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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	) Docket No. 72-22
	) ASLPB No. 97-732-02-ISFSI
PRIVATE FUEL STORAGE L.L.C.	)
	) TELEPHONE DEPOSITION OF:
	)
(Private Fuel Storage Facility)	) **KRISHNA P. SINGH** and
	) **ALAN I. SOLER**
	)
	) (Utah Contention L/QQ)

Wednesay, March 6, 2002 - 9:12 a.m.

Location: Office of the Attorney General
160 East 300 South, 5th Floor
Salt Lake City, Utah

Reporter: Vicky McDaniel
Notary Public in and for the State of Utah

State's
Exhibit 120

Template = SECY-028 SECY-02

NUCLEAR REGULATORY COMMISSION

Docket No. ______ Official Exh. No. ~~##~~ 120

In the matter of PFS

Staff ______	IDENTIFIED ✓
Applicant ______	RECEIVED ✓
Intervenor ✓	REJECTED ______
Other ______	WITHDRAWN ______
DATE 5/7/02	Witness ______
Clerk V. McDaniel	

cohesiveness, and also checking that the input data was correct, that the model followed accepted engineering principles and that the results made sense.
Q. And Dr. Soler, what was your role with respect to this document? I'm sorry, Dr. Singh.
A. (DR. SINGH) My role is the same in every work that's done in the company in the areas where I have direct expertise. I review the work, and the engineers who do the work, they can consult with me on different aspects of the solution. And I'm generally familiar with the work done because of the interaction, but I don't do the work myself. And I very seldom serve as a direct reviewer of the document.
Q. And the third document, Dr. Soler, do you have in front of you a Holtec document entitled "Dynamic Response of Freestanding HI-STORM 100 Excited by 10,000-Year Return Earthquake at PFS"?
A. (DR. SOLER) Yes.
Q. And are you the principal author for this document?
A. (DR. SOLER) Yes, I am.
Q. And Dr. Singh, what was your involvement with this document?
A. (DR. SINGH) My involvement, Ms. Nakahara -- do you like to be called Ms. or Mrs.? How do you like

to be addressed?
MS. NAKAHARA: It doesn't matter -- Ms.
A. (DR. SINGH) My involvement in all these documents has been uniform in respect of providing consulting assistance, discussing the theoretical and methodological aspects of the solution, and providing general guidance to the others.
Q. And I forgot to make a copy of a fourth document entitled "Evaluation of the Confinement Integrity of a Loaded Holtec MPC under a Postulated Drop Event."
A. (DR. SINGH) Oh, you do have it.
A. (DR. SOLER) You already mentioned that or asked that.
A. (DR. SINGH) I don't think so.
Q. And that document -- okay. What about the "PFSF Site Specific HI-STORM Drop Tipover Analysis"? I don't have that document, correct?
A. (DR. SINGH) Correct, you don't.
A. (DR. SOLER) Yes.
Q. Are you familiar -- Dr. Soler, are you familiar with that document?
A. (DR. SOLER) I'm familiar with that document, yes.
Q. Did you have any role with that document?

A. (DR. SOLER) I believe my role was as a reviewer of the document, and of course I had some discussions early on as to the procedure that we would follow.
Q. And Dr. Singh, was your role with respect to the drop tipover analysis the same as your role in the other PFS Holtec documents?
A. (DR. SINGH) That is correct.
Q. Dr. Singh, you stated that you very seldomly do the direct analysis any more. Have you ever been the principal analyst for a HI-STORM cask to analyze the response of a HI-STORM cask to a seismic event?
A. (DR. SINGH) No. I have not been the principal analyst for seismic analysis of Holtec's cask systems. In recent years I have not done direct analysis myself.
Q. When was, approximately, the last time you have performed direct seismic analysis or been the principal analyst?
A. (DR. SINGH) Probably about ten years ago.
Q. And Dr. Soler, do you recall in your deposition in November I asked you questions about other cask stability analyses performed by Holtec for other sites?
A. (DR. SOLER) Yes.

Q. I have a few more questions in that area. Is it correct that Holtec evaluated the cask stability at Diablo Canyon?
A. (DR. SOLER) We have evaluated our -- of course still in the process, it's an ongoing project. Currently under review by the NRC.
Q. Have you performed multiple analyses for Diablo Canyon -- what I'm trying to ask is, you have a current analysis. Did you have -- did you perform an analysis previously in --
A. (DR. SOLER) Well, if your question deals with casks on a pad, there has really been one analysis which has been independently reviewed and modified over the time period of this project.
Q. Okay. And that was for the HI-STORM 100, and now it's the HI-STORM 100F; is that correct?
A. (DR. SOLER) That is correct.
Q. And did you use the same mathematical -- strike that. Is it correct for the PFS cask analysis you used a lump mass mathematical model developed by Holtec?
A. (DR. SOLER) Correct.
Q. And did you in your analysis -- strike that. Were you principally involved in the Diablo Canyon cask stability analysis?

A. (DR. SOLER) **Yes.**
Q. Did you use the same lump mass mathematical model used for the PFS site in the Diablo Canyon analysis?
A. (DR. SOLER) **No. Let me qualify that to some extent. The report on the 10,000-year return earthquake at PFS uses the same computer code that we've used for Diablo Canyon.**
Q. Is it correct that Holtec conducted a cask stability analysis for Entergy Northwest?
A. (DR. SOLER) **Energy.**
Q. Oh, Energy. Sorry.
A. (DR. SOLER) **Yes.**
Q. Were you involved in the principal analysis?
A. (DR. SOLER) **I believe that I acted as a reviewer for that analysis.**
Q. And did that analysis use the same lump mass mathematical model used in the PFS 2,000-year return?
A. (DR. SOLER) **The same mathematical model was used. There were obviously a different number of casks involved. Dimensions of the pad were different.**
Q. When did you perform this analysis, or when was this analysis performed?
A. (DR. SOLER) **I can only hazard a guess here, that roughly a year ago, maybe year and a half.**

Q. Do you recall what the zero period acceleration for Energy Northwest was?
A. (DR. SOLER) **Again, I'm making a guess here without a report in front of me, but I suspect on the pad it was on the order of a half a g horizontal.**
Q. Do you recall what the maximum horizontal displacement was at Energy Northwest?
A. (DR. SOLER) **No, I don't, but it was on the same order as PFS, meaning that it wasn't ten inches or quarter of an inch.**
Q. And do you recall what the maximum vertical uplift, if any, was?
A. (DR. SOLER) **I can't recall that, no.**
Q. And is it correct that Holtec provides a portion of the cask system, will provide a portion of the cask system at Trojan?
A. (DR. SOLER) **That is correct.**
Q. Did you do -- did Holtec do a cask stability analysis for the Trojan facility?
A. (DR. SOLER) **I do not believe so.**
Q. And other than -- is it correct that Holtec performed a cask stability analysis for the Tennessee Valley facility?
A. (DR. SOLER) **That's correct.**
Q. And when did you conduct this -- strike

that. Were you principally involved in the analysis, cask stability analysis?
A. (DR. SOLER) **I was involved as a reviewer and giving some guidance as to the methodology.**
Q. And approximately when was this analysis conducted?
A. (DR. SOLER) **This analysis is still ongoing.**
Q. And do you recall what the zero period acceleration for Tennessee Valley is?
A. (DR. SOLER) **I don't recall exactly.**
Q. And Dr. Singh, your involvement with -- is it accurate to characterize your involvement with the Diablo Canyon, the Energy Northwest, the Tennessee Valley cask stability analysis the same as your involvement with PFS as a reviewer and consultant available for technical consulting with your staff?
A. (DR. SINGH) **That is correct.**
Q. Dr. Soler, have you conducted other cask stability analysis for the HI-STORM 100 at other locations than we've discussed that have a peak ground acceleration of above 0.4 g's?
A. (DR. SOLER) **Performed some scoping analysis for Humboldt Bay, but that does not involve HI-STORM. Let me correct that. Early in the game before there was a choice by the utility, we did subject the**

HI-STORM to the same kind of scoping analysis.
A. (DR. SINGH) **Can I supplement that answer?**
Q. Yes.
A. (DR. SINGH) **We had made generic submittals to the NRC back in 1994-95 time frame where we submitted a complete treatment of seismic loads, generic seismic loads, and that would be defined seismic loads well in excess of .5 g's, actually in excess of .6 g's.**
Q. And is that with the Safety Analysis Report?
A. (DR. SINGH) **Yes.**
Q. Was that part of the Safety Analysis Report?
A. (DR. SINGH) **Yes.**
Q. Topical Safety Analysis Report?
A. (DR. SINGH) **That would be a correct characterization also.**
Q. The scoping for Humboldt Bay was originally for the HI-STORM and then for what cask system?
A. (DR. SOLER) **It's for the HI-STAR.**
Q. And was the seismic analysis for a freestanding cask system or an anchored cask system?
A. (DR. SOLER) **Humboldt Bay, it was for a freestanding cask system. Some of the generic work that we did used a bounding earthquake that in effect bounded both Humboldt Bay and Diablo Canyon. So we**

can't necessarily characterize it as one or the other.
Q. And the bounding, when you --
A. (DR. SOLER) An earthquake larger than would be expected at either of the sites.
Q. But the bounding work, was that in the Diablo Canyon or Humboldt Bay cask stability analysis or in the topical Safety Analysis Report?
A. (DR. SOLER) We did bounding work specifically for the utility, and some of the work found its way into the submittal to the NRC.
Q. Submittal -- I'm sorry. The submittal to the NRC for Diablo Canyon or for the TSAR, or both?
A. (DR. SINGH) Both.
A. (DR. SOLER) Yeah, although the submittal to the -- official submittal to the NRC on Diablo Canyon deals only with anchored casks.
Q. (BY MS. NAKAHARA) Dr. Singh, are you familiar with the document that's been marked as L/QQ Exhibit 1 entitled "Joint Submittal of Unified Geotechnical Contention, Utah L and Utah QQ"?
A. (DR. SINGH) Yes, I am.
Q. Dr. Singh, is it correct that you've been named as a witness by PFS with respect to this contention, consolidated contention?
A. (DR. SINGH) Yes, I believe I have.

Q. Will you please review the contention -- and as a preface to Dr. Soler, I'll be asking you the same thing -- and identify which specific areas you expect to testify about.
MR. GAUKLER: Limit the response to Section C and D for the scope of this deposition. Look at Section C and D and answer counsel's question.
A. (DR. SINGH) I've marked the ones that I believe I will testify or provide information either completely or in part.
Q. Will you identify those sections and briefly describe what portions, if -- strike that. Will you identify the sections, and you mentioned that you may testify in part, describe what parts of those sections you plan to testify with respect to.
A. (DR. SINGH) Okay, you've set me up for a speech here. All right, I'll try to be brief.
Under "Characterization of Subsurface Soils," broad category upper case C, I will specifically address item 3.e without limitation.
Under category D, upper case D, "Seismic Design and Foundation Stability," I will specifically address 1.b, c, e, f, g, h, and i, with the limitation that under h.(ii) my opinion with respect to fault fling would be only from the perspective of a cask

dynamic system. That's as brief as I can get. Modify me if --
DR. SOLER: I think that's fine.
Q. And Dr. Soler, you --
A. (DR. SOLER) I would say -- I would answer in the same manner.
Q. Dr. Soler, if you can, can you describe how your testimony will differ or supplement Dr. Singh's with respect to these areas?
A. (DR. SOLER) I would suspect that my testimony might be more direct to specific points of the report, because I was actively involved in the guidance and review of most of them in addition to being a consultant. So I would have more direct knowledge of the details.
Q. And Dr. Singh, do you agree or do you want to supplement how you believe your testimony will coordinate or supplement Dr. Soler's testimony?
A. (DR. SINGH) I think Dr. Soler described it quite succinctly.
Q. Dr. Soler, what expertise do you bring to this testimony that Dr. Singh does not have?
A. (DR. SOLER) For this specific project?
Q. Yes.
A. (DR. SOLER) I have a direct knowledge of

some of the applications of the computer codes involved, hands-on experience, if you will.
Q. And Dr. Singh, do you have any expertise with respect to your planned testimony that Dr. Soler does not possess?
A. (DR. SINGH) Well, he's quite self-sufficient. He can deal with the issue entirely on his own. But I have the advantage of having some intellectual remove from the problem, and therefore I can provide perhaps perspectives that one would have from not being in the trenches and doing the analysis day in, day out.
Q. The next area I'd like to ask you about is the lump mass mathematical model. Dr. Soler, who developed the lump mass mathematical model code that you used for the PFS site?
A. (DR. SOLER) It was modified from an existing code in a textbook that was published in 1976, and I adapted it for use in both wet storage and dry storage.
Q. And I'm sorry; you did this in 1966 or the original --
A. (DR. SOLER) The book -- the original code, which was a general lumped mass analysis code, was published in a book that was published in 1976 that

had -- it was a general dynamic analysis textbook. I took that code over the years and adapted it first for use in wet storage seismic analysis, and later on used it for dry storage seismic analysis.
Q. And when did you adapt it for -- approximately when did you adapt it for wet storage?
A. (DR. SOLER) I believe, but this is not -- let me see if my resume will give me a clue, but I believe we're talking about 1979, '80, '81 time frame.
Q. And when did you adapt it for dry storage?
A. (DR. SOLER) Probably in early 1992.
Q. In general, what type of adaptions did you need to make so the code would work for dry storage?
A. (DR. SOLER) Dry storage, actually we made no direct adaptions or modifications to the code. We developed some what I'll call preprocessors that enabled us to automatically generate the spring constants that are used to simulate the contact phenomena around the periphery of the cask.
I'll qualify that a little bit. We did add some output statements to the code, enabling us to get some information that was directly usable for reports, for instance, to be able to generate information to predict the maximum displacements of one or more casks.
Q. Is there a limit to the number of casks you

can evaluate in your model?
A. (DR. SOLER) There is a current limit set by the dimension statements in the FORTRAN code, but that limit could be changed simply by modifying the dimension statements. With the size capability of computers now, your only restriction is the time it would take to do a much larger system.
Q. The preprocessor that automatically calculates spring constants, has it been verified with another mathematical model?
A. (DR. SOLER) That particular code was simply a tool and was verified by actually doing a sample calculation and checking it manually to see that it gave you the same results that you got from a hand calculation. It was simply a program enabling you to avoid doing a lot of things manually.
Q. Is it correct that you used a different model for the 2000-year analysis at PFS versus the 10,000-year analysis?
A. (DR. SOLER) A different computer code, but essentially the same model. In other words, if your definition of model is that I have an MPC that is inside an overpack and that overpack is sitting on a pad or portion of the pad and that pad or the portion of the pad is being excited, then the models are the

same; the algorithm, the engine by which the program solves the problem is different.
Q. And why did you use a different algorithm?
A. (DR. SOLER) The 10,000-year earthquake was a beyond design basis earthquake. We fully expected from our previous results at other plants that the 2,000-year earthquake would give us what I will loosely call small deformation results, in other words, that we would not show extremely large rotations of the cask during the motion.
The code which you have labeled as a lumped mass model is a small deformation code in that it does not -- it's not capable without modification of modeling the potential for a cask to execute a large rotation.
The 10,000-year earthquake, being beyond the design basis, was a scoping analysis, and therefore it was quite likely to expect that we would experience large rotations of the cask, and therefore we used a program that was capable of managing that kind of a motion.
Q. And what program did you use?
A. (DR. SOLER) It's called Visual NASTRAN Desktop. It used to be called Working Model, but there was a corporate takeover.

Q. And do you have a name for Holtec's code that you developed?
A. (DR. SOLER) It has over the years gone by various names depending upon whether it was in the wet storage arena. In wet storage it was known as DynaRack. In early dry storage work it was sometimes called DynaCask. Lately, to avoid confusion, we have taken to calling it Dynamo.
Q. If I can remember to call it Dynamo, you'll know that I'm talking about your -
A. (DR. SOLER) I'll know what you're talking about.
Q. Okay. And I just have to remember that.
A. (DR. SOLER) Let me add a little bit more just to avoid confusion. Internally and in some references it was also known as MR-2, the MR standing for "multi-rack" at the time.
Q. So is it correct that Dynamo without modification cannot be used to evaluate the 10,000-year ground motions at PFS?
A. (DR. SOLER) I believe that it would give erroneous results.
Q. Is it correct that you did not use Dynamo for the Diablo Canyon cask stability analysis?
A. (DR. SOLER) That is correct.

Q. And was that for all revisions of the cask stability analysis?
A. (DR. SOLER) Yes. We did not use Dynamo for anything at Diablo Canyon that has been submitted to the NRC for their site license.
Q. And did you use Visual MASTRAN?
A. (DR. SOLER) Yes.
A. (DR. SINGH) NASTRAN.
A. (DR. SOLER) Yes. That's N, with an N, NASTRAN, not MASTRAN.
Q. I'm sorry. Thank you. And what model did you use in the Energy Northwest cask stability analysis?
A. (DR. SOLER) Dynamo.
Q. And for Tennessee Valley?
A. (DR. SOLER) Dynamo.
Q. Approximately what range of zero period accelerations do you believe Dynamo is capable of processing?
A. (DR. SOLER) I would say, without having pushed it, but I -- to the extent that zero period accelerations imply a certain cask motion, I would not hazard a guess as to the upper limit on Dynamo. I would have to run it and check on the results. And if those results remained in what I would call the small

rotation range, then I would accept the results from Dynamo. However, the reason for not using Dynamo for the 10,000-year earthquake was simply at the outset I expected large rotations to validate the results from Dynamo.
Q. And when you say "large rotations" --
A. (DR. SOLER) I'm talking qualitatively in the range of, say, 20 degrees, 15 degrees or higher.
Q. In your last deposition I asked whether Holtec's computer code, which I didn't ask it as Dynamo, but --
A. (DR. SOLER) A lumped mass model.
Q. Yes.
A. (DR. SOLER) Okay.
Q. Had been compared to other nonlinear codes. And is it correct to characterize your answer that portions of the NRC had compared it to portions with respect to wet storage?
MR. GAUKLER: Objection. I'd like to have you show the witness the question and answer before you ask whether that is the correct characterization.
A. (DR. SOLER) Do you want me to look at the stuff in yellow?
Q. No. Starting right there and through there (indicating).

Off the record.
(Discussion off the record.)
A. (DR. SOLER) Okay, now ask your question again.
Q. Is it fair to characterize your response in the last deposition, or I guess in general that NRC had compared portions of what I now know as Dynamo for wet storage to other nonlinear codes?
A. (DR. SOLER) Well, I'm not sure what the NRC has done independently, but as part of a number of submissions for particular utilities in wet storage applications, we were of course asked questions by the NRC staff reviewer, and previous to the submittal we were also sometimes asked questions by the utility reviewers before submittal. And if you take all of the submittals that we've made since when we started and through the wet storage period, there have been a whole range of problems considered. And there of course is a validation report that's been issued with different classical problems, both linear and nonlinear. Their "exact" solutions or their numerical solutions from other sources were compared with the results that we would get for the same problem.
So while you could not say that a particular wet storage submittal was completely modeled by another

program and compared with the results that we got, portions of the program were compared by testing the problem that had been done in the literature, or, in one case, a finite element model using ANSYS that was made up by a utility to characterize all of the features like nonlinear springs and gap elements that was in their model.
Q. You mentioned a validation report. Is this a formal document that's submitted to NRC?
A. (DR. SOLER) Yes, I believe it's in the public document now.
Q. And approximately how large is that validation?
A. (DR. SOLER) Like that (indicating). I believe, maybe I'm wrong, but we submitted at one time a table of contents to that report.
Q. Did you submit a validation report with the TSAR?
A. (DR. SOLER) No.
Q. Dr. Singh, do you want to add?
A. (DR. SINGH) May I supplement the response?
Q. Yes.
A. (DR. SINGH) One of the essential undertakings we have in nuclear plant design and analysis activities is to ensure that the computer

predicted displacements in the order of inches.
And to confirm that ANSYS was giving us reasonable results, we modeled the same thing on our Dynamo program and got the same order of magnitude of displacements. We were not at that time trying to check the specific details that we had to put on the client's racks against Dynamo. But we left those details off and just made a general check that our program was not predicting a quarter of an inch when ANSYS was predicting five inches. We got a general level of agreement there, and beyond that we used ANSYS.
Q. You mentioned with respect to this project that you used a large earthquake. Do you recall approximately what the zero period acceleration --
A. (DR. SOLER) No.
MR. GAUKLER: Objection. What project? The one you're talking about that uses ANSYS?
MS. NAKAHARA: Yes.
A. (DR. SOLER) I do not recall what we used to make that check. It was an informal check, what any competent engineer would do when he's developing a new model with a program that he's not used before on that particular application. So we just picked a time history that we had.

Q. With respect to Dynamo, do you directly apply ground acceleration time histories, or do you have to make some modifications to the time histories?
A. (DR. SOLER) We directly apply the acceleration time history with a change of variables.
Q. And what do you mean "with a change of variables"?
A. (DR. SOLER) Well, you can either treat a seismic problem by assuming that the ground is moving with some displacement time history and forcing through the connection to the ground or friction and gap elements, forcing the racks to move, or you can make a change of variables and assume -- not assume, and make everything relative to a fixed ground. And in that case the forces are applied to the rack or to the cask in the form of acceleration time histories, the ones you have, times the mass of the particular component. Based on the questions yesterday, I believe that that's what was done in the Altran report, too.
MS. NAKAHARA: How about if we take a ten-minute break.
(Recess from 10:39 to 10:56 a.m.)
Q. (BY MS. NAKAHARA) Dr. Soler, I have a few more questions to ask about the mathematical codes. What is the difference between Dynamo and Visual

NASTRAN that allowed Visual NASTRAN to accommodate potentially large rotations?
A. (DR. SOLER) Okay. Well, if you write the equations of motion of a system and restrict it to small rotations, you can simplify the equations.
In a nutshell, the Dynamo code does not alter the equilibrium equations step by step. It assumes to always satisfy equilibrium based on the original configuration.
The Visual NASTRAN code was written from the outset to accommodate large motions, falling objects that could tumble, turn over, bounce. Therefore, it did not make internally any simplifications to the equations that are presumably programmed at the site. So if you attempt to take a code that is written for small deflections and blindly just apply it and get a result that would indicate large deflections, either your program will blow up on you or it will just give you ridiculously large results that have no physical meaning, or it will simply give you wrong results that you may think there's a physical meaning to it. So you have to be careful to make sure that you don't pose to a code a problem that has a chance of going outside the range of validity of the code.
Q. And how can you ensure that the results for

the PFS 2,000-year return period using Dynamo are accurate results?
A. (DR. SOLER) If I take, say, the peak displacements that are predicted from any of the runs, we're talking about numbers on the order of three inches, say; and if I take three inches, which is a maximum excursion laterally and assume the worst, that the bottom of the cask was somehow pinned and it was rotating, which is usually the case with a .8 coefficient of friction, if you take three inches and divide by the height of the cask, which is 231 inches, and calculate that angle, that angle is very small and it's a commonly accepted number that would tell you you're still in a small deflection range.
Q. Jumping to the cask stability analysis for Diablo Canyon, were all cask stability analyses for unanchored casks conducted with Visual NASTRAN?
A. (DR. SOLER) Well, all analyses that were submitted to the NRC were for anchored casks and were conducted with Visual NASTRAN.
Q. What about the scoping analysis that you conducted for unanchored casks?
A. (DR. SOLER) The scoping analyses which were most likely a few years ago we're talking were analyzed with Dynamo, perhaps internally Visual NASTRAN, but I

Q. (BY MS. NAKAHARA) Let's go back on the record. Dr. Soler, what total vertical contact stiffness value did you use in the cask stability analysis?
A. (DR. SOLER) Total number, I think was 468 times 108. That's the pounds per inch. That's the sum of all the individual springs.
MR. GAUKLER: That was the total from all the --
MS. NAKAHARA: 468? Off the record.
(Discussion off the record.)
A. (DR. SOLER) It was a little more than that if you take numbers from the actual math book. That's the range, 450 plus times 106.
Q. Will you briefly explain how you calculated that?
A. (DR. SOLER) Okay, that number was calculated -- and this goes back to almost the beginning of our analysis. It had nothing to do with the earthquake. That number was calculated by taking the semi-infinite solution I referred to earlier this morning and looking at the problem of if I just simply took the cask, which has an 11-foot diameter, placed it down on a pad of concrete, knowing the properties of concrete in terms of the Young's modulus and the

radius, you can calculate a spring constant for that section of concrete. Then, since I was modeling 36 springs around the periphery, which I felt was a reasonable number, I simply divided that spring constant by 36 and imposed the result at each one of the vertical springs.
There are, of course, other ways to compute that spring constant, but the underlying rationale would be when you're finished and you can imagine that cask resting on whatever it's resting, that the deflection to predict should be small.
Q. And you calculate the deflection according to Exhibit 7; is that correct?
A. (DR. SOLER) That would be the formula I would use to determine whether the number that I came up with was a rational number to use. But I would have to determine the spring constant from the method I just described.
Q. And what total horizontal stiffness value did you use in your analysis?
A. (DR. SOLER) I'd really have to consult one of my outputs to refresh that number. I've got it here, so let's see if it's -- oh. In Section 5.3 of this report it says refer to an earlier report to get that spring constant. So I guess the report that I

really need to look at to give you that number is --
Q. Is that the '97 report?
A. (DR. SOLER) Yeah, probably 97-1631.
MS. NAKAHARA: I need to do a better search, but I don't believe we ever got the '97 report.
MR. GAUKLER: Okay.
MS. NAKAHARA: We have two other earlier versions of this report, none of the '97 that I could find. That was one of my problems looking at some of the references.
DR. SOLER: So I can't really give you that answer.
MS. NAKAHARA: So to the extent we don't have that report, we would like a copy of it.
MR. GAUKLER: Dr. Khan had a reference to it.
Q. (BY MS. NAKAHARA) Will you explain how you calculated, in general, the horizontal stiffness value?
A. (DR. SOLER) Generally speaking, what we usually do is -- again, the phenomena we're trying to simulate is what's called in the literature a stick-slip phenomena, meaning that nothing happens until you slip, and therefore something suddenly happens after that and you jump up to the value U times whatever the download is. So our simulation of that is

with a spring that has a very stiff spring constant so that it behaves like a linear spring up until the force predicted in that spring is greater than the coefficient of friction times the normal force in the contact spring that goes along with it.
Now, the number you choose is again based on physical principles. Again, if I take the object, whatever it is, and I assume a spring constant that is trying to simulate really something very stiff so that I don't get any deflection without sliding, I want a number that's big enough so that if I put on a load that's less than mu times W, I don't predict some unreasonably large number like quarter of an inch, half an inch. I want to predict something like .00 something, just for this simple problem. That way I know when I do the dynamics problem that what I'm going to see is the slipping behavior and not some elastic motion. So again, it's chosen mainly to get a result that you would expect from your physical intuition and physical observing the problem.
Q. Do you believe that the total contact stiffness for an unanchored cask is constant or varies during the entire duration of the earthquake motion?
A. (DR. SOLER) First let me ask, is that -- the term "total contact stiffness" means what to you?