4 Now, add to the fact that the cask is an
5 11 feet in diameter object, it's a large surface,
6 the friction coefficient varies point to point in
7 that surface, how would you ever replicate a cask
8 on a pad on a shake table? And if you cannot
9 replicate in any experiment, if you cannot
10 replicate the physical problem, if you don't know
11 what you're doing, then you cannot benchmark it.
12 You have to look precisely what the principal
13 parameters are. And that is just one aspect of the
14 problem. If Mr. Soper is interested later, I'll
15 explain more. But it is absolutely impossible to
16 run a shake table test and get a meaningful data.

17 JUDGE FARRAR: But doesn't everything
18 you've just said about why you can't do a shake
19 table test run counter to what you said earlier,
20 that this is a very simple, well defined problem?

21 DR. SINGH: That is very perceptive of
22 you to ask the question, Judge Farrar.

23 JUDGE FARRAR: Oh, thank you.

24 DR. SINGH: The way engineers deal with
25 these uncertainties is that they downed the

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1 problem. In the case of friction, we do two sets
2 of problems. We assume .2 interface coefficient,
3 which is the integrated average, and then we assume
4 .8, which is the upper limit. And then we do, and
5 we don't always represent everything in the reports
6 we write, we do random coefficient of friction, but
7 we allow the friction in the computer simulation to
8 vary within these two limits.

9 Whenever a problem cannot be physically
10 modeled, the engineer's only recourse is to make it
11 conservative, and that's what we do. But indeed,
12 friction is one of the elusive parameters that one
13 deals with in analyzing freestanding structures.

14 Q. (By Mr. Gaukler) Dr. Singh, do you have
15 State Exhibit 195 in front of you?

16 DR. SINGH: If you will refresh my
17 memory. Which one is that? They're not labeled
18 here.

19 Q. State Exhibit 195 is the curves that we
20 were talking about yesterday evening in terms of
21 the response spectra.

22 DR. SINGH: I remember it.

23 Q. Dr. Singh, what's your understanding
24 that these curves represent, and do they have any
25 relevance to the cask stability analysis that

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1 Holtec -- well, what is that relevance?

2 DR. SINGH: These curves are called
3 response spectra, as Dr. Khan capably explained
4 yesterday. The response spectra is the footprint
5 of the earthquake. It really is -- you understand
6 the nature of the earthquake by looking at the
7 spectra. These spectra give you the information
8 that this earthquake that has been generated has
9 been, as I said earlier, richly populated with
10 higher frequency harmonics, which means that this
11 earthquake has been made extremely conservative.
12 Typical earthquakes, they don't have much energy
13 content over 25 cycles per second. Here this
14 earthquake, this response spectra shows to you that
15 the earthquake has been enriched with harmonics
16 well above 25 Hz. That's one information it gives
17 you.

18 The second information it gives you is
19 that in every other respect it is a normal
20 earthquake. Every response spectrum has peaks and
21 valleys. That is the nature of an earthquake. If
22 you take an earthquake and create a response
23 spectrum from it, that spectrum will have this
24 appearance, and there is nothing magical, nothing
25 mystical about the fact that this spectrum has

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1 peaks and valleys.

2 Now, in a linear structure, if you had
3 an anchored linear structure, then the insights
4 that Dr. Khan offered yesterday would be
5 meaningful. In the case of a nonlinear structure
6 where time history is the only acceptable way to do
7 evaluation, these peaks and valleys don't mean
8 anything. They have very little relevance to the
9 dynamic problem.

10 Q. And in particular, for example, do peaks
11 and valleys at frequencies of 5, 10, or 15 Hz have
12 any relevance in terms of the contact stiffness to
13 be used or the spring to be used between the pad
14 and the cask in your cask stability analysis?

15 DR. SINGH: Yes. The peaks and
16 valleys -- actually the shape of the spectrum all
17 together. It informs you. It gives you the
18 following information. It informs you that the --
19 if you have an exciting mechanism, in this case the
20 earthquake, if its frequency content is
21 concentrated in a certain range or it is a broad
22 earthquake where it really goes out to much higher
23 frequencies, and it will react to a structure,
24 linear structure whose natural frequency is in this
25 range, in this case between up to -- spotted up to

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1 about 33 cycles per second, it will respond in that
2 range to a structure whose frequencies is in that
3 range by amplifying, in most cases, the response.

4 Now, in case of a cask and pad that we
5 have observed here before, the stiffness is
6 extremely high; the frequency, therefore, the
7 pseudo frequency that can be calculated by assuming
8 the cask attached to the pad would be very high,
9 111 Hz, I guess we informed the Board earlier
10 today, and therefore there is no interaction,
11 there's no amplification, there is no --
12 "relevance" is a bad word but it describes the
13 effect. There is no coupling between the
14 earthquake and the structure itself. That is
15 the -- that is what one must look for to see
16 whether this earthquake and the physical
17 characteristics of the system will interact.

18 The information that this earthquake
19 gives me is that even though it has been richly
20 populated with harmonics in high range, the
21 frequency of the structure is so high that there
22 will still not be any amplification. However, if
23 you were to take a lower value of contact
24 stiffness, then you will begin to see
25 amplification. That is what it will tell you. The

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1 frequency of 33 Hz will show some amplification. A
2 frequency of 5 Hz will definitely show much greater
3 amplification.

4 MR. GAUKLER: May I just have a second,
5 your Honor?

6 No further questions, your Honor. I do
7 want to go through the exhibits, I guess. Let's
8 take the -- first of all, I would move for
9 admission of PFS Exhibit 225 and 226.

10 MR. SOPER: Can we do one at a time
11 here?

12 JUDGE FARRAR: Let's do one at a time.
13 225 is the --

14 MR. GAUKLER: Excuse me. Let's leave
15 that one to the end since I know there's going to
16 be a fight. Let's take those that there's no fight
17 about first. Do the simple ones first, okay?

18 JUDGE FARRAR: All right.

19 MR. GAUKLER: PFS Exhibit 226, which is
20 the excerpt from an earlier Holtec report where
21 there was the calculation of the contact stiffness
22 of 454 million pounds per inch.

23 JUDGE FARRAR: Mr. Soper, any objection
24 on 226?

25 MR. SOPER: No objection, your Honor.

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1 JUDGE FARRAR: Staff?

2 MR. O'NEILL: No objection, your Honor.

3 JUDGE FARRAR: That will be admitted.

4 (APPLICANT'S EXHIBIT-226 WAS ADMITTED.)

5 MR. GAUKLER: Next I'd like to move for
6 the admission of PFS Exhibit 221. That was the
7 excerpt from the ANSYS training manual that also
8 had the reference to the Hertzian method for
9 calculating contact stiffness.

10 JUDGE FARRAR: Was that today?

11 MR. GAUKLER: Yeah. We marked it
12 yesterday, but I went through it again today and I
13 now request admission of it. We have an extra
14 copy, your Honor.

15 MR. SOPER: That was the bolt pretension
16 training manual?

17 MR. GAUKLER: It was the three-page
18 exhibit, 221.

19 JUDGE FARRAR: Off the record.

20 (Discussion off the record.)

21 JUDGE FARRAR: 221, any objection?

22 MR. SOPER: No objection, your Honor.

23 MR. O'NEILL: No objection.

24 JUDGE FARRAR: Okay.

25 (APPLICANT'S EXHIBIT-221 WAS ADMITTED.)

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1 MR. GAUKLER: Then I would like to move
2 for the admission of PFS Exhibit 92, which was
3 labeled Horizontal Displacement Just Prior to
4 Sliding at Cask/Pad Interface.

5 JUDGE FARRAR: When did we mark that
6 one?

7 MR. GAUKLER: That was marked way back
8 with Dr. Khan's cross-examination, and we decided
9 we would not admit it at that time since he didn't
10 support it; therefore I brought it up again with my
11 witnesses to have them support it, the admission of
12 it.

13 JUDGE FARRAR: Okay. Mr. Soper?

14 MR. SOPER: No objection, your Honor.

15 JUDGE FARRAR: Staff?

16 MR. O'NEILL: No objection, your Honor.

17 JUDGE FARRAR: Okay, that will be
18 admitted.

19 (APPLICANT'S EXHIBIT-92 WAS ADMITTED.)

20 MR. GAUKLER: And then I would move for
21 admission of PFS Exhibit 94. This was the one that
22 showed how contact stiffness would vary in the
23 analysis if the cask were to lift up and not be
24 pressing down on all the springs.

25 JUDGE FARRAR: Mr. Soper?

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1 MR. SOPER: No objection, your Honor.

2 JUDGE FARRAR: Staff?

3 MR. O'NEILL: No objection, your Honor.

4 JUDGE FARRAR: Okay, that will be
5 admitted.

6 (APPLICANT'S EXHIBIT-94 WAS ADMITTED.)

7 MR. GAUKLER: Then I would move for the
8 admission of PFS Exhibit 225, which is the report
9 labeled Additional Cask Analyses for the PFSF. And
10 I would clarify that this report includes the
11 simulations that were discussed today. It also
12 includes two simulations or two analyses that would
13 be rebuttal to Dr. Ostadan, and we've not gone
14 through those today. We will go through those in
15 the rebuttal to Dr. Ostadan later this week.

16 JUDGE FARRAR: Mr. Soper?

17 MR. SOPER: State objects to 225 on
18 numerous grounds, first of which is this is
19 rebuttal of Dr. Khan, and as Mr. Gaukler has noted
20 and is noted in the introduction, that there are
21 two issues addressed.

22 The second of it is the soil cement
23 matter which is not rebuttal to the witness that
24 we're doing rebuttal on. Ought not to be combined
25 with anything else.

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1 JUDGE FARRAR: Is it rebuttal to another
2 of your witnesses? Because if it is, should we
3 just wait to admit it until it's considered for
4 that purpose?

5 MR. SOPER: Well, it is rebuttal to
6 another witness, another state witnesses; but if
7 we're talking about the whole report, I have a list
8 of other things I'd like to bring to the attention
9 of the Board.

10 JUDGE FARRAR: Why don't you get to
11 those. If it's rebuttal to another witness and
12 it's fair to wait until we actually hear that
13 rebuttal testimony, then it can wait. But give me
14 your other ones.

15 MR. SOPER: The real concern about this
16 report is that it again is part of the moving
17 target problem. It is not a technical report
18 strictly. It is an argument, a characterization of
19 state witnesses interlaced with some results of
20 computer runs. For example, page 15 reads, the
21 conclusion of the State's witnesses are that, while
22 the parameters he used are not necessarily
23 meaningful data set, and it goes on to complete
24 some recharacterization of a state witness. Again,
25 the state witnesses acknowledges that SAP 2000 is a

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1 small deflection program but claims that this
2 limitation does not affect the validity of his
3 results.

4 Page 16 goes on to say, the first set
5 was to respond to a claim by the state witnesses
6 that if two pads are located with different numbers
7 of casks, so forth.

8 JUDGE FARRAR: Let me ask you a
9 question. If they didn't submit this report and
10 the witnesses just took the stand and Mr. Gaukler
11 asked him these questions, says, now, you recall
12 when the state witness said such-and-such, and read
13 the transcript, and they'd say, what do you want of
14 that? Well, we went to the drawing board and we
15 did some analyses, and here's what we came up with.
16 Then you'd object that you didn't have those
17 analyses in front of you. So --

18 MR. SOPER: Well, what I would do
19 first --

20 JUDGE FARRAR: In other words, I
21 understand your concern that this is not what we've
22 seen in the past in terms of the technical paper,
23 but at this stage of a technical trial I'm not sure
24 I know a better way to do it. Will you address
25 that?

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1 MR. SOPER: Yes. Let me -- for example,
2 on page 22, let me just further explain. Bottom of
3 the page, the last paragraph reads as follows.
4 "The State's witness appears to suggest" -- appears
5 to suggest, I repeat, "that 1 percent of critical
6 damping is an appropriate value for contact damping
7 and that the value of 40 percent used by PFSF is
8 too large." "The State's witness appears to
9 suggest." Now, first of all, I would object to the
10 form of that question and ask for what reference in
11 his testimony. This is rebuttal to prefiled direct
12 testimony. And that's how it starts out and that's
13 how it's characterized.

14 MR. GAUKLER: Um --

15 MR. SOPER: Let me finish, please. And
16 I say that because on page 5, very last sentence in
17 the first paragraph, the last three lines, "And in
18 prefiled direct testimony several issues were
19 raised by the State of Utah that are addressed in
20 this report to support rebuttal testimony by PFS."

21 Now, this is new testimony, prefiled new
22 testimony not in the form of question and answer,
23 not limited to technical issues, not the results of
24 calculations, but commentary recharacterization of
25 state witnesses without even referring to the names

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1 of the state witnesses. We know by the face of it
2 that it's rebuttal to at least two panels of state
3 witnesses. We have no way to object to a question
4 that's about to be answered.

5 Prefiled testimony has only been
6 approved in this matter as to direct testimony, and
7 there's been a procedure set out for responding to
8 it, whether it's going to be filed simultaneously,
9 if there's going to be a first filing, a second
10 filing, so forth. This is prefiled testimony for
11 rebuttal that is not permitted on the procedures
12 that we've been operating under.

13 Now, I got this document at eight
14 o'clock this morning. I understand it was e-mailed
15 at 10:40 last night, and that last week we got a
16 draft. Some pages are absolutely, totally
17 different. Our expert was sent a draft which is,
18 like I say, far different Saturday. And here we
19 are again with a moving target on a document that's
20 argumentative, is testimony, and we're starting in
21 on a whole new area here.

22 This is the time for rebuttal. If they
23 want to ask questions based on Dr. Khan's testimony
24 for rebuttal, totally appropriate. If they have
25 documents that -- calculations they've done in

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1 response, appropriate. But to file a document
2 which is laced with arguments, recharacterization
3 of testimony, not in the question and answer form.
4 This is not a technical report, not a technical
5 report. This is a piece of prefiled testimony.

6 JUDGE FARRAR: Let me ask you this.
7 Earlier today you objected to the freeform nature
8 of the questioning where some question like, with
9 all due respect, a lecture; and yet usually the
10 objection is the opposite, you're leading the
11 witness. In other words, the counsel is putting
12 words in the witness's mouth. Here you have the
13 opposite. And I sympathize with your objection
14 because we had lost the question in a long answer.
15 But usually the objection -- the objection is the
16 opposite. Counsel is telling them what to say. If
17 anything, counsel is -- it was the opposite here.
18 So help me --

19 MR. SOPER: Let me explain --

20 JUDGE FARRAR: -- with why this is a
21 problem for you sitting there to have it done this
22 way, and also to have it -- which to me there's
23 some advantage that you have it in advance in a
24 document. So tell me why these are disadvantages
25 rather than advantages.

1 MR. SOPER: Thank you, your Honor. Very
2 observant, and a very good point. This is probably
3 leading testimony in the worst example. This
4 document, if we were to believe that this hasn't
5 been reviewed and gone over and changes made by
6 PFS's counsel, and these answers are not exactly
7 what they want us to have, not through testimony of
8 these witnesses but as a prepared document by
9 counsel because that's what we have here, it is the
10 worst form of leading the witness that you could
11 possibly have.

12 JUDGE FARRAR: Any other basis for your
13 objection?

14 MR. SOPER: I think that covers it, your
15 Honor. Thank you.

16 JUDGE FARRAR: Okay. Mr. Gaukler?

17 MR. GAUKLER: First of all, I would say
18 there definitely are calculations. This is a
19 technical document, there's calculations, and it's
20 the basis, the reason we put this document together
21 because there were calculations and analyses and we
22 wanted to put a document together that would have
23 all the input and technical basis for the
24 calculations that witnesses were doing and with
25 respect to rebuttal. The rebuttal is both with

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1 respect to prefiled testimony as well as testimony
2 given at the hearing, and that was very clear in
3 that sentence that Mr. Soper read part of.

4 The statements in terms of description
5 of the State's claim is their understanding of the
6 State's claim, and they can cross-examine them on.
7 The sole purpose of those assertions, statements is
8 to put a perspective to what part of the issues the
9 analysis would pertain to. To the extent that
10 counsel for the State has problems with that, he
11 could cross-examine the witnesses with respect to
12 it in terms of leading, et cetera. Prefiled
13 testimonies are, as observed before, you're leading
14 the witness, everybody is leading the witness in
15 that respect.

16 And in terms of the analyses and the
17 explanations, et cetera, that is the witnesses'.
18 They swore to it, they gave it, they did the work,
19 and they explained it. And they're open to
20 cross-examination on it.

21 JUDGE FARRAR: Did they swear to this?
22 I mean, I know it's their work.

23 DR. SINGH: We're willing to swear to
24 it.

25 JUDGE FARRAR: Well --

1 MR. GAUKLER: I think Dr. Soler, this is
2 a report prepared by him under his supervision.

3 JUDGE FARRAR: But in -- Mr. Soper has a
4 point that this looks like a technical report, but
5 it's really rebuttal testimony, which is, in that
6 sense it strikes me from things he's pointed out in
7 it that it is different from the prior technical
8 report. Now, obviously every technical report is
9 done with some aim in mind -- litigation aim,
10 technical aim -- so it's not like technical reports
11 are pure and testimony is not.

12 But this is, from what he points out, a
13 different kind of technical report than we're used
14 to seeing, or at least so it appears.

15 MR. GAUKLER: Well, first of all, the
16 structure of the technical report is the same as
17 other Holtec technical reports in terms of the way
18 it's structured in terms of this section. As the
19 report says openly up front, the purpose of the
20 analyses is for rebuttal testimony. And it's
21 trying to put together in one place all of the
22 analyses, the inputs and the assumptions in part to
23 deal with objections we've had from the State in
24 the past. They don't have the data or the
25 information or the analyses. And so we tried in

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1 this instance to try to put together into a
2 document. We also went to the point of sending a
3 draft to the State last week. There were changes
4 in it. I admit that. But we sent them a draft
5 last week, last Thursday so they would have it
6 beforehand to look at. There's some changes, but
7 the basic analyses, et cetera, are the same.

8 So we've gone out of our way here to try
9 to make a document available to the State
10 beforehand such that this could go forward in an
11 expeditious fashion. And we believe, by the same
12 token, for example, we've offered to file written
13 rebuttal testimony this Friday to allow the hearing
14 to proceed expeditiously on Saturday. It seemed to
15 me to be an expeditious way of moving, proceeding
16 forward to have, to allow us a chance to get our
17 rebuttal testimony in, allow the State a chance to
18 review it, look at it, understand it, be ready to
19 cross-examine on it, et cetera.

20 And everything's open to
21 cross-examination and just like other stuff in
22 terms of exhibits or anything like that in terms
23 of -- your Honor points up to a witness swearing, I
24 guess you don't technically, I don't know if he'll
25 have the witness swear to an exhibit or not, he may

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1 introduce an exhibit, but certainly Dr. Soler and
2 Dr. Singh, since it's their report, they prepared
3 it under their supervision, and obviously they
4 stand by it. They've talked about and described
5 how this report, under oath, how this report sets
6 forth the evaluation and conclusions regarding
7 various claims raised by the State witnesses. And
8 that's appropriate rebuttal testimony, and we
9 believe it should be heard and admitted by the
10 Board.

11 MS. MARCO: May the Staff have an
12 opportunity to comment, your Honor? While it does
13 appear that this is a unique exhibit in the fact
14 that it does reference the statements or
15 allegations that are made by the State's witnesses,
16 glancing through here, it does not look like it is
17 so replete with those types of references that it
18 makes it a different type of document, technical
19 document. In fact, it does look like, in the few
20 instances I've seen that it's setting up as as to
21 why they're even here or why they're even writing
22 it.

23 And at the end you have at least ten
24 figures of what looks like strictly technical
25 information, and an appendix that is supporting

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1 calculations which I don't see any reference to
2 legal argument at all. And I would -- from my
3 opinion, I would think that this is more in terms
4 of a technical document rather than prefiled
5 testimony. In fact, I would be shocked to see
6 something like this coming in as prefiled,
7 purporting to be prefiled testimony.

8 MR. TURK: May I add one thing, your
9 Honor? I'm back. Are you only hearing from one
10 lawyer per side?

11 JUDGE FARRAR: And we were doing so
12 well.

13 MR. TURK: I'd like to take some credit,
14 or blame, I should say, for the introduction. I
15 had suggested to the other parties that they try to
16 prefile their rebuttal so that we could move faster
17 other than waiting to hear it for the first time in
18 oral direct testimony. And I think it serves to
19 expedite the proceeding rather than anything else.
20 Otherwise it would be a long question and answer
21 series of development.

22 JUDGE FARRAR: Mr. Soper, I'll give you
23 another chance to be heard. Let me consult with my
24 colleagues first.

25 (The Board confers off the record.)