RAS 5273 72-22-ISFSI — Applicant Exhibit 88 — Rec'd 5/7/02



# COPY OF TRANSCRIPT

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

| | | |
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| In the Matter of | ) | Docket No. 72-22 |
| | ) | ASLPB No. 97-732-02-ISFSI |
| PRIVATE FUEL STORAGE L.L.C. | ) | DEPOSITION OF: |
| | ) | |
| (Private Fuel Storage Facility) | ) | **DR. MOHSIN R. KHAN** |
| | ) | |
| | ) | |
| | ) | (Utah Contention L/QQ) |

Tuesday, March 5, 2002 - 12:10 p.m.

Location: Office of Parsons, Behle & Latimer
201 S. Main, Suite 1800
Salt Lake City, Utah

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

analysis is part of your review of the cask stability, your work in general --

A. Yes.

Q. -- element analysis. Finite element analysis, is that a broad area in terms of a general description --

A. Yes.

Q. -- of work? And I guess you could do finite element analysis in many different types of components and structures?

A. Yes.

Q. Is there any particular ones you would point to here as being relevant, or not?

A. Not really.

Q. Not really? Is there any -- did you do while you were at Altran any finite element analysis of freestanding objects?

A. Not at -- let me see. Not at Altran but in my previous jobs, yes.

Q. In your previous jobs, what --

A. Sliding analysis.

Q. Of what types of objects?

A. Just rigid bodies.

Q. Rigid bodies?

A. Yes.

Q. Can you tell me some examples of rigid bodies that you've analyzed?

A. This, sliding.

Q. He's moving a cup, okay. Can you give me some examples of some equipment or components, I take it, you did sliding analysis on?

A. Yeah. We took some blocks, we took some racks, did some studying of the sliding objects.

Q. What size blocks did you use?

A. With analysis it doesn't really matter. It's just a parameter. It could be thousands of pounds, it could be 50,000 pounds. It wasn't an actual test, it's just a mathematical simulation.

Q. It wasn't what?

A. It was just a mathematical simulation, so you can put in any input parameters and it would give you a seismic sliding analysis.

Q. I guess my question: did you model -- using finite element analysis, did you model a freestanding object that could slide or tip?

A. That's right.

Q. You did?

A. Yes.

Q. Okay. My question is, what freestanding object did you model?

A. The freestanding object that we did study was Holtec high-density racks using ANSYS.

Q. Okay, that was the spent fuel racks for Diablo Canyon?

A. Yes.

Q. And the spent fuel racks were freestanding?

A. Yes.

Q. And what time period was this?

A. I believe maybe '87, '88 time frame.

Q. In addition to doing these study analyses for the freestanding spent fuel racks for Diablo Canyon, what other freestanding objects have you modeled?

A. I did not model specifically but studied whole bunch of freestanding models when I was at PG&E. And doing designs which are being submitted by various vendors, including Holtec at that time, for cask design in freestanding conditions.

Q. So you're referring to having reviewed models involving sliding and freestanding objects done by various vendors of casks. Is that what I understand you to say?

A. That's right. That was also a part of it, yes.

Q. Any other examples of models of freestanding

objects that you reviewed?

A. In the plant you have, you know, going into control room, you have racks which are freestanding. And you look at the anchorages, see how far they can move.

Q. Did you do any finite element modeling of such racks?

A. No.

Q. So am I correct that the only finite element modeling of a freestanding object model that you did yourself was your modeling of the Diablo Canyon spent fuel racks?

A. The spent fuel racks. We were looking at some blocks just sliding on the free surfaces. We did those studies, rigid objects sliding.

Q. Was this part of your analysis of the spent fuel?

A. No, it was separate. It was not part of this.

Q. What was the purpose for the sliding of the blocks?

A. Oh, it was just part of the studies. We used to do studies, evaluations of abnormal conditions.

Q. Now, going back to your work for Altran, you identify in the fourth bullet of your resume under your

entire available space in such a way that you can maximize the fuel space.

Q. So it would be correct to say that in terms of sliding, the racks were more restrictive than -- spent fuel racks; sliding with respect to spent fuel racks is more restrictive than sliding with respect to spent fuel casks on the pad; is that correct?

A. Oh, much more, much more, much more. And I think that's the only way you can really stack up more fuel into the pool.

Q. Is to use freestanding racks?

A. Or racks that can store more fuel.

Q. You indicated, and I take it that -- let's just use Holtec for the spent fuel racks, even though they may have gone through a transition at this point in time, okay, for describing the spent fuel racks at Diablo Canyon.

A. Yes.

Q. Holtec had designed those spent fuel racks, and did they do a stability analysis or finite element stability analysis with respect to the racks at that point in time?

A. Holtec did -- yeah, nonlinear, they did do nonlinear analysis. But again, this sliding displacement is very limited. They were very limited

based on the available space inside the pool on either side of that rack itself.

Q. Did you review the model that Holtec used to do the stability analysis with respect to spent fuel racks?

A. I saw the results, yes.

Q. You saw the --

A. Conclusions, yeah.

Q. Do you know what program Holtec used to do that model?

A. No, I don't remember, but it was in-house program.

Q. Can you compare that program for modeling the spent fuel racks with the program that Holtec used for modeling the spent fuel casks at PFS, do you know?

A. No, I don't know.

Q. Do you know what modifications, if any, would need to be made to it?

A. I don't know.

Q. At Diablo Canyon with respect to spent fuel racks, weren't the spent fuel racks also analyzed to see whether or not they would tip over on the same program? Let me rephrase the question. Do you know whether a single spent fuel rack, single spent fuel rack in isolation was analyzed to see whether it would

tip over using the model that Holtec had developed?

A. It could have been. But the pool, the -- when the cask is inside the pool, you have --

Q. You're talking about the racks?

A. The racks inside the pool has water surrounding. So there's a lot of difference with respect to the effect of damping for water or effect of water affecting the rack and then vice versa. So there was significant variation in terms of the effect of surrounding water on the rack dynamics.

Q. You indicated that you had done some analysis on your own to -- you modeled the spent fuel racks yourself, I take it, at Diablo Canyon?

A. (Witness nods head.)

Q. And how did you model the spent fuel racks?

A. The way that we did at that time was, we basically looked at the strength of rack itself. You know, there were numbers coming from rack analyses in terms of impact loads, and we were modeling locally the racks itself at that time to see whether the rack was starting to take all these impact loads coming out of the rack dynamics.

Q. Did you model the potential for sliding or tip-over of the racks?

A. There was -- we did one study with ANSYS

simply to look at interaction, you know, very simple interaction between a stiffness constraint and how the rack impacts, but that was the only part that we did. We did not do in the greater detail as a rack vendor would do, because they had more -- lot of design parameter, a lot of analysis parameters than we did. We didn't have that.

Q. And they had a more detailed program specifically designed to analyze that?

A. That was for cask design, yes, of the rack design.

Q. They had a more detailed program to analyze the sliding and tip-over aspects?

A. Yeah, because you could put in all the racks' parameters from whatever geometrical constraints you had.

Q. I take it that with your analysis and with the analysis that Holtec did, you agreed with the use of the freestanding racks at Diablo Canyon, the spent fuel racks?

A. It was litigated and I believe what they won was a judgment, everybody bought into it.

Q. Well, I guess, you agreed yourself personally or professionally? You agreed with the --

A. I agreed professionally that the racks were

sturdy enough to store the fuel. I may not agree or disagree, I may not have known exact value of numerical value. But the way I looked at this, there's a pool, racks are not going to go anywhere, and there's very little movement or their casks -- the racks are very sturdy, and so we made our own independent judgment that, yes, everything's all right, they are very structural.

Q. So you agreed with the use of the freestanding racks?

A. Yes.

Q. You indicated in your resume, I think, that you provided expert testimony on the high density spent fuel rack design. What type of testimony did you provide and where?

A. It was I guess expert deposition that I was supposed to provide to say that the rack itself looked -- they were internal PG&E folks, and I provided that at that time. But nobody really cross-questioned me. It was just written statements provided by myself on the integrity of the racks itself.

Q. When you say a written statement --

A. Yeah. It was testimony like this, but --

Q. Like what? Like a declaration?

A. Yeah, I think it was a declaration. But

nobody -- at that time I think we had -- I know there were folks from outside, Mothers for Peace, who were on the other side, and they had a whole bunch of questions. We were in the same team trying to provide the racks are okay. So that's where I provide my testimony.

Q. At the -- let me ask this. At the licensing board here, was it heard before the licensing board in this case?

A. No, I don't think so.

Q. You don't think --

A. No.

Q. -- licensing board?

A. No.

Q. Do you know if there was any live testimony in that case, people got up on the stand and were sworn in?

A. No, I did not do that.

Q. You did not do that?

A. I did not do that.

Q. Do you know if anybody else did that on behalf of PG&E in defense of the spent fuel racks?

A. Oh, I'm sure there were lot of people involved at that time, lot of attorneys involved. Dr. Singh might know more than I would.

Q. Structural analysis and structural dynamics is a very broad category, right?

A. That's right.

Q. Anything that you would point out as being most relevant?

A. They all form the basis of relevancy, but not, you could say -- so I couldn't say one paper is more applicable than all the others.

Q. Do any papers involve structural analysis or seismic analysis of freestanding objects?

A. No.

Q. With respect to your presentations, you have referred to one presentation really that we've discussed. Other than the one that you referred to previously, are there any presentations that you would consider to be particularly relevant to the area of your expected testimony here?

A. No.

Q. Do any of your presentations involve structural seismic analysis of freestanding objects?

A. No.

MR. GAUKLER: Let's take a break.

(Recess from 1:30 to 1:50 p.m.)

Q. (BY MR. GAUKLER) With respect to several matters we were talking about, Dr. Khan. First of all,

NRC that forms the design basis for a freestanding object?

A. Do I have a --

Q. Any work that's been docketed with the NRC that forms the design basis for a freestanding object?

A. No.

MR. GAUKLER: I'd like to have marked as Exhibit 4 a Joint Declaration of Dr. Steven F. Bartlett, Dr. Mohsin R. Khan, and Dr. Farhang Ostadan.

**(Exhibit 4 marked.)**

Q. (BY MR. GAUKLER) Do you recognize what's been marked as Exhibit 4?

A. Yes.

Q. Is this the joint declaration that you prepared or assisted in preparing?

A. Yes.

Q. And it's dated December 7th, 2001?

A. Yes.

Q. And if you turn back I think to the last page of the document, is that your signature that appears on the bottom of that page?

A. Yes.

Q. Now, is it correct that the paragraphs of this document for which you are responsible or completely or partially responsible are identified by

A. Yeah. These are large manuals and provides how to use those.

Q. Did you review any other documents in the preparation of this report?

A. No.

Q. In paragraph 10 of the declaration identified as Exhibit 4. Go back to Exhibit 4, please. In paragraph 10 you say that you have "extensive experience designing and interpreting non-linear finite element models to show the structure, systems, or component performance under seismic forces." What do you mean by non-linear in that sentence?

A. Well, I think things which are not anchored down, you know, it's a -- give you an example, a relay, okay. That has an open contact and closed contact, and they're very sensitive to seismic motion. If they close it in a seismic environment, you may shut down the plant or you may have a trip. So we do all this testing to ensure that systems and equipment perform their intended safety function as they are going through seismic motion.

Q. Are you saying that anything that's not anchored is a nonlinear system? Are you saying anything that's not anchored is a nonlinear system?

A. It depends on the analysis that you're

performing.

Q. What makes a system nonlinear as opposed to linear?

A. A linear is if we have in a linear fashion, and a nonlinear is at a given point it does not behave in a linear fashion. So it may be sitting here, apply small force, it's not doing anything. You apply forces, it starts sliding. That's a nonlinear system. So the behavior with respect to the load application is not a linear function of code application.

Q. What components have you done nonlinear analysis for?

A. I did a lot of testing.

Q. What type of components?

A. These are cabinets containing switch gears, electrical items, mechanical items. You could have a pump, for example, you know, running, and it has clearances. So you want to make sure that when it's going through a seismic excitation the shaft does not bend enough to create unnecessary deformations so that it could become a potential problem while it's going through motion.

Q. And is this part of your work doing equipment qualification with respect to -- for PG&E?

A. Yes.

Q. And what type of nonlinear behavior did you model for these components?

A. We -- every time there was an issue that we have a nonlinear problem, in general we try to test it. Because we couldn't really analyze the nonlinear system in a realistic way, so we went and shook it.

Q. Did you analyze sliding of these components?

A. Which component?

Q. These --

A. No, we anchored them, most of them.

Q. So these are not -- the nonlinear system or the nonlinear type of phenomena that you were evaluating was not sliding, then?

A. It was impact.

Q. Impact?

A. Impact.

Q. So it was not --

A. Yes, that's right.

Q. And what size, how large were these components that you worked with, generally speaking?

A. It was very small to where they would fit in the room, maybe a few thousand pounds.

Q. Couple thousand pounds?

A. Yeah.

Q. Like a cabinet?

A. Yeah. In nonlinearity it is relevant, mass, how it is anchored and what kind of mounting conditions. So mass --

Q. I was asking about the size. So irrelevant, mass is irrelevant, do you think?

A. Well, it -- you know, if an earthquake comes, it's going to move a 500-pound item the same way it's going to move a 1,000-pound item or 2,000-pound item. It all depends on how it is anchored to the floor and what kind of boundary condition exists.

Q. In Exhibits 5 and 6 you're evaluating the nonlinear behavior of the HI-STORM cask, correct?

A. Yes.

Q. And you're evaluating the sliding and tipping potential of the HI-STORM cask?

A. (Witness nods head.)

Q. Prior to this case have you ever evaluated -- undertaken a simulation and evaluated the sliding and tipping for a dry cask storage system?

A. No.

Q. And I gather from what I understood your testimony to be before, you've not analyzed the potential for sliding or tipping of a freestanding object, taking a freestanding object, model it and analyze the potential for sliding and tipping of them?

A. Not the cask. Not the cask, but other sliding analysis studies, yes, I have done.

Q. But you -- if we can go back. The only thing I could gather of what you told me about were two things. I want to make sure I'm correct on this. One, you stated you had looked at or evaluated the freestanding spent fuel racks --

A. That's right.

Q. -- for Diablo Canyon.

A. That's right.

Q. But then you got into and discussed that, and you said you were focusing more on the structural strength and not the sliding or tipping of those elements.

A. Because they were not as critical.

Q. So your study there did not focus on sliding and tipping?

A. No, they were not as critical.

Q. And the only other thing I heard you talk about were evaluating some sliding blocks.

A. That's right.

Q. And I take it, this was kind of like almost hypothetical blocks, correct?

A. Sure. You could call it, sure.

Q. You weren't modeling any real equipment or

components, correct?

A. That's right.

Q. And what contacts, stiffness, for example, did you use in evaluating those sliding blocks? Do you recall?

A. No, I do not recall.

Q. Other than those two instances, correct me if I'm wrong, have you ever evaluated the potential for sliding or tipping of a freestanding object?

A. That's correct.

Q. Those are the only two instances?

A. Yes.

Q. Going to paragraph 30, you talk about -- it's in Exhibit 4. You say, "During the course of my work associated with dry cask storming projects for Pacific Gas and Electric ('PGE'), NRC staff has not granted a license for unanchored vertical casks at any sites with peak ground accelerations greater than 0.4 g due to the greater potential for sliding and tipping of these casks containing irradiated fuel assemblies."

What is the basis for that statement?

A. I guess -- back in those days we were going back to, I guess with various vendors and looking at that time what cask has been licensed. And most of the casks which had been licensed were I guess east of the

A. We use stiffness values all the time, every time we analyze the structure. For an anchored cask it could be zero in the upward direction.

Q. So how many times have you picked a contact stiffness value for sliding analysis?

A. A program --

Q. How many times have you picked a contact stiffness value for sliding, for lift-off analysis?

A. For this case?

Q. No, just in general. How many times have you picked a contact stiffness analysis for purposes of analyzing sliding or tipping?

A. This is the case.

Q. This is the first case?

A. Yes.

Q. First time you've done it, correct?

A. That's right.

Q. Okay. Dr. Khan, you say in paragraph 70, I believe it is, "The Altran analysis did not take into account for the amplification due to soil structural interaction in the 2,000-year earthquake input time histories." Then you go on to say, therefore, the vertical input motions at the base of the cask should be higher. I'm confused what you're saying in that paragraph 70. I think you also have something in your