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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 May 6, 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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E X A M I N A T I O N

E X H I B I T S

9:00 a.m. May 6, 2002

P R O C E E D I N G S

JUDGE FARRAR: Good morning, everyone. Over the weekend I think you were working on a couple of things, Dr. Luk's deposition, I take it, since we didn't hear from everybody, that must have been done and completed.

MR. TURK: That's correct, your Honor.

JUDGE FARRAR: And did you make any progress on the Solomon testimony?

MR. GAUKLER: We're going to talk at the first break.

JUDGE FARRAR: Then are we ready to proceed with the Luk/Guttman panel; is that right?

MR. TURK: Yes, your Honor.

JUDGE FARRAR: Any preliminary matters?

MR. TURK: No.

JUDGE FARRAR: Then let's start.

MR. TURK: Your Honor, at this time the Staff would ask to call to the stand Dr. Vincent Luk and Mr. Jack Guttman. As they take their seats, may I give your Honors a brief general background. Mr. Guttman is employed by the Nuclear

Regulatory Commission. He is Chief of the Technical Review Section in the Spent Fuel Project Office within the office of Nuclear Material, Safety and Safeguards.

To his left is Dr. Luk. Dr. Luk is trained in civil engineering as a start, he has a Bachelor's from the University of Mississippi. He also has a Master of Science and a Ph.D. in theoretical and applied mechanics from Northwestern University. As Dr. Luk's testimony will make clear today, he has been conducting a study on behalf of the NRC's Office of Nuclear Regulatory Research related to the stability of freestanding casks at Independent Spent Fuel Storage Installations, and he has also modeled a site-specific cask pad and soil foundation model with respect to the PFS facility. I would ask at this time that the witnesses stand and be sworn.

JUDGE FARRAR: Please raise your right hand.

JACK Guttman and VINCENT K. LUK, called as witnesses, being first duly sworn, were examined and testified as follows:

DIRECT EXAMINATION

BY MR. TURK:

Q. Good morning, gentlemen.

DR. LUK: Good morning.

Q. Gentlemen, have you filed your written testimony for presentation in this proceeding?

MR. Guttman: Yes, we have.

DR. LUK: Yes.

Q. And do you have a copy of that testimony before you?

MR. Guttman: Yes.

DR. LUK: Yes.

Q. And is this the document entitled NRC Staff Testimony of Vincent K. Luk and Jack Guttman Concerning Unified Contention Utah L/QQ (Geotechnical Issues)?

MR. Guttman: Yes.

DR. LUK: Yes.

Q. And have you also prepared statements of your professional qualifications?

MR. Guttman: Yes.

DR. LUK: Yes.

Q. And are your statements of professional qualification attached to this testimony?

MR. Guttman: Yes.

DR. LUK: Yes.

Q. Do you have corrections, revisions, modifications to make to the testimony?

MR. Guttman: Yes, we do.

DR. LUK: Yes.

Q. And have you written those in and interlined them within the prefiled testimony?

MR. Guttman: Yes, we have.

MR. TURK: Your Honor, we have distributed to the licensing Board members and the court reporter copies of the testimony with the interlinings marked in. Also, we shared that with counsel for PFS and counsel for the State over the weekend so they have copies as well.

Now, would your Honors like us to read them into the record or just accept them as --

JUDGE FARRAR: No. As long as they're in the copy that you've given to the court reporter. Unless there are any that represent a particular change of position that would highlight it for us.

MR. TURK: Your Honor, I don't see any changes of positions. I do see some corrections to make the testimony more accurate.

JUDGE FARRAR: Then we'll just, with the

revisions, this is their testimony and we can have it bound into the record at this point as if read, including the corrections.

MR. TURK: Yes. I would ask one more preliminary question, if I make.

JUDGE FARRAR: Go ahead.

Q. (By Mr. Turk) With the revisions marked in your testimony, is your testimony true and correct to the best of your knowledge, information and belief?

MR. Guttman: Yes.

DR. LUK: Yes.

MR. TURK: Thank you, your Honor. At that point I would ask that the testimony be bound into the record as if read.

JUDGE FARRAR: Thank you, Mr. Turk, we will do that.

(Insert prefiled testimony of Vincent K. Luk and Jack Guttman.)

5/6/02

April 1, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE, L.L.C.	)	Docket No. 72-22-ISFSI
	)	
(Independent Spent	)	
Fuel Storage Installation)	)	

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NRC STAFF TESTIMONY OF VINCENT K. LUK
AND JACK GUTTMAN CONCERNING UNIFIED
CONTENTION UTAH L/QQ (GEOTECHNICAL ISSUES)

Q1. Please state your names, occupations, and by whom you are employed.

A1(a). My name is Jack Guttmann ("JG"). I am employed as Chief of the Technical Review Section, Spent Fuel Project Office ("SFPO"), Office of Nuclear Material Safety and Safeguards ("NMSS"), U.S. Nuclear Regulatory Commission ("NRC"), in Washington, D.C. A statement of my professional qualifications is attached hereto.

A1(b). My name is Vincent K. Luk ("VKL"). I am employed as a Principal Member of the Technical Staff in the Nuclear Technology Programs Department at Sandia National Laboratories ("SNL"), in Albuquerque, New Mexico. I am providing this testimony under a technical assistance contract between the staff of the U.S. Nuclear Regulatory Commission ("NRC Staff" or "Staff") and SNL. A statement of my professional qualifications is attached hereto.

Q2. Please describe your current responsibilities.

A2(a). (JG) As Chief of the Technical Review Section in the Spent Fuel Project Office, my responsibilities include direction and supervision of various technical reviews related to the licensing and certification of radioactive material transportation and storage packages, under 10 C.F.R. Parts 71 and 72, respectively, including technical reviews related to independent spent

fuel storage installations ("ISFSIs"). Among my other responsibilities, I routinely direct and supervise the evaluation and use of computer code modeling and analytical methodologies in assessing the safety and performance of radioactive material transportation and storage packages.

A2(b). (VKL) I currently serve as Leader of the Structural Analysis and Evaluation Team for an NRC Integrated Vulnerability Assessment Project, examining the vulnerability and structural integrity of nuclear power plants subjected to external high-energy impacts. In addition, I serve as the Principal Investigator in an NRC project, establishing criteria and review guidelines in evaluating the seismic behavior of dry cask storage systems; and in examining the dynamic seismic behavior of free-standing dry cask storage systems and soil-structure interaction effects in simulated earthquake events.

Q3. Please explain what your duties have been in connection with the NRC Staff's review of the application filed by Private Fuel Storage, L.L.C. ("PFS" or "Applicant") for a license to construct and operate an Independent Spent Fuel Storage Installation ("ISFSI") on the Reservation of the Skull Valley Band of Goshute Indians, geographically located within Skull Valley, Utah (the "proposed PFS Facility").

A3(a). (JG) As Chief of the Technical Review Section in SFPO, I requested, through the Office of Nuclear Regulatory Research, that a confirmatory analysis be performed by Sandia National Laboratories on behalf of the Staff to evaluate the potential for cask sliding, collision and tipover at the proposed PFS Facility. This analysis was considered to be confirmatory in nature, ~~in that the Staff had previously concluded, on the basis of its review of~~ to verify the conclusions in the PFS application and supporting analyses, that tipover and collision of the casks on the PFS concrete storage pads will not occur under design basis seismic conditions. *See* Consolidated SER, §5.1.4.4, at 5-28 to 5-32; and NRC Staff Testimony of Goodluck I. Ofoegbu and Daniel J. Pomerening on Unified Contention Utah L/QQ, Part D. In addition, I and other members of my staff provided information and

expertise, as appropriate, to assist in the review of cask stability under seismic conditions at the proposed PFS Facility.

A3(b). (VKL) As part of my official responsibilities, at the Staff's request I conducted an analysis to evaluate the seismic behavior and stability of the freestanding, cylindrical HI-STORM 100 casks to be installed on concrete pads at the proposed PFS facility, including the potential for cask sliding, collision and tipover. As Principal Investigator in this project, my role was to develop a three-dimensional coupled finite element model of the proposed PFS dry cask storage system to examine the nonlinear and dynamic behavior of the casks, and to simulate the effects of soil-structure interaction, under prescribed seismic conditions. I am the principal author of several documents describing this confirmatory analysis, including (1) "Summary Report on Seismic Analysis of HI-STORM 100 Casks at Private Fuel Storage (PFS) Facility," dated February 22, 2002; (2) "Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage (PFS) Facility," dated March 8, 2002; and (3) "Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage (PFS) Facility," Rev. 1, dated March 31, 2002 (herein cited as "Final Report, Rev. 1").

Q4. What is the purpose of this testimony?

A4. The purpose of this testimony is to provide the results of the NRC Staff's confirmatory analysis of the stability of the freestanding HI-STORM 100 casks at the proposed PFS Facility, with respect to the potential for cask sliding, collision and tipover under seismic conditions, as set forth in Unified Contention Utah L/QQ, Part D.1.i.

Q5. Are you familiar with Unified Contention Utah L/QQ, Part D.1.i. ?

A5. Yes. We understand that Part D.1.i. of this contention states:

> Because of the above errors, omissions and unsupported assumptions [stated in preceding portions of Contention Utah L/QQ, Part D], the Applicant has failed to demonstrate the stability of the free standing casks under design basis ground motions. Thus, the Applicant's analyses do not support the Applicant's conclusions that

excessive sliding and collision will not occur or that the casks will not tip over. 10 CFR § 72.122(b)(2) and NUREG-1536 at 3-6.

Q6. Please describe the Staff's analysis of the stability of the HI-STORM 100 casks and the potential for cask sliding, collision and tipover at the proposed PFS Facility?

A6. An ongoing generic program for developing guidance on seismic hazards analysis was established by NRC's Office of Nuclear Regulatory Research. A research team consisting of analysts and engineers from SNL, ANATECH Corporation, and Earth Mechanics, Inc., was assembled for this purpose, under the leadership of Dr. Vincent Luk, as Principal Investigator. As part of this ongoing effort, the Staff requested technical assistance from the Sandia National Laboratories in conducting an analysis of the behavior of loaded HI-STORM 100 storage casks under seismic conditions at the PFS Facility. The Staff provided basic information to the research team, with respect to cask design, pad dimensions, soil-cement layers under and adjacent to the pad, the site-specific soil profile, and time histories of seismic accelerations.

In conducting this analysis, three-dimensional coupled finite element models were developed, and seismic analyses were performed, to examine the dynamic and nonlinear behavior of the HI-STORM 100 casks to be installed on the concrete storage pads at the proposed PFS Facility, including the soil-structure interaction effects during a seismic event. Three different sets of seismic conditions were modeled: (1) the 2,000-year return period earthquake for the PFS Facility site; (2) the 10,000-year return period earthquake for the PFS Facility site; and (3) a sensitivity study based on the 1971 San Fernando Earthquake (Pacoima Dam record). The analyses thus modeled ground motions for the design basis 2,000-year event; the 1971 San Fernando Earthquake (Pacoima Dam record), for which the ground motions are somewhat similar to the ground motions of the PFS 2,000-year event; and ground motions for the PFS 10,000-year event, which significantly exceed the design basis ground motions for the proposed PFS Facility.

Q7. Please describe the nature of the model that was utilized in the analysis.

A7. (VKL) The ABAQUS/ Explicit code was used to analyze the three-dimensional coupled finite element models, that consist of a single cylindrical HI-STORM 100 cask (with the MPC-68 option), a flexible full-sized concrete pad (30-ft x 67-ft x 3-ft), a shallow surface layer of compact aggregate around the pad (5-ft x 10-ft x 8-in), a soil-cement layer under and adjacent to the pad (approximately 2-ft thick), and an underlying layered soil foundation. The layout of the entire coupled model is shown as Figure 1 of the Final Report, Rev. 1 (page 14). The cask was modeled as an elastic solid component, while the gravel, concrete pad, soil-cement, and soil were modeled as flexible linearly elastic materials. Structural damping ratios, whose values are tabulated in each horizontal layer and for each of the three cases of soil profile data (*see* Final Report, Rev. 1, Tables 2 to 7), were used for the soil and soil cement materials, while a zero damping was used for the concrete pad and the cask.

The shallow surface layer and the concrete pad are placed on a continuous 2-ft soil-cement layer that is on top of the soil foundation. The coupled model has three interfaces, which include the (1) cask/pad, (2) pad/soil-cement layer, and (3) soil-cement layer/soil foundation interfaces. In addition to incorporation of the aforementioned structural elements, development and use of the model also required selection of appropriate cask/pad and soil material properties and application of properly prescribed seismic time history sets to the model. To this end, the NRC staff provided the research team with the basic information on cask design, pad dimensions, soil-cement layers under and adjacent to the pad, the site-specific soil profile, and time histories of seismic accelerations. The analytical results obtained from the model address the dynamic and nonlinear response of the cylindrical cask in terms of its wobbling and sliding by examining closely the nonlinear contact behavior at the three interfaces and accounting for soil-structure interaction effects.

Q8. What assumptions did you make with respect to cask and pad rigidity/elasticity and damping in your model?

A8. (VKL) The cask and pad were modeled as elastic bodies with zero damping.

Q9. Please describe the principal factors you considered in modeling and evaluating the dynamic response of the casks during an earthquake event?

A9. (VKL) This particular modeling effort focused on performing sensitivity studies on the cask response with respect to three key factors: (1) prescribed seismic loading, (2) coefficients of friction at the three interfaces in the coupled model, and (3) soil profile data used for the soil foundation model.

Q10. With respect to the first factor you identified (seismic loading), please describe the seismic loading conditions or events that were used in performing dynamic analyses of the cask.

A10. (VKL) Three sets of seismic time histories were used as input excitations in the coupled model analyses. First, a prescribed artificial time history of seismic accelerations with a duration of 30 seconds, using design basis response spectra for the PFS site for a 2,000-year return period earthquake, was used to generate the response of the cask under design basis conditions. Second, a similar site-specific time history of seismic accelerations for a 10,000-year return period with a duration of 30 seconds was used to provide a limiting or upper-bound case assessment of cask response. Third, a sensitivity study was performed using the 1971 San Fernando Earthquake, Pacoima Dam record.

Each set of seismic time histories has one vertical and two horizontal components of statistically independent seismic accelerations. For the 2,000-year return period earthquake, the peak ground accelerations ("PGAs") that were modeled, based on artificial time histories specific to the PFS site, were 0.728 g (horizontal, east-west), 0.707 g (horizontal, north-south), and 0.721 g (vertical); these PGAs envelop the 2,000-year design basis response spectra of 0.711 g (horizontal)

and 0.695 g (vertical), stated in the Consolidated SER for the PFS Facility. For the 10,000-year return period event, the PGAs that were modeled, based on site-specific artificial time histories, were 1.25 g and 1.23 g for the horizontal components, and 1.33 g for the vertical component, which envelop the PFS earthquake hazard spectra. For the 1971 San Fernando Earthquake, Pacoima Dam record, the PGAs that were modeled were 0.641 g for the two horizontal components, and 0.433 g for the vertical component; the duration for this event was 41.8 seconds.

Each of the three seismic acceleration components of a set of time-histories was treated with a deconvolution procedure to produce a modified time history of deconvoluted accelerations with properly adjusted amplitudes and frequencies of the surface-defined accelerations. All three components of deconvoluted accelerations were applied simultaneously at the base of the soil foundation in the coupled model. Deconvolution is a mathematically rigorous solution process that applies the wave propagation equation of the free-field surface along with the boundary conditions, that modifies the seismic acceleration input to account for the site-specific soil properties (*i.e.*, linear shear modulus and viscous damping model). This serves to preserve the dynamic characteristics of the original seismic motions and achieve the desired (*i.e.*, appropriate) surface shaking intensity.

Q11. With respect to the second factor you mentioned (coefficients of friction at the three interfaces in the model), please describe how such coefficients were used in the coupled model.

A11. (VKL) Three interfaces were used in the coupled model: cask/pad, pad/soil-cement layer, and soil-cement layer/soil foundation. In order to determine the governing cases for both (a) the maximum horizontal sliding displacement, and (b) the angular rotation of the cask, different combinations with upper and lower bound coefficients of friction were used in the analyses. For the 2,000-year (design basis) event, the best estimate soil profile data (*see* discussion *infra*), a lower bound coefficient of friction of 0.20 (for investigating cask sliding) and an upper bound coefficient of friction of 0.80 (for investigating the potential for cask tipover) were used at the

cask/pad interface; also, bounding coefficients of friction of either 1.00 or 0.31 were assumed at the other two interfaces, as shown in Table 8 of the Final Report, Rev. 1 (Best Estimate, Model Type 1) (at page 30).

These sensitivity studies showed that the maximum horizontal displacement (sliding) of the cask was obtained when using a coefficient of friction of 0.20 at the cask/pad interface and 0.31 at the pad/soil-cement layer and soil-cement layer/soil foundation interfaces, as shown in Table 8 of the Final Report, Rev. 1 (Best Estimate, Model Type 1). Consequently, this combination of coefficients of friction was selected as the governing case for other seismic analyses reported in Table 8 of the Final Report, Rev. 1 (page 30), for the 2,000-year event.

Similarly, several studies were conducted for the 1971 San Fernando Earthquake (Pacoima Dam record) and the 10,000-year return period event, using a coefficient of friction of 0.20 at the cask/pad interface, and 0.31 at the other two interfaces, in order to maximize the potential for horizontal displacement (sliding) of the cask. The results of these studies are shown in Tables 9 and 10 of the Final Report, Rev. 1 (pages 31-32). Finally, two additional analyses were conducted for the 1971 San Fernando Earthquake and the 10,000-year return period event, using a coefficient of friction of 0.80 at the cask/pad interface, and 1.00 at the other two interfaces, in order to maximize the potential for cask tipover. These results are also shown in Tables 9 and 10 of the Final Report, Rev. 1.

Q12. With respect to the third factor you identified (soil profile data), please describe the soil profile data used for the soil foundation model.

A12. (VKL) As discussed above, the compact aggregate surface layer and concrete pad (the 2'4" soil-cement layer, and the) are placed on top of a 2-ft thick soil-cement layer that is on top of the soil foundation. The soil foundation submodel utilized in the model was 330-ft in the east-west direction and 757-ft in the north-south direction; these lateral dimensions exceed the recommended minimum as defined in

U.S. Corps. of Engineers soil-structure interaction modeling guidelines. Also, the coupled model partitions the soil into six horizontal layers to a depth of 140 feet, to represent the soil foundation; and the top surface was further divided into layers. The 140-ft depth was selected, in part, to reach a level below which the soil stiffness increases monotonically with depth. Sensitivity studies were performed to demonstrate the adequacy of this discretization scheme (using six layers to a depth of 140 feet) to incorporate the depth variation of soil properties such as shear wave velocity and damping profiles. As shown in Section 3.4.1 and Tables 2-7 of the Final Report, Rev. 1 (pages 9-12), specific soil properties considered include Young's Modulus, Poisson's ratio, density, damping ratio and a mass-related damping factor. This foundation modeling and its rationale are discussed in greater detail in sections 3.2.4 to 3.4.1 of the Final Report, Rev. 1 (pages 7-12).

To provide for broad variation in the soil properties, three sets of soil profile data - the best estimate, the lower bound, and the upper bound - were used separately in the analysis. The same soil profile data (best estimate, the lower bound, and upper bound) were used in performing the cask analyses for the seismic event with a 2,000-year return period and the 1971 San Fernando Earthquake, Pacoima Dam record, as shown in Tables 2 to 4 of the Final Report, Rev. 1 (pages 10-11). Different soil profile data were used for the 10,000-year return period seismic event, in which the shear modulus and damping of each layer of the soil foundation were adjusted for shear strains, as shown in Tables 5 to 7 of the Final Report, Rev. 1 (pages 11-12); in contrast, for seismic events with a 2,000-year return period, the low strain shear modulus and damping were used.

13. What does the coupled model predict as the maximum horizontal cask sliding displacements for each of the three seismic events considered?

A13. (VKL) The results from the seismic analyses indicate that the maximum horizontal cask sliding displacements are 3.98 inches for the 2,000-year return period event, 3.00 inches for

the 1971 San Fernando Earthquake, Pacoima Dam record, and 15.94 inches for the 10,000-year return period event.

It should be noted that these results are based the original coupled model ("Model Type 1"). However, two other cases of interest were also examined for the seismic event with a 2,000-year return period, using the best estimate soil profile data. In one case ("Model Type 2"), the ground surface preparation with compacted aggregate and soil-cement layers was removed from the coupled model. In the other case ("Model type 3"), the dead loads of the seven adjacent casks and neighboring pads were included in the coupled model. The maximum horizontal sliding displacements of the cask for both additional cases for the 2,000-year return period event were determined to be less than those obtained using the original coupled model. This is shown in Table 8 of the Final Report, Rev. 1 (page 30).

Q14. Based on the maximum horizontal cask sliding displacements predicted by the model, is the collision of adjacent casks likely to occur?

A14. (VKL) No.

Q15. Please provide the basis for this conclusion.

A15. (VKL) The separation distance between neighboring casks is 47.50 inches. Half of this distance, or 23.75 inches, is regarded as the cask collision criterion. Inasmuch as maximum displacements under the design basis 2,000-year earthquake is 3.98 inches, no cask collisions were found to occur. Further, no collisions were found to occur at the PFS site for the 1971 San Fernando earthquake, Pacoima Dam record, for which the maximum displacement was 3.00 inches. Similarly, under 10,000-year seismic conditions, the maximum displacement was 15.94 inches, which is less than the collision criterion of 23.75 inches. Thus, even under the beyond-design basis 10,000-year event conditions, cask collisions were not found to occur.

Q16. What does the coupled model predict as the maximum cask rotation with respect to the vertical axis of the cask?

A16. (VKL) With respect to the 2,000-year return period seismic event, the analysis results indicate that the maximum cask rotation in either horizontal direction with respect to the vertical axis is equal to or less than 0.03 degrees, using a coefficient of friction of 0.20 for the cask/pad interface. Further, using a coefficient of friction of 0.80, in order to maximize the amount of cask rotation, results in a maximum cask rotation of about 0.22 degrees in the east-west direction and about 0.40 degrees in the north-south direction, with respect to the vertical axis, for the 2,000-year earthquake. In sum, the maximum cask rotation, with respect to the vertical axis, is equal to or less than 0.40 degrees under 2,000-year return period seismic conditions.

With respect to the 1971 San Fernando Earthquake (Pacoima Dam record), the maximum cask rotation in either horizontal direction with respect to the vertical axis, using a coefficient of friction for the cask/pad interface of 0.20, results in a maximum cask rotation with respect to the vertical axis, of 0.02 degrees in the east-west direction and 0.01 degrees in the north-south direction. Further, using a coefficient of friction of 0.80, in order to maximize the amount of cask rotation, results in a maximum cask rotation of 0.06 degrees in the east-west direction and 0.07 degrees in the north-south direction for the 1971 San Fernando Earthquake (Pacoima Dam record). In sum, the maximum cask rotation, with respect to the vertical axis, is equal to or less than 0.07 degrees for the 1971 San Fernando Earthquake (Pacoima Dam record).

With respect to the 10,000-year return period seismic event, the maximum cask rotation in either horizontal direction with respect to the vertical axis, using a coefficient of friction for the cask/pad interface of 0.20, results in a maximum cask rotation with respect to the vertical axis, of 0.10 degrees in the east-west direction and 0.05 degrees in the north-south direction. Further, using a coefficient of friction of 0.80, in order to maximize the amount of cask rotation, results in

a maximum cask rotation of 0.65 degrees in the east-west direction and 1.16 degrees in the north-south direction, for the 10,000-year earthquake. In sum, the maximum cask rotation, with respect to the vertical axis, is equal to or less than 1.16 degrees even under 10,000-year return period seismic conditions.

Q17. Based on the maximum cask rotation predicted by the model, is cask tipover likely to occur during either the 2,000-year or 10,000-year return period seismic events?

A17. (VKL) No.

Q18. Please provide the basis for this conclusion.

A18. (VKL) The cask rotation that is associated with tipover is approximately 29 degrees. A rotation of less than 29 degrees would be insufficient to result in tipover of a loaded HI-STORM 100 cask.

Q19. How much movement of the cask in the vertical direction did your analyses predict?

A19. (VKL) A detailed evaluation of cask movement in the vertical direction was conducted. This evaluation indicates that the cask does not experience much displacement in the vertical direction in any of the three seismic events. The cask base is never entirely lifted off the top surface of the pad throughout the seismic event with a 2,000-year return period or the 1971 San Fernando Earthquake (Pacoima Dam record). Further, during either the 2,000-year return period seismic event or the 1971 San Fernando Earthquake (Pacoima Dam record), the maximum vertical displacement at any location of the cask base is much less than 1 inch above the top surface of the pad.

During the seismic event with a 10,000-year return period, the analysis results reveal that the cask base will entirely lift off the top surface of the pad by a maximum 0.26 inches, for a total duration of less than 0.30 seconds. Detailed examinations of the analysis results also indicate that

the maximum vertical displacement at any point along the perimeter of the cask base is less than 2.7 inches above the top surface of the pad, for the 10,000-year event.

Q20. In your analysis, did you reach any conclusions as to the importance of the dynamic coupling or soil-structure interaction ("SSI") effect of the cask with the soil foundation?

A20. (VKL) Yes. As discussed in section 4.1 of the Final Report, Rev. 1 (pages 27-29), the dynamic coupling or SSI effect of the cask with the soil foundation was examined in detail, using acceleration results in the east-west direction for the governing case. The model analyses indicate the presence of a significant SSI effect, as shown in Figures 17 through 19 in the Final Report, Rev. 1 (pages 34-35). More specifically, as shown in these Figures, when the acceleration results at four locations on the soil surface are compared to the acceleration results at various depths along the central axis of the pad, noticeable differences in acceleration are observed. The SSI effect is further demonstrated by plotting the corresponding response spectra in Figures 20a through 22b. These differences demonstrate the presence of the SSI effect and justify the development of the coupled finite element model in the Staff's research effort.

Q21. What is your overall conclusion with respect to stability of the freestanding HI-STORM 100 casks at the proposed PFS Facility, and the potential for cask sliding, collision, and tipover?

A21. (VKL, JG) For the reasons discussed above and in the Final Report, Rev. 1, it is our conclusion that excessive cask sliding or cask collisions will not occur. Further, it is our conclusion that cask tipover will not occur during either a 2,000-year return period or 10,000-year return period seismic event at the PFS site. Accordingly, we believe that Part D.1.i. of Unified Contention Utah L/QQ does not present a valid concern.

A22. Does this conclude your testimony?

A22. Yes.

Vincent K. Luk

EDUCATION:

Ph.D., Theoretical and Applied Mechanics, Northwestern University, 1978
M.S., Theoretical and Applied Mechanics, Northwestern University, 1975
B.S., Civil Engineering, University of Mississippi, 1974

WORK EXPERIENCE:

December 1993 to Present — Principal Member of Technical Staff
Nuclear Technology Programs Department, 6420
Sandia National Laboratories / New Mexico

- Team Leader of the Structural Analysis and Evaluation Team for an NRC Integrated Vulnerability Assessment Project. This project examines the vulnerability and structural integrity of nuclear power plants subjected to external high-energy impacts.

- Principal Investigator for the International Nuclear Energy Research Initiative (INERI) Project on "Condition Monitoring through Advanced Sensor and Computational Technology." This project is an international joint project with Korea Atomic Energy Research Institute (KAERI) of South Korea. This project focuses on developing and demonstrating advanced sensor and computational technology for continuous monitoring of the condition of components, structures, and systems in advanced and next generation nuclear power plants.

- Task Leader in the Nuclear Energy Research Initiative (NERI) Project on "Development of Advanced Technologies to Reduce Design, Fabrication and Construction Costs for Future Nuclear Power Plants." This task focuses on investigating the feasibility of developing the design-to-analysis tool to be used to enhance the efficiency of design/analysis cycle.

- Principal Investigator of an NRC project to examine the seismic behavior of freestanding dry cask storage systems subjected to earthquake excitations. In this project, coupled finite element models consisting of casks, concrete pad, and soil foundation were developed to investigate the nonlinear dynamic seismic behavior of cask systems and the soil-structure-interaction effect.

- Lead Engineer for the Steel Containment Vessel Project. This project is a part of the Cooperative Containment Program between Nuclear Power Engineering Corporation (NUPEC) of Japan and US NRC. Responsibilities include overall project management and coordination to conduct an overpressurization test of a scale model of a steel containment vessel and to perform finite element analyses to simulate model responses.

- Analysis Coordinator for NUPEC/NRC Cooperative Containment Program. Responsibilities include defining and monitoring pretest and posttest analysis tasks for simulating structural responses of scale models of steel and prestressed concrete containment vessels under severe pressure loading conditions. Additional assignments are to coordinate the Round Robin analysis activities that involve the participation of various US and international groups to perform independent analyses in pretest predictions and post-test evaluation.

April 1985 to November 1993

Senior Member of Technical Staff
Advanced Munitions Department, 9723
Sandia National Laboratories / New Mexico

- Developed analytical penetration models based on spherical and cylindrical cavity-expansion approximations to predict dynamic loads on projectiles, projectile trajectories, and final penetration depths. Penetration problems included penetration and perforation of aluminum and steel targets, penetration of concrete and soil targets, and perforation of concrete slabs.

- Conducted laboratory-scale ballistic tests and full-scale sled-track tests.

- Team Coordinator for Penetration Technology Team, starting in 1991. Responsibilities included serving as a single point of contact for penetrator technology project activities, to interface with customers, to develop new projects and expand customer base, and to provide team networking of communication and interaction among participants of different disciplines.

- Project Manager for the MOU (Memorandum of Understanding) Tandem-Rod Kinetic Energy Projectile Project. This project involved activities from concept definition, system design and analysis, hardware design and fabrication, to the eventual system demonstration for dual penetrators as an anti-armor system.

- Project Manager for the MOU Penetration Technology Project. Principal project tasks included advancement of penetration technology in the common interests of weapon programs for DOE and DoD laboratories.

- Project Manager for the DOE/DP Penetrator Tech Base Project. Project tasks included providing penetrator technology support to the Defense Program to broaden operational options for the development of future penetrating weapons and developing computational codes as reliable weapon design tools.

January 1981 to March 1985

Senior Staff Engineer
Engineering Mechanics Group
Franklin Research Center, Philadelphia, PA

- Performed structural analysis using finite element techniques on nuclear power plant containment vessel, condenser waterbox flange, valve/actuator assemblies, fan pedestals, and cartridge and barrel assembly of machine guns.
- Performed stress analyses, fatigue evaluation, and heat transfer analyses.
- Section Leader in an NRC project to review the feasibility and adequacy of the kinetic expansion process used to repair damaged tubes and to evaluate the performance of expanded tubes in the Once-Through Steam Generators at Three Miles Island Nuclear Power Station (TMI-1).

July 1978 to December 1980

Stress Analyst
Joseph Oat Corporation
Camden, NJ

- Performed seismic analysis and design of heat exchangers and pressure vessels.
- Performed water-hammer analysis of piping system in heat exchangers for flow-induced vibration during start-up condition.
- Performed response spectra analysis and impact evaluation of new and intermediate fuel storage racks.
- Performed thermal fatigue analysis of tubesheets in regenerative heat exchangers.
- Project Leader in an EPRI project to conduct an experimental study on feedwater heater tube erosion; a laser doppler velocimeter was used to measure 3-dimensional turbulent flow profile inside the inlet header of a plexi-glass model of feedwater heater.

September 1974 to June 1978

Research Assistant
Northwestern University
Evanston, Illinois

- Major fields: elasticity, fracture mechanics and solid contact problems.
- Fracture analysis of spot-welded elastic layers subjected to shear loads.
- Fracture analysis of a cylindrical cavity containing a circumferential edge crack.
- Three-dimensional stress analysis of an elastic half-space containing a partially embedded finite rod.

Awards and Honors:

Sandia National Laboratories

- Award for Excellence in November 1999 for outstanding work in executing the PCCV Round Robin Analysis task.
- 1996 President's Quality Award - Turquoise Award as a member of the NUPEC/NRC Containment Project Team.
- Award for Excellence in June 1992 for outstanding leadership of the Tandem Rod Project that resulted in high praise from the project sponsor.
- Award for Excellence in April 1993 for exceptional leadership of the EPW Tech Base Project.

Northwestern University

- Walter P. Murphy Fellowship in 1974-1975.
- Royal E. Cabell Fellowship in 1977-1978.

University of Mississippi

- Foreign Student Scholarship in 1971-1974.
- Faulkner Concrete Pipe Company Scholarship in 1972-1974.
- Recipient of Taylor Medal in Civil Engineering in 1973.
- Recipient of Taylor Medal Citation in Civil Engineering in 1974.
- President of the Student Chapter of the American Society of Civil Engineers in Senior Year.
- Recipient of the Outstanding Civil Engineering Student Award in 1974.
- Student Marshall for the School of Engineering in the 1974 Commencement.
- Chi Epsilon, Tau Beta Phi and Phi Kappa Phi

Professional Society Affiliations:

Member, American Society of Mechanical Engineers.

Journal Publications:

1. L. M. Keer and V. K. Luk, "Stress Analysis of an Elastic Layer Attached to an Elastic Half Space of the Same Material," International Journal of Engineering Science, Vol. 14, pp. 735-747, 1976.

2. L. M. Keer, V. K. Luk, and J. M. Freedman, "Circumferential Edge Crack in a Cylindrical Cavity," Journal of Applied Mechanics, Vol. 99, No. 2, pp. 250-254, 1977.

3. V. K. Luk and L. M. Keer, "Stress Analysis for an Elastic Half Space Containing an Axially-Loaded, Rigid Cylindrical Rod," International Journal of Solids and Structures, Vol. 15, pp. 805-827, 1979.

4. V. K. Luk and L. M. Keer, "Stress Analysis of a Deep Rigid Axially-Loaded Cylindrical Anchor in an Elastic Medium," International Journal for Numerical and Analytical Methods in Geomechanics, Vol. 4, pp. 215-232, 1980.

5. K. P. Singh and V. K. Luk, "An Approximate Analysis of Foundation Stresses in Horizontal Pressure Vessels," Journal of Engineering for Power, Vol. 102, No. 3, pp. 555-557, 1980.

6. K. P. Singh, M. Holtz, and V. K. Luk, "On Minimization of Rad-Waste Carry-Over in an N-Stage Evaporator," Heat Transfer Engineering, Vol. 5, Nos. 1-2, pp. 68-73, 1984.

7. M. J. Forrestal, Z. Rosenberg, V. K. Luk, and S. J. Bless, "Perforation of Aluminum Plates with Conical-Nosed Rods," Journal of Applied Mechanics, Vol. 54, No. 1, pp. 230-232, 1987.

8. V. K. Luk and M. J. Forrestal, "Penetration into Semi-Infinite Reinforced-Concrete Targets with Spherical and Ogival Nose Projectiles," International Journal of Impact Engineering, Vol. 6, No. 4, pp. 291-301, 1987.

9. M. J. Forrestal, V. K. Luk, and H. A. Watts, "Penetration of Reinforced Concrete with Ogival-Nose Penetrators," International Journal of solids and Structures, vol. 24, No. 1, pp. 77-87, 1988.

10. M. J. Forrestal and V. K. Luk, "Dynamic Spherical Cavity-Expansion in a Compressible Elastic-Plastic Solid," Journal of Applied Mechanics, Vol. 55, No. 2, pp. 275-279, 1988.

11. M. J. Forrestal, K. Okajima, and V. K. Luk, "Penetration of 6061-T6 Aluminum Targets with Spherical, Ogival, and Conical Nose Rods," Journal of Applied Mechanics, Vol. 55, No. 4, pp. 755-760, 1988.

12. V. K. Luk and M. J. Forrestal, "Comments on 'Penetration into Semi-Infinite Reinforced-Concrete Targets with Spherical and Ogival Nose Projectiles'," International Journal of Impact Engineering, Vol. 8, No. 1, pp. 83-84, 1989.

13. M. J. Forrestal, A. J. Piekutowski, and V. K. Luk, "Long-Rod Penetration into Simulated Geological Target at an Impact Velocity of 3.0 km/s," Proceedings of the 11th International Symposium on Ballistics, Brussels, Belgium, May 9-11, 1989.

14. M. J. Forrestal, V. K. Luk, and N. S. Brar, "Perforation of Aluminum Armor Plates with Conical-Nose Projectiles," Mechanics of Materials, Vol. 10, No. 1-2, pp. 97-105, 1990.

15. V. K. Luk, M. J. Forrestal, and D. E. Amos, "Dynamic Spherical Cavity-Expansion of Strain-Hardening Materials," Journal of Applied Mechanics, Vol. 58, No. 1, pp. 1-6, 1991.

16. M. J. Forrestal, N. S. Brar, and V. K. Luk, "Penetration of Strain-Hardening Targets with Rigid Spherical-Nose Rods," Journal of Applied Mechanics, Vol. 58, No. 1, pp. 7-10, 1991.

17. V. K. Luk and D. E. Amos, "Dynamic Cylindrical Cavity-Expansion of Compressible Strain-Hardening Materials," Journal of Applied Mechanics, Vol. 58, No. 2, pp. 334-340, 1991.

18. V. K. Luk and A. J. Piekutowski, "An Analytical Model on Penetration of Eroding Long Rods into Metallic Targets," International Journal of Impact Engineering, Vol. 11, No. 3, pp. 323-340, 1991.

19. M. J. Forrestal, V. K. Luk, Z. Rosenberg, and N. S. Brar, "Penetration of 7075-T651 Aluminum Targets with Ogival-Nose Rods," International Journal of solids and Structures, Vol. 29, No. 14/15, pp. 1729-1736, 1992.

20. M. J. Forrestal and V. K. Luk, "Penetration into Soil Targets," International Journal of Impact Engineering, Vol. 12, No. 3, pp. 427-444, 1992.

21. Y. Xu, L. M. Keer, and V. K. Luk, "Elastic-Cracked Model for Penetration into Unreinforced Concrete Targets with Ogival Nose Projectiles," International Journal of Solids and Structures, Vol. 34, No. 12, pp. 1479-1491, 1997.

22. Y. Xu, L. M. Keer, and V. K. Luk, "Stress Properties at the Tip of a Conical Notch," International Journal of Solids and Structures, Vol. 34, No. 12, pp. 1531-1546, 1997.

23. L. M. Keer, Y. Xu, and V. K. Luk, "Analysis of High Speed Axially Symmetric Cutting for Stripping Peripheral Coating," Journal of Manufacturing Science and Engineering, Vol. 120, No. 1, pp. 185-191, 1998.

24. L. M. Keer, Y. Xu, and V. K. Luk, "Boundary Effects in Penetration or Perforation," Journal of Applied Mechanics, Vol. 65, No. 2, pp. 489-496, 1998.

Conference Proceedings and Presentations:

1. G. K. Haritos, L. M. Keer, and V. K. Luk, "Two and Three Dimensional Stress Analysis of an Elastic Half Space Containing a Partially Embedded Finite Rod," presented at the 15th International Congress of Theoretical and Applied Mechanics, Toronto, Canada, August 18-22, 1980.

2. M. J. Forrestal, M. M. Hightower, V. K. Luk, and B. K. Chritensen, "Penetration and Perforation of Reinforced-Concrete Targets," Proceedings from the Workshop on Weapon Penetration into Hard Targets, Norwegian Defense Research Establishment, May 30-31, 1988.

3. V. K. Luk, J. Hickerson, A. E. Hodapp, and A. D. Foster, "System Development of a 120-mm Tandem-Rod Kinetic Energy Projectile," Proceedings of the Second Ballistics Symposium on Classified Topics, Johns Hopkins University, October 26-29, 1992.

4. J. D. Cargile, M. E. Giltrude, and V. K. Luk, "Perforation of Thin Unreinforced Concrete Slabs," Proceedings of the Sixth International Symposium on Interaction of Nonnuclear Munitions with Structures, Panama City Beach, Florida, May 3-7, 1993.

5. T. Matsumoto, K. Takumi, Y. Kobayashi, M. Fujii, S. Nakajima, J. F. Costello, W. A. von Riesemann, M. B. Parks, M. F. Hessheimer, and V. K. Luk, "Plan on Test to Failure of a Steel, a Prestressed Concrete and a Reinforced Concrete Containment Vessel Model," Proceedings of the 13th International Conference on Structural Mechanics in Reactor Technology, Vol. VI, pp. 89-94, Porto Alegre, Brazil, August 13-18, 1995.

6. V. K. Luk, M. F. Hessheimer, T. Matsumoto, K. Komine, and J. F. Costello, "Testing of a Steel Containment Vessel Model," Proceedings of the 14th International Conference on Structural Mechanics in Reactor Technology, Vol. 5, pp. 73-79, Lyon, France, August 17-22, 1997.

7. T. Matsumoto, K. Komine, S. Arai, V. K. Luk, M. F. Hessheimer, and J. F. Costello, "Preliminary Results of Steel Containment Vessel Model Test," Proceedings of the 14th International Conference on Structural Mechanics in Reactor Technology, Vol. 5, pp. 81-87, Lyon, France, August 17-22, 1997.

8. R. A. Dameron, Y. R. Rashid, V. K. Luk, and M. F. Hessheimer, "Preliminary Analysis of a 1:4 Scale Prestressed Concrete Containment Vessel Model," Proceedings of the 14th International Conference on Structural Mechanics in Reactor Technology, Vol. 5, pp. 89-96, Lyon, France, August 17-22, 1997.

9. V. K. Luk, M. F. Hessheimer, V. L. Porter, T. Matsumoto, and J. F. Costello, "Results of 1:10 Scale Steel Containment Vessel Model Test," SMiRT 14 Post Conference Seminar, Saclay, France, August 25-26, 1997.

10. R. A. Dameron and V. K. Luk, "Preliminary Assessment of Potential Liner Tearing Near the Equipment Hatch of a 1:4 Scale PCCV," SMiRT 14 Post Conference Seminar, Saclay, France, August 25-26, 1997.

11. T. Matsumoto, K. Komine, J. F. Costello, V. K. Luk, and M. F. Hessheimer, "Pressurization Test of a 1/10 Steel Containment Vessel Model," Proceedings of the Workshop on Severe Accident Research in Japan (SARJ-97), pp. 210-218, Yokohama, Japan, October 6-8, 1997.

12. D. W. Pace, M. F. Hessheimer, V. K. Luk, R. A. Dameron, M. Iriyama, and J. F. Costello, "Preliminary Analysis and Instrumentation of a Prestressed Containment Vessel Model," Proceedings of the Workshop on Severe Accident Research in Japan (SARJ-97), pp. 219-224, Yokohama, Japan, October 6-8, 1997.

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14. V. K. Luk, J. S. Ludwigsen, M. F. Hessheimer, K. Komine, T. Matsumoto, and J. F. Costello, "Results of Steel Containment Vessel Model Test," Proceedings of 1998 ASME/JSME Joint Pressure Vessels and Piping Conference, PVP-Vol. 362, pp. 177-188, San Diego, California, July 26-30, 1998.

15. R. A. Dameron, Y. R. Rashid, V. K. Luk, and M. F. Hessheimer, "Investigation of Radial Shear in the Wall-Base Juncture of a 1:4 Scale Prestressed concrete Containment Vessel Model," Proceedings of 1998 ASME/JSME Joint Pressure Vessels and Piping Conference, PVP-Vol. 362, pp. 189-198, San Diego, California, July 26-30, 1998.

16. V. K. Luk, M. F. Hessheimer, K. Komine, M. Iriyama, T. Matsumoto, and J. F. Costello, "Steel Containment Vessel Model Test: Results and Evaluation," Proceedings of the 15th SMiRT Conference, Vol. VI, pp. 267- 274, Seoul, Korea, August 15-20, 1999.

17. V. K. Luk, E. W. Klamerus, M. F. Hessheimer, K. Komine, M. Iriyama, T. Matsumoto, and J. F. Costello, "Round Robin Analyses of the Steel Containment Vessel Model," Proceedings of the 15th SMiRT Conference, Vol. VI, pp. 203-210, Seoul, Korea, August 15-20, 1999.

18. J. S. Ludwigsen, V. K. Luk, M. F. Hessheimer, T. Matsumoto, K. Komine, and J. F. Costello, "Posttest Analyses of the Steel Containment Vessel Model," Proceedings of the 15th SMiRT Conference, Vol. VI, pp. 219-226, Seoul, Korea, August 15-20, 1999.

19. V. K. Luk, J. A. Smith, S. K. Shaukat, R. M. Kenneally, R. A. Dameron, Y. R. Rashid, and V. P. Sobash, "Seismic Analysis of Evaluation of Spent Fuel Dry cask Storage Systems," Transactions, SMiRT 16, Paper # 1369, Washington DC, USA, August 12-17, 2001.

20. V. K. Luk, E. T. Eager, D. M. Mattson, L. D. Gerdes, and J. M. O'Connell, "Development of an Automated Design-to-Analysis Process for a Nuclear Power Plant," Transactions, SMiRT 16, Paper # 1904, Washington DC, USA, August 12-17, 2001.

21. M. F. Hessheimer, V. K. Luk, E. W. Klamerus, S. Shibata, S. Mitsugi, and J. F. Costello, "Pretest Round Robin Analysis of 1:4-Scale Prestressed Concrete Containment Vessel Model," Transactions, SMiRT 16, Paper # 1305, Washington DC, USA, August 12-17, 2001.

22. R. A. Dameron, Y. R. Rashid, V. K. Luk, and M. F. Hessheimer, "Pretest Analysis of a 1:4-Scale Prestressed Concrete Containment Vessel Model," Transactions, SMiRT 16, Paper # 1271, Washington DC, USA, August 12-17, 2001.

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1. R. W. Ostensen, E. S. Hertel, C. W. Young, and V. K. Luk, "Evaluation of the Missile Threat for the NPR-HWR Containment," SAND 90-3256, 1991.

2. A. D. Foster, R. C. Henry, J. Hickerson, A. Hodapp, R. A. LaFarge, and V. K. Luk, "System Development of a 120-mm Tandem-Rod Kinetic Energy Projectile," SAND 93-1818, 1995.

NUREG Reports:

1. V. K. Luk and E. W. Klamerus, "Round Robin Pretest Analysis of a Steel Containment Vessel Model and Contact Structure Subject to Static Internal Pressurization," NUREG/CR-6517, 1998.

2. V. K. Luk and E. W. Klamerus, "Round Robin Posttest Analysis of a Steel Containment Vessel Model," NUREG/CR-5678, 2000.

3. J. S. Ludwigsen, V. K. Luk, and M. F. Hessheimer, "Posttest Analysis of the Steel Containment Vessel Model," NUREG/CR-6649, 2000.

4. V. K. Luk, M. F. Hessheimer, G. S. Rightley, L. D. Lambert, and E. W. Klamerus, "Design, Instrumentation and Testing of a Steel Containment Vessel Model," NUREG/CR-5679, 2000.

5. V. K. Luk, "Pretest Round Robin Analysis of a Prestressed Concrete Containment Vessel Model," NUREG/CR-6678, 2000.

Thesis and Dissertation:

1. "Fracture Analysis of a Spot Welded Elastic Layer in Shear," M.S. Thesis, Northwestern University, August 1975.

2. "Elastostatic Load-Diffusion Characteristics of Embedded Axially-Loaded Cylindrical Structures," Ph.D. Dissertation, Northwestern University, June 1978.

Jack Guttmann

Chief, Technical Review Section
Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards (NMSS)
U. S. Nuclear Regulatory Commission

Education:

B.S. in Mechanical Engineering, Michigan Technological University, 1973
M.S. Nuclear Engineering, University of Michigan, 1974

Experience:

Mr. Guttmann has experience in nuclear engineering related to thermal-hydraulic and mechanical engineering analysis. Mr. Guttmann worked at the Idaho National Engineering Laboratory as a contractor to the NRC in the area of thermal-hydraulic computer code validation and analysis. He performed analyses that quantified the conservatism between the accident analysis requirements for licensing nuclear power plants (10 C.F.R. Part 50, Appendix K), validated the computer code RELAP for regulatory application by the NRC, and performed independent confirmatory transient and accident analyses of operating reactor events and safety issues defined by the NRC.

While working at the NRC, Mr. Guttmann was responsible for reviewing and approving the computer codes used by the nuclear industry for transient and accident analysis. He represented the Office of Nuclear Reactor Regulation (NRR) on the Advanced Code Review Committee, the Loss of Fluid Test Facility, and the Semiscale Test Facility. Mr. Guttmann performed independent analyses of plant operating events, including regulatory responses to the TMI-2 accident. He was a member of the BWR Bulletins and Orders Task Force that reviewed the ramifications of the TMI-2 events for boiling water reactors. He reviewed and approved emergency operator procedures for PWR designs and performed quality assurance inspections. Mr. Guttmann developed standard review plans for analyzing reactor transient and accident events, developed regulatory guidance and NUREG documents for implementing Risk-Informed In-Service Testing of Piping, and was on the task force and project manager for developing Risk-Informed regulatory guidance documents (i.e., RG-1.174, -1.175, - 1.176, -1.177, and 1.178).

With respect to policy development, Mr. Guttmann served as a technical assistant to Commissioner Forrest J. Remick. He advised Commissioner Remick on policy development of advanced nuclear power plants, operating reactor issues, research needs, international activities, and represented the Commission as an observer on INPO inspections.

Mr. Guttmann is currently Chief of the Technical Review Section at the Spent Fuel Project Office. His responsibilities include licensing and certification of storage (10 CFR Part 72) and transportation (10 CFR Part 71) packages of radioactive materials, including independent spent fuel storage installations. Mr. Guttmann is also responsible for assessing vulnerabilities of storage and transportation packages to terrorist events.

Professional Chronology:

Jr. Engineer, Detroit Edison Co., Enrico Fermi Atomic Power Plant-I, 1972-73; Research Engineer, Idaho National Engineering Laboratory, 1975-1976; Nuclear Engineer, Office of Nuclear Reactor Regulation, NRC, 1976-1985; Technical Coordinator, Office of the Secretary, NRC, 1985-1990; Technical Assistant, Office of the Commission, NRC, 1990-1994; Sr. Reliability and Risk Assessment Engineer, Office of Nuclear Regulatory Research, NRC, 1994-1999; Sr. Nuclear Engineer, Office of Nuclear Material Safety and Safeguards, NRC, 1999-2000; Chief, Technical Review Section, Spent Fuel Project Office, Nuclear Material Safety and Safeguards, 2000-2002.

Q. (By Mr. Turk) I should say, I guess, one more question. Do you adopt this testimony as your sworn testimony in the proceeding?

MR. Guttman: Yes.

DR. LUK: Yes.

MR. TURK: Thank you, your Honor.

JUDGE FARRAR: Thank you.

MR. TURK: Your Honor, before proceeding to cross-examination the Staff has an Exhibit we would like to offer into evidence.

JUDGE FARRAR: Okay.

(STAFF EXHIBIT-P WAS MARKED.)

MR. TURK: And I have given copies of the reporter, the Licensing Board members and counsel for the State and counsel for PFS also have copies, and I would identify this as Staff Exhibit P, as in Peter. It is a document entitled NRC Project on Seismic Behavior of Spent Fuel Storage Cask Systems, Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage Facility, Revision 1, and the document is dated March 31, 2002. And by way of preliminary questioning, your Honor, may I direct a question to Dr. Luk?

JUDGE FARRAR: Certainly.

Q. (By Mr. Turk) Dr. Luk, do you recognize

the document we have identified as Staff Exhibit P?

DR. LUK: Yes.

Q. And is it, in fact, a report that you prepared on behalf of the NRC Staff for filing in this proceeding?

DR. LUK: Yes.

MR. TURK: Your Honor, at this time I would ask that Staff Exhibit P be admitted into evidence.

MR. GAUKLER: No objection, your Honor.

MS. NAKAHARA: Your Honor, we stated our objections in the Motion in Limine based on the timing in which this Exhibit was proffered. And notwithstanding those objections, we have no additional.

JUDGE FARRAR: All right. And had we denied your motion at that point or have we carried it with the case?

MS. NAKAHARA: It was my understanding you denied it pending any new objections with respect to our opportunity to depose Dr. Luk, and we have none based on that.

JUDGE FARRAR: All right. Then our previous ruling will stand and the motion will be admitted. I'm sorry, the Exhibit will be admitted.

(STAFF EXHIBIT-P ADMITTED.)

MR. TURK: Thank you, your Honor. At this time then the witnesses are available for cross-examination and Board questioning.

MR. FARRAR: All right. Then we'll begin with the applicant.

CROSS EXAMINATION

BY MR. GAUKLER:

Q. Good morning, Dr. Luk and Mr. Guttman. How are you doing this morning?

MR. Guttman: Fine, thank you.

DR. LUK: Good morning.

Q. Dr. Luk, you referred to in question 6, question and answer 6, a generic program for developing guidance on seismic hazardous analysis in which you have been involved. Could you briefly describe that generic program?

DR. LUK: It is my recollection in March of 1999, at the request of the Office of Nuclear Research at NRC, that we started investigation to examine the seismic stability of dry cask storage systems. And when this project was started the focus was to conduct a generic or parametric analysis. The parameters or variations include

different cask designs, different seismic load and different soil property data.

Q. And was this generic program a review of the seismic behavior of freestanding dry storage casks?

DR. LUK: Yes, sir.

Q. They were not anchored in any way?

DR. LUK: Our study is focused on freestanding dry cask storage systems.

MR. TURK: Excuse me one moment. May we go off the record for a moment?

(Discussion held off the record.

JUDGE FARRAR: Back on the record.

Q. (By Mr. Gaukler) What plants or sites or types of dry cask storage systems did you study as part of this program?

DR. LUK: As we continued with our generic analysis of dry cask storage systems we were called upon to do site-specific analysis. The first ones that we were asked to do the analysis is for San Onofre Nuclear Generating Power Plant, the second one is Hatch, and the third one is the Private Fuel Storage.

Q. What steps did you take prior to doing these plant-specific analyses in terms of

developing a methodology or other general steps in terms -- enabling you to analyze the seismic behavior of freestanding dry storage casks?

DR. LUK: It is my recollection that when we started this seismic evaluation of dry cask storage systems we were tasked by the staff at the NRC to search for the state-of-the-art numerical modeling technology, to use the best method that we know how. So in the process I put together I researched here which we think would enable us to do the problems that we were asked.

Q. And would you please describe the research team that you put together for this project?

DR. LUK: Yes. I have two fellow workers at Sandia to support me within Sandia, and I also have two consultants. One is Mr. Robert Dameron from Anatech and the second one is Mr. Po Lam from Earth Mechanics.

Q. And what are their areas of expertise?

DR. LUK: Mr. Dameron's expertise is that he has been working on finite element analysis in the past 20 years. He is a very good and practical engineer. So he knows how to bridge the gap between theory and what has been adopted as the

traditional engineering practice in the field.

Q. What is his background in terms of what he has -- the type of work he has done?

DR. LUK: He has a Master of Science in civil engineering from UC Davis and he is the vice president -- he is the vice president of Anatech Corporation, and he is one of the leading authorities in the finite element analysis of the varieties of components, of reactor containments, per se, and I think over the past few years he has spent a lot of time working on the seismic analysis of bridges in California.

Q. And Mr. Lam or Dr. Lam?

DR. LUK: Mr. Lam is trained as a seismologist. He got his Master degree of Science from Cal Tech, I think it's either in the late '60s or early '70s. So he's been working in the field of doing seismic analysis, in particular related to the seismology for the past 25 years at least.

Q. What was Mr. Guttman's role in the work on your project?

DR. LUK: This is my understanding. Mr. Guttman is one of the principal investigator in the office of MMSS at NRC. I got the request from my project manager at NRC in the Office of Regulatory

Research that Mr. Guttman asked him the possibility that we can somehow participate and start to do the seismic analysis for Private Fuel Storage cask.

Q. So he was the one that kind of was the overseer with respect to the Private Fuel Storage analysis?

DR. LUK: Yes, sir.

Q. Did you feel that you had available to you all the technical expertise you needed to conduct your review of the Private Fuel Storage project as well as these other projects?

DR. LUK: Yes. But if you don't mind, I want to make clear one matter, is that it is not our task to do review. It is our job that if we were given the appropriate informations that we need as input to our three-dimensional coupled finite elements model we will proceed with the analysis and then we would interact with the Staff at NRC to get those informations.

Q. And did you feel you had adequate technical capability and expertise background to conduct such an analysis?

DR. LUK: Yes, sir.

Q. Would you please describe to me, you referred to start-of-the-art methodology in

computer programs. Would you please describe for me the computer code or methodology, standard methodology you used for analyzing the seismic behavior of freestanding casks at these various sites?

DR. LUK: Yes. It is my recollection when we first started this project we make an extensive survey of all the available technology in doing finite elements analysis related to freestanding structures. And also based on the NRC requirement that we need to use a commercially available code that we eventually choose ABAQUS finite elements code to use that as the base for our finite elements model development.

Q. And what type of code is ABAQUS, is it an all-purpose code or --

DR. LUK: ABAQUS is a general purpose nonlinear dynamic fine elements code.

Q. So you can do nonlinear dynamic problems with ABAQUS?

DR. LUK: Yes. In particular, it is suited to do problems that will experience large deformations.

Q. And another way to say large deformations would be large rotations of the casks

or large movements of the casks and be capable of modeling those if such were found to exist?

DR. LUK: Yes. Large deformation theory include large rotation, large displacements.

Q. In developing your methodology, did you conduct any sensitivity studies with respect to the general methodology that you developed for your analysis?

DR. LUK: Yes. As part of the development of the three-dimensional finite elements model we feel it is essential step that we go through various sensitivity evaluations to find out how will the coupled model respond for different inputs.

Q. And what type of sensitivity studies did you undertake?

DR. LUK: One of the critical issues when we develop the finite elements model is that we have to address the issues whether the analysis results that we obtained are actually a representative of the typical behavior of the cask system under investigations. In particular, we have to address whether we actually arrive at a converged solutions.

So in the process when we change the

input parameters in terms of the size of the model, this is in particular the size of the soil foundation model, because we feel that the soil structure interaction is a key feature in this coupled model. So we actually spent a lot of time to find out what is the appropriate selection for the geometry for the soil foundation model.

Q. And how did you determine you had the appropriate geometry for the soil foundation model?

DR. LUK: What we did is that we basically changed two things. One is the finite -- the finest of the finite element grid which represents the fine elements model as well as the overall geometries of the model. The technical issues on hand is that we have the task to use a finite -- a model with finite geometries to represent the behavior of semi-infinite soil foundations or technically people call that half-space. So it is very important for us to do a very systematic evaluations by changing the geometry of the soil foundation model so that we can arrive at a converged solution.

Q. And that's the process you undertook in the methodology?

DR. LUK: Yes, sir.

Q. Did your analysis take into account or did your methodology take into account uncertainties as to the input parameters to the model?

DR. LUK: Can you repeat the question?

Q. Would your methodology take into account uncertainties that may exist with respect to the input parameters that would be used for the model?

DR. LUK: Would you mind if you substantiate what is the nature of the input to the model?

Q. I'm talking in terms both of -- primarily in terms of soil properties.

DR. LUK: In our site-specific analysis we got all the information related to the soil profile data from the Staff at NRC, but we want to make sure that we get all the information -- we got all the informations that include -- that would include all ranges of variations so for this Private Fuel Storage cask, for example, we got the information on the best estimate lower bound and upper bound soil profile data.

Q. And you ran your model for all three of those soil properties?

DR. LUK: Yes, sir.

Q. Did your model evaluate the potential uncertainties in the seismic input for the earthquake in any respect?

DR. LUK: Would you mind to repeat the question?

Q. Well, did your modeling for the PFSF take into account the potential uncertainty as to the seismic input? For example, did you evaluate different types of earthquakes or not?

DR. LUK: There's two parts to this question. The one is that we did obtain the specific details what is required for the seismic load from the staff at the NRC, but we feel it is also our job try to do extensive study on the seismic loading that was given to us by the Staff at NRC.

Q. And how did you do that?

DR. LUK: What we do is that first we study the response spectra and its associations with the time history of seismic acceleration for the three independent components and then we go through systematic evaluations in terms of whether those three components are truthfully independent on a statistical sense as well as try to find out whether the so-call fault normal/fault parallel

directions are truthful in its meaning.

Q. I would like to now focus you on your report for the Private Fuel Storage Facility which is Staff Exhibit R -- Staff Exhibit P, excuse me. And I believe that you developed three types of models for your seismic analysis of the freestanding cask at the PFSF facility?

MR. TURK: I'm sorry, could you repeat that question. Did you say three types of models?

Q. (By MR. Gaukler) Yeah, three models. I think you refer to them on page -- they're identified in Table 8 and you refer to them in Section 4, Analysis Results.

DR. LUK: Yes, sir.

Q. And if you look at Table 8 you refer to Model 1, and would you please describe generally what Model 1 consisted of?

DR. LUK: Yes. When we look at the three-dimensional coupled models and we start from the top there will be a single cask, and that is sitting on a concrete pad. And then right in the close vicinity of it in adjacent area there is the compact aggregate, below that is soil cement layer and then just surface as well as the concrete pad, they are sitting on a 2 foot thick of soil cement

layer, and below all of this is the soil foundations.

Q. And do you have a soil cement layer around the pads?

DR. LUK: Yes, we have a soil cement surrounding the pad.

Q. And that comprises your first model or Model 1?

DR. LUK: Yes. And if you don't mind me to substantiate, the model is actually described in detail in this report on page 17, Figure 6.

Q. And that figure shows the concrete pad, the aggregate gravel and soil cement surrounding the pad?

DR. LUK: Yes, sir.

Q. Now, you said you modeled 1 cask on the pad on Model 1?

DR. LUK: Yes.

Q. And why did you decide to model 1 cask instead of 8 casks or some other number of casks on the pad?

DR. LUK: When we started the generic analysis this was a very challenging issues. The question that we try to address is that what is the most technically correct way to investigate the

seismic stability of a dry cask storage system on top of a concrete pad. We know with different designs they have different numbers of casks on pad, but based on the physical principles we feel it is adequate to actually only model a single cask on pad.

And the reason is as follows: If we look at a nonlinear dynamic system such as a freestanding dry cask, there's two extreme cases we considered. One is the symmetrical -- sorry, strike that. One is the -- yeah, it's the symmetrical case in which all cask on the pad will move in phase or in harmony. So what that simply mean is that every cask can behave independent of each other.

But then if you also look at the other extremes the anti-symmetrical case in which all casks on pad are moving in totally opposite way, in that case the results will be much -- the results in terms of sliding and rotations will be much lower than the first case, which is the symmetrical case.

So in considering the two extreme cases we feel it is actually adequate to model or to investigate the dynamic behavior of a cask by just

using a single cask on pad. Now, this assumption and this procedure, we did go through the investigations by going through a systematic analysis, and the results of the sensitivity study did indicated that that was a correct approach.

Q. Would you please describe that sensitivity study?

DR. LUK: Yes. This is actually, if you don't mind, I will make reference to Table 8 on figure -- Table 8 on page 30 of the same report. There we said is for the case Type 3. Type 3, which I'll read directly from the description that was include in the report on page 30. For Model Type 3 is the coupled model includes the dead loads of 7 adjacent cask and neighboring concrete pads.

What that simply mean is that we developed the model for Type 3, we include 1 cask which has all the mobility and the dead weight of the 7 other casks on the pad. And in going through this sensitivity study, it is actually indicated in Table 8 when you compare the Type 1 model with the Type 3 model you find out the results for Type 1 is actually -- the results in terms of translational motion of the cask is actually higher than those we got from Model Type 3.

Q. So Model Type 3 where you assumed a fully loaded pad you got less displacement than you did in the Model 1, correct?

DR. LUK: Yes.

Q. And in Model 3 you also considered, you said, the adjacent pads fully loaded with 8 casks, and would you describe what adjacent pads you assumed in Model 3?

DR. LUK: Yes. If you look from the top view of a cask that we have, I'll make reference to Figure 4 on page 15. This is the top view of a single cask on a single pad. In Model Type 3 when we include the neighboring fully-loaded pad we put one pad in each of the four sides of the pad that we highlighted in this figure.

JUDGE FARRAR: Mr. Gaukler, could I interrupt for clarification? Is there supposed to be a rule about where the first cask goes on a pad in terms of the 8 spots? Does the first cask go in one of the corners or more toward the -- or in the middle?

DR. LUK: I am not aware that for Private Fuel Storage facilities whether they have decided the sequencing of the installation of the pads. But can I substantiate a little bit of we

knew for quite some time there is actually a technical issue. If -- well, we did decided to only use a single cask on a pad so the follow-up question is that where are we going to put the pad.

JUDGE FARRAR: The cask.

DR. LUK: Oh, yeah, the cask. Sorry. Where to put the cask, sorry. If you look at the configuration for the 8 casks on the pad, it's 2 by 4.

JUDGE FARRAR: Right.

DR. LUK: So the choices are actually quite limited. Either you use the one at the corner or the one right next to it, but it's away from the corner.

JUDGE FARRAR: And those are the only two cases -- well, there's four sub cases. They're all, in effect, the same.

DR. LUK: Yes. So there's only two locations to pick. And we did go through the sensitivity study to decide which of the two locations is a better one. But also, as I indicated before, if we do go by the first case of the symmetry that we consider, it virtually doesn't matter where we put the locations because each cask with its virtual square space that it occupies, the

analysis results indicated that we almost get identical results when we either -- when we pick either one of the two locations.

JUDGE FARRAR: Go ahead, Mr. Gaukler.

Q. (By Mr. Gaukler) Yes. Why didn't you analyze the movements, say, of all 8 casks on the pad? Is there a particular reason why not?

DR. LUK: Yes. Our model actually used the finite elements representation for all individual substructures. We did went through the technical evaluations that deserved merit to include all 8 casks on the pad, and the conclusion is that if we do that we're going to have to pay huge penalty in related to executing the finite elements model. But as engineers, we always feel that we have to come up with a very efficient model that will enable us to get the best accurate results within practical limits. And we do not feel by using 8 casks on the pad will gain us anything as compared to using a single cask on pad.

Q. So you would expect the same general results if you ran 8 casks or one cask on the pad?

DR. LUK: Yes. But the reason, if you don't mind me to repeat, is that it is our basic assumption that all of the 8 casks on pad actually

behave independent of each other. So that would not make any difference whether we have 1 cask or 2, or for that matter, 8 cask on a pad.

Q. How long did it take to run your program for one run for 1 cask?

DR. LUK: It is our intention try to use the state-of-the-art modeling technology, but we also try to make sure that we are not using a super computer at the Sandia National Lab. So what we used is with this sophisticated model an execute it on a PC network, and in that framework for the complete one run for duration of 30 seconds for seismic event for the Private Fuel Storage cask it took close to 48 hours.

MR. TURK: I'm sorry. The question was how long to do a run rather than to develop the model?

MR. GAUKLER: Yes.

Q. (By Mr. Gaukler) I think you referred to in your previous answer, to one or two questions ago penalties, in terms of having to run with 8 casks on pad. And what penalties are you referring to, just penalties in the time it took to run the computer program?

DR. LUK: Yes. The time it would take

to execute the model and the time it would take to go through the process of what people referred to as the input/output and also the memory space that needed to complete the analysis.

Q. Going back now to your Model 3, the model where you had the one cask that was allowed to move and the 7 other casks on that pad, the dead weights, and then the 4 adjacent pads surrounding that 1 pad with the dead weight of 8 casks on each. First of all, were the casks -- strike that. First of all, were the pads allowed to slide in that model, the pads on which the casks were resting, concrete pads?

DR. LUK: Yes. In our coupled models, in all cases the concrete pad is allowed to slide.

Q. And how is that reflected, say, on Table 8 where you have your results?

DR. LUK: I would like to repeat, it is our principal task to try to study the seismic stability of the cask. And that's why our focus is on the relative displacements of the cask with respect to the pad. We do not spend a lot of time to investigate the movement of the pad. But we did look at the results of the movement of the pad and since we did allow the pad to slide with respect to

the soil cement layer, yeah, we saw some movement, but the amount of sliding movement is very small.

Q. And would this Model 3 in which you allowed the pad to slide, would that take into account, therefore, the sliding effects of pad-to-pad interaction? In other words, would it take into account the effect of one pad sliding and impacting another pad in the cask stability on that other pad?

THE WITNESS: Would you like to repeat your question?

MR. GAUKLER: Would you please reread the question?

(The record was read as follows:

"Q. And would this Model 3 in which you allowed the pad to slide, would that take into account, therefore, the sliding effects of pad-to-pad interaction? In other words, would it take into account the effect of one pad sliding and impacting another pad in the cask stability on that other pad?")

DR. LUK: In terms of the inertial effect when subjected to the seismic excitations the answer is yes.

Q. (By Mr. Gaukler) Would you now briefly

describe for me Model 2 that you ran with respect to the PFS site.

DR. LUK: Yes. I'll refer back to Table 8 on page 30 of the report. The Model Type 2 reads as follows: The coupled model without compact aggregate and soil cement layer (concrete pad directly on soil foundations). What it simply mean is that we remove all the surface work related to compact aggregates as well as two different kinds of soil cement layers. So if you look at the model it will have a single cask on top of a concrete pad and the cask and the pad subassembly sits on the soil foundation model.

Q. So you move all the soil cement both around the pad and underneath the pad?

DR. LUK: Yes.

Q. And why did you run that model?

DR. LUK: We try to find out quite a few different things. It is my recollection is that with the complexity that involved the two different kinds of soil cement layers we have to create extra interface that actually slow down the execution of the model tremendously. Since we have to develop a practical model eventually we hope will be useful to the industry, we try to find out is there any

way that we can do to simplify the model without a significant loss of the accuracy of the analysis results. And we feel we want to go through this exercise try to find out whether the presence of soil cement layers does provide what is called as a passive constraint to the movement of the pad.

Q. And what did you find out from the analysis using this Model 2 and comparing it to Model 1?

DR. LUK: We find out that in -- I'll refer back to the same table, Table 8. When you look at the results for Type 1 with the combination of Mu 1 equals to point 2, of 0.20 and Mu 2 equals to 0.31 versus the same combination of coefficient of friction, but for Model Type 2. When you look at the two sets of results it was simply indicated that the relative displacement of cask on pad is higher for Model Type 1 versus Model Type 2.

Q. How much higher, approximately?

DR. LUK: If you look at the maximum horizontal displacement of cask for the Type 1, it's 3.98 versus the results from Model Type 2 is 1.76 inches. And if you don't mind me substantiate a little bit. In that sense, the Model Type 1 actually experience higher relative displacement

with respect to pad.

And what that simply mean from the PFS perspective is that without the presence of the soil cement adjacent to pad, the pad may have a little bit more lateral displacement, and in that sense energy has been consumed partially due to this movement. And the net outcome is that the relative displacement of cask with respect to pad is reduced because we're talking about the same energy input through seismic excitations. The question is that how does input energy due to seismic excitation will be consumed in the process. And the clear answer is that if the pad is allowed to move more because of the absence of the passive constraint due to the presence of soil cement layer, it will have more displacements and in the process consumes a little bit higher energy. And the energy that will left to move the cask is getting smaller.

Q. And by comparing the results of Model 1 and Model 2 for that case you talked about you can see the effects of soil cement -- including soil cement at the PFS site in terms of on the cask movement?

DR. LUK: Yes. The presence of the soil

cement adjacent to the concrete pad does demonstrate this effect on the dynamic behavior of the cask on the pad.

Q. And the use of soil cement would be beneficial in the sense of keeping the pad from sliding and it would have no significant effect overall on the cask stability at the PFSF site; is that correct?

DR. LUK: If you don't mind me saying that, okay, the presence of the soil cement did not prevent the pad from sliding, but it did reduce the amount of sliding of the concrete pad.

Q. And both these cases were run for a coefficient of friction between the soil and -- going back to the table, why don't you explain what the Mu 1 and Mu 2 represent.

DR. LUK: Yes. Mu 1 is the coefficient of friction at the interface between the bottom of the cask and the top of the concrete pad. Mu 2 is the coefficient of friction at the interface between the bottom of the concrete pad and the top of the soil cement layer.

Q. And you assume a U2 in these two cases of 0.31. And what does that represent in terms of the capability of the pad to slide?

DR. LUK: Would you like to qualify the question?

Q. I'll rephrase the question. Does using a U2 of 0.31, does that incorporate any of the shear strength of the soil in being able to resist sliding?

DR. LUK: When we use Mu as the coefficient of friction at the interface it is purely a kinematic representation of the frictional resistance of one substructure on top of the other. It probably does not address the question that you just mentioned.

Q. Okay. And the use of a lower coefficient of friction would make it more likely that an object would slide?

DR. LUK: Yes. In purely theory base when you use a lower coefficient of friction at the interface, there will allowed one substructure have a higher mobility with respect to the other.

Q. Now, in your model was the pad free to move up or down or tilt in response to seismic forces?

DR. LUK: Can you repeat the question?

Q. In your model was the pad free to move up or down or tilt in response to seismic forces?

DR. LUK: Yes.

Q. And what type of tilting or movement did you see of the pad, if any?

DR. LUK: In the process of examining the analysis result we did spend some time to looking at the mobility of the concrete pad. Since we did not constrain the mobility of the concrete pad in the coupled models, there is a very small amount of translation as well as the rotational movement of the concrete pad.

Q. So the concrete pad in your model was free to move in response to the seismic forces in any which way it would move?

DR. LUK: Yes.

Q. In addition, did your model allow local deformations or account for potential flexibility of the pad?

DR. LUK: Yes. We modeled the concrete pad as an elastic body. So we do include the flexibility of the concrete pad.

Q. And what type of deformations, local deformations did you see in the concrete pad, if any, in your analysis?

DR. LUK: Within the theory of elasticity, once we use elastic body to represent a

concrete pad, the analysis results will show some deformations. But the amount of deformations, to the best of my recollection, is very small.

Q. Now, all your models include the flexibility of the pad, all three models that you ran for the PFSF site?

DR. LUK: Yes. We, for the most part, when we do, with the exception of Model Type 2 and Type 3, we use actually Type 1 model for the significant portion of the investigations. What this simply mean is that we only have one model.

Q. And, therefore, all of your models would have taken into account the effects or -- would have accounted for the effects of a flexible pad on the results that you obtained?

DR. LUK: Yes.

Q. Does your general program or model methodology account for the effects of nonvertically propagating waves, nonvertically propagating seismic waves?

DR. LUK: Yes. This actually falls back in the selection of the code that we used to develop the finite model. It is very important that we know in the theory of ABAQUS code that all of those equation of stay constituted relations to

related to wave propagations are included in the theory in the development of the ABAQUS code. So in that sense all kinds of ways that's associated with a physical phenomenon related to a seismic excitation has been incorporated.

Q. And does your general modeling program or methodology incorporate the potential frequency effects of the earthquake waves?

DR. LUK: Would you mind repeat the question?

Q. Does your model take into account any resonate frequencies that may develop as a result of the soil properties or is that included in the model itself?

DR. LUK: Yes, yes. As I said before, since the ABAQUS code does incorporate in its theory development the equation of stay, that include the dynamic motions as well as the constituted relations which deals with the material properties. And in that sense the frequency content of the input seismic motion is included.

Q. And so, therefore, the soil structure interaction effects are included in your model?

DR. LUK: Yes. This is a very technically challenging issue. We have spent a lot

of time to make sure that the effect of soil structure interaction has been incorporated in our model.

Q. And, therefore, your model would account for any effects of soil, site-specific soil layering?

DR. LUK: Would you like to repeat your question?

Q. Your model would account for the effects of site-specific soil layering, in other words, too?

DR. LUK: Yes, yes. We paid very special attention in the process of developing the soil foundation model. We want to make sure two things. One is that by going through the discretization scheme that we will have the soil foundation model developed into separate various horizontal layers to mainly capture the dynamic soil behavior based on the soil profile data that was given to us by the Staff at the NRC.

And second, we know this is a very important task, but we also try to make sure that we need to come up with a practical model. What that simply mean is that if we don't have that requirement in mind we can actually model as much

as we feel like for the soil foundations, but it is our task in trying to come up with a soil foundation model that is practical but at the same time it does reflect substantially the dynamic behavior for the site specific soil based on the soil profile data that we were given.

Q. I believe you referred to in your answer discretization scheme. I probably didn't pronounce that correctly.

DR. LUK: Yes.

Q. Would you please describe what that is, what you meant by that?

DR. LUK: Yes. What we do is that after we have an extensive review of the setup of the information that's related to the site-specific soil profile data, that we go through a systematic sensitivity evaluations by changing the combination for the different horizontal layers in the soil foundation model. And in every combination of the soil foundation model that we go through the investigation try to find out whether for this specific combinations it does represent the soil profile data that we have on hand. So in the process we accomplish that, but also we go through the optimization process to actually come up with

what we feel is the most effective model to represent dynamic behavior of the soil foundation.

Q. So the discretization process is a process of sensitivity studies by which you assure yourself that you model adequately and appropriately represents the soil structure at the site?

DR. LUK: Yes. But if you don't mind, I want to add is that not only that, it will also optimize the soil foundation model.

Q. And what do you mean by optimize?

DR. LUK: Optimize means is that what is the best combination of horizontal layers that we should use in the soil foundation model without paying too much penalty in increasing the size of the finite elements grid to represent the soil foundation model.

Q. Would you also briefly describe how soil damping is accounted for in your general methodology and program?

DR. LUK: Yes. The effect of damping in soil foundation has been a very technically related issues for many years. In our model development we are very knowledgeable to use Rayleigh damping. Rayleigh is spell R-A-Y-L-E-I-G-H, Rayleigh

damping. Rayleigh damping is a well-established theory. What it simply states is that damping can be represent in two portions. One is related to the mass and the second one is related to the stiffness of the structures.

In our model we investigate the relative technical merits of either use both terms of damping or just use a single term damping that is related to the mass of the structures. And at the end of our sensitivity evaluations we did conclude that in order not to pay huge penalty on the computational time that we choose to use a single term mass-related damping in our model.

Q. And what was the -- by introducing a single term damping model, what was not damped as much as would have been damped if you had included both terms in the model?

DR. LUK: We are very much aware of the fact that since we only use a single term mass-related damping that our three-dimensional coupled model will be underdamped. What that mean technically is that some of the high frequency response in terms of the analysis results will show up. They probably will not be damped out in the process. But if you don't mind me to add, since

they are -- since those things that will appear more related to the high frequency domain, it would not have much effect on the structural response of the system that we tried to investigate, in particular to the structural response of the cask on the pad.

Q. That would also be true for the structural response of the pad, albeit that wasn't the focus of the investigation here?

DR. LUK: Yes, sir.

Q. Would you please turn to Figure 16 on page 33 of your report? Would you please describe for me what Figure 16 depicts and the general purpose for this figure?

DR. LUK: Yes. When we started this project three years ago we know we need to go through model development that will include the coupling phenomenon, mainly trying to address the issue of soil structure interactions. So the question comes, in which way can we demonstrate it is valid to actually use the model as we developed to simulate the soil structure interaction effect. And the answer to the question is actually by going through the exercise of evaluating or examining the analysis results at the few points that we

described on this Figure 16.

Q. So these points that you describe on Figure 16 are just specific nodes or points from your analysis, that were involved in your analysis?

DR. LUK: Yes. What we did is that we draw from the raw analysis results at all the single node points that's associated with the identify the locations in Figure 16. And if you don't mind me to say one thing, is that the purpose of going through this exercise is try to find out the effect of soil structure interactions as well as the amplification of the results with respect of different depth of soil foundations. We have no intention to use this exercise as part of the examination of the structural response of the cask with respect to the pad because if analysts or engineers, when they really want to examine the structural response of any substructure, any subassembly, it is crucial for them to go through some averaging effect to reduce the danger of actually using the results of a single node. But here our choice of using the results at a single node is nothing more than to demonstrate there is difference at different locations to demonstrate the presence of the effect of soil structure

interaction.

Q. Now, if you would turn to Figures 17 through 22b in your report, these are the -- what do these figures represent, why don't you tell me?

DR. LUK: All these figures are the results at points that we make reference to on Figure 16 and is also for the case for 2,000-year return seismic event.

Q. And these are the results at a single node?

DR. LUK: Yes, sir.

MR. TURK: I'm sorry. For clarification, do you mean a single node or for the specific node show?

Q. (By Mr. Gaukler) And these are the results for the specific nodes shown in the graphs?

DR. LUK: Yes. As indicated in all this figures that the results are related to specific locations based on single node point in the model.

Q. So Figure 17, for example, you have two points there. The green represents the response at node A' and the red represents the response at node D', correct?

DR. LUK: Yes.

Q. Now, you mentioned one thing in terms of

a structural response one would average the results over several nodes, not use just the results at one node. Can you kind of show or give an explanation of this by looking at the free-field point -- strike that for now. I'll ask you a preliminary question first.

Looking at Figure 7 through 15, Figure 7 through 15 at pages 18 through 26 of your report, would you briefly describe for us, taking, say, Figure 7 as an example, what the three graphs represent in each of those pages?

DR. LUK: Yes. In the process of evaluating the structural response of the cask, in particular here when we're trying to find out whether our deconvolution process is construct correct, it does preserve the dynamic characteristics of the input seismic loading that is defined at the free surface at the free-field locations.

What we simply take is following: If you look at the model from the top, there is a huge rectangle which represents the outside boundary of the soil foundations. And inside there's a small rectangle which represents the outside geometry of the concrete pad. If you join the two corners of

this, one from the small, the other one from the big, and you draw a line and you find a mid point of that line and you go through that process for all corners, then we have four mid point locations. And we find out the analysis results at those four points and we go through the averaging process.

It is essential for people who perform finite elements analysis to go through this process mainly try to eliminate the undesirable feature as respect -- that's with respect to the single node behavior and that will actually represent or is the entering approach to find out effect on the structural response of a structure.

JUDGE FARRAR: Mr. Gaukler, let me ask for clarification. When you were just talking about the large rectangle and the small rectangle, was that with respect to a specific figure in your report or was that conceptually?

DR. LUK: Yeah. I'm sorry, yeah, I will try to find that figure.

MR. TURK: May I ask whether that might be Figure 4?

DR. LUK: Yes, it should be Figure 4 on page 15 of the report. I'm sorry. So what we did is that take, for example, the corner on the

right-hand side at the bottom. And all we did is that we joined the two corners with a straight line and find a mid point of the line and go through the process for all four corners.

MR. TURK: And just for clarity, your Honor, as I understand the witness, he's saying draw the line from the corner of the inside box to the corner of the outside box, do that four times and then you average the mid point of those four lines you draw. Is that correct?

DR. LUK: The averaging is only analysis results of all those four mid points.

Q. (By Mr. Gaukler) Now, the analysis results you're referring to particularly -- when you refer to the analysis results you're particularly referring to Figure (c) on each one of these pages or graph (c) on each one of these pages?

DR. LUK: Yes. What we have in mind is to find out the response in terms of the analysis results at the free-field locations on the free surface. That's on top of the composite of soil cement layer and soil foundation model.

Q. So if I understand correctly, I'll walk through Figure 15. Graph (a) on Figure 15 is the

original time history that you were provided for the -- this one is the 10,000-year earthquake, correct?

DR. LUK: Yes.

Q. And then graph (b) is the earthquake excitation that you arrived at through deconvolution, which was the earthquake you placed at the bottom of the soil foundation, correct?

DR. LUK: Yes.

Q. And then graph (c) is the recreated response history at the free-field surface from running the deconvoluted earthquake in your model; is that correct?

DR. LUK: If you don't mind, can I rephrase the -- I want to rephrase the technical contents on the part (b).

Q. Okay.

DR. LUK: Or part (c), sorry.

Q. Okay.

DR. LUK: Is that this is actually the averaged analysis results by going through the averaging scheme that I described in my answers a little bit earlier.

MR. GAUKLER:

Q. So this is the time history shown in (c)

is the result of this averaging scheme from the four points you've described previously?

DR. LUK: Yes. And it does represent the dynamic behavior at a free-field locations on the free surface.

MR. TURK: Incidentally, I would point out maybe for clarification and ask the witness, this is for the U3 direction for the 10,000-year earthquake, correct?

DR. LUK: Yes.

Q. (By Mr. Gaukler) And the other figures show the information for the other earthquakes that you used in terms of Figures -- going from Figures 7 through 15, correct?

DR. LUK: Yes. What we did is that we look at each specific components for the input seismic loading and go through systematic way to make sure that our analysis results does reflect our intent in executing the finite elements model.

JUDGE FARRAR: Mr. Gaukler, wait just a second. Mr. Turk, you just said it was the U3 direction for the 10,000. I thought he was talking about the average in Figure (c), which is the U4 direction, or am I confused?

MR. TURK: Your Honor, looking

specifically at Figure 15, at the bottom of the page there's a caption that says, "PFS accelerations for seismic event with 10,000-year return period in the vertical U3 direction for best estimate soil profile data." At the top of that it looks like there's a typo right above the chart for item (c), it says the U4 direction. There is no U4. That should say U3. The only directions are U1 and U2 which are the horizontal directions and U3 is the vertical.

JUDGE FARRAR: Thank you. I was trying quickly to figure out what the U4 direction was.

MR. TURK: That shows you how long it can take to verify a typographical error when a lawyer tries to describe it.

Q. (By Mr. Gaukler) Going back to Figure 17, which is the graph for two nodes, one is the free-field point A', how does the response at the free-field point A' as shown in this figure, which is the response at one point compared to the average response for the free field at the surface that you calculated in one of the Figures 7 through 15?

MR. TURK: And this is with respect to Figure 17?

Q. (By Mr. Gaukler) Yes. First of all, Figure 17 is without averaging of any points, correct, as you said?

DR. LUK: Yes. The analysis results in Figure 17 are the raw data analysis results. I think it will be important just to compare the results at point A' with the results in Figure 7 because both of them are for the 2,000-years event. As you can see in the green on page 17, which represents the analysis results at a single point A' --

MR. TURK: I'm sorry, that's Figure 17?

DR. LUK: Yes. And is showed in green color, it does give you -- give people much higher accelerations in U1 directions as compare to the similar results, but after the averaging process that's demonstrated in part (c) of Figure 7.

What it simply mean is that for analysts, for engineers who are doing the post processing in examining the analysis results, if it is related to examining the structural response it is very important that this person or this people should not use the analysis results on a single node point.

Q. And, therefore, the figures such as

Figure 17 cannot be used to show the earthquake accelerations on the casks or the pad; is that correct?

DR. LUK: Yes. It is not the intent here for Figure 17 and use that to examine the structural response of the cask, for example.

Q. Now, you also mentioned previously when we just was talking about damping, that you did not include one of the terms in the Rayleigh damping function which would have had the effect of reducing high frequency or damping of high frequencies. What effect would it have -- if you had included that term in your damping analysis, what effect would that have had on the specific points that are shown on Figure 17? For example, the point shown for D' at approximately 7 seconds at approximately -3 g?

DR. LUK: We did not use the two term damping in this particular execution of the model, but in a previous sensitivity analysis what we find is that for the case when two terms of damping effect were incorporate into the model, those higher response at single points were reduced.

What that simply mean is that for the case when we're using the two term dampings, the

high frequency domained response will be properly damped, but in this -- in the case for the same sensitivity study when we only use one term, mass-related damping, those response in high frequency domain would appear.

Q. And those high frequency domain responses are not of interest in terms of cask response or pad response, correct?

DR. LUK: Two issues here, and if you don't mind me repeat, is that if engineers or analysts are interest in evaluating the structural response, people should never use the results at a single node point. But if put the evaluational structure response aside, people just want to look at the point specific analysis result, yes. If two term dampings are included the response in high frequency domain will be properly damped and its amplitude will be reduced as compared to the case when only one term mass-related damping is used.

Q. And by increasing both terms there would be a sizable reduction in this peak that's shown at the 7 seconds?

MR. TURK: I'm sorry, by increasing or including?

Q. (By Mr. Gaukler) By including both

terms there would be a sizable reduction in the peak that is shown at 7 seconds?

MS. NAKAHARA: Can you quantify what you mean by "sizable," please?

MR. GAUKLER: I'll let the witness quantify it if he can.

DR. LUK: This will be my interpretation and my answer to your question as follows: Referring back to Figure 17, when you look at the analysis results at point A' which is represented in green color, just a little bit after the 5 seconds it does indicated there's a peak of the accelerations in U1 direction about 1.34, and we know from the seismic input as well as from the part (c) of Figure 7 the maximum accelerations in U1 directions in the realistic sense is only of the order .7. And that is -- that actually demonstrate some of the high frequency response does show up in this point specific analysis results for the case when we only used one term mass-related damping.

So in that sense, and of course it is not advisable to have any quantitative discussions based on this two numbers, but on a qualitative sense we can figure out there is sizeable amount of reduction if people try to go through an averaging

scheme as well as if they use two term dampings that all this response in high frequency domain will probably not show up. Now, this is only from a qualitative discussion perspective.

Q. Thank you, Dr. Luk. I would like to go back to a couple of other topics.

MR. TURK: Your Honor, may I inquire. It's about 10:30. Is this a good time for a break? I don't know what counsel's plans are for cross-examination.

JUDGE FARRAR: Are you nearly finished, Mr. Gaukler.

MR. GAUKLER: I would guess I have about -- less than a half hour, I know that.

JUDGE FARRAR: And, Ms. Nakahara, not trying to limit you, but just how long do you think?

MS. NAKAHARA: Currently about a couple of hours.

JUDGE FARRAR: Lanette, are you here all morning by yourself?

REPORTER: I think we have someone else back there.

JUDGE FARRAR: Oh, I didn't see you back there. Let's take a 15-minute break. Now it's 25

of. We'll be back at 10 of and can switch reporters.

(A recess was taken.)

Q. (By Mr. Gaukler) Dr. Luk, if you would please turn to page 17 of your report, Figure 6. That figure shows the finite elements for the modeling of the cask and pad and the surrounding area; is that correct?

DR. LUK: Yes.

Q. Can you describe for me how the boundary between the cask and the pad or the cask-pad interface was modeled?

DR. LUK: Yes. My response would be as follows. In the horizontal directions between the boundary of the bottom of the cask and the top of the pad, for example, the boundary is actually simulated by an interface layer. What it simply means is that at the interface of between the two substructures, in this case would be the cask and the pad, we use contact elements, c-o-n-t-a-c-t, contact elements. Contact elements is mainly trying to deal with the relative motions of one substructure on top of the other at the interface.

Q. And does the model incorporate the -- first of all, do you know what the concept "contact

stiffness" means?

DR. LUK: Yes.

Q. And would you please describe for me your understanding of contact stiffness?

DR. LUK: Anytime when you have two structures interacting with each other, in this case at the interface, there is an effect on one on top of the other. And in that sense of -- people use the contact stiffness in the sense that trying to quantify what will be the motion of one in the context of its strength with respect to the other. But in our model we do not input contact stiffness, mainly because in the theory to develop the ABAQUS code, it included equation of state and the constitutive relations which would deal with the dynamic behavior of the model that we have on hand. Actually have proper treatment of a lot of physical behavior that includes the contact stiffness.

Q. So you would put into your model the properties of the cask and the pad in the finite elements, and from that the model would itself develop the appropriate contact stiffness?

DR. LUK: It is our job as model developer, as analysts that we prescribe the behavior or what are the input characteristics

associated with the contact elements, which will directly call upon in the codes the specific details based on well-established theory for those behaviors.

Q. So that's the manner in which you include contact stiffness in your model; is that correct?

DR. LUK: Yes. To be specific, we do not input contact stiffness, but the effect of such technical term has been incorporated in the ABAQUS finite elements code.

Q. In terms of -- would your model predict the static deflection of the effect of the cask on the pad prior to the start of the earthquake?

DR. LUK: Yes. When people are performing a nonlinear dynamic analysis such as what we have in examining the dynamic response of the cask on top of pad, it is very crucial that we go through the first step that we call the deadload initiation step. What that simply would do is to provide the initiation or initial conditions for all points, for all nodes in the coupled model before we start the non-linear dynamic execution of the model. So in that sense the first step for deadload initiation will provide the base in terms

of the static load deflection of the pad.

Q. And what would be the order of magnitude of that static deflection that would be predicted by your program for this situation here?

DR. LUK: It is my recollection the amount of static vertical deflection of the pad is very small, but I don't have the specific number that is included in the report.

Q. Would it be less than three-eighths of an inch?

DR. LUK: I do not recollect that the amount of static vertical deflection of the pad is as high as three-eighths of an inch.

Q. You would expect it to be smaller?

DR. LUK: Yes, sir.

Q. Does the ABAQUS model also include the potential -- or does it include damping between the interface of the cask and the pad?

DR. LUK: Can you repeat the question?

Q. Does the ABAQUS model incorporate in the model itself appropriate damping between the cask and the pad should the cask lift off of the pad and come down and impact the pad?

DR. LUK: Yes. We did go through some exercise, flow sensitivity evaluations of a

concrete block or from a given height onto a concrete foundation. We more or less duplicated the available test data.

What I'm basically trying to describe is that if you drop a tennis ball onto a concrete foundation and you would measure the height of rebound with respect to time, we simply using a concrete block to fall from a given height to a concrete foundations and duplicated the test data. In that perspective, the presence of damping has been demonstrated through the proper use of the ABAQUS code. But we do not prescribe any specific value for the damping that's associated with the dynamic behavior of the cask as well as for the pad.

Q. So if I understand your answer correctly, your model is validated or calibrated to show that it would show the same effect as if you dropped a big piece of concrete on the pad in terms of the amount of energy dissipation due to damping?

DR. LUK: What we did is try to demonstrate in a quantitative manner the effect of the presence of damping as far as the coefficient of restitution as actually part of the theory based on which the ABAQUS code was developed.

Q. So you demonstrated that was part of the ABAQUS code as you had modeled it; is that correct?

DR. LUK: Yes, sir.

Q. Going back to the question of static deflection of the cask on the pad. Would a large amount of deflection, assuming the program were shown to have a large amount of deflection of the cask on the pad, say, order of an inch, what result would that have with respect to the running of the model?

MR. TURK: Excuse me. You're talking about vertical deflection of the cask on the pad?

MR. GAUKLER: Yeah.

MR. TURK: In other words, compressing downwards?

MR. GAUKLER: Compressing downward on the pad. Assuming you had an inch of deflection of the pad from the vertical cask resting on the pad.

MR. TURK: My only problem was, you used the word "large." I want to make sure that the witness is not saying that that's large. He's just responding to the question of if there was an inch of deflection.

Q. (By Mr. Gaukler) Yes. Assuming there was an inch of deflection. Assuming that the model

showed an inch of deflection from the bending of -- strike that. Assume the model showed an inch of deflection of the cask being placed on the pad. What effect would that have on the results of the model run, the dynamic model run you did?

DR. LUK: My answer is that they would have to put in the context of the presence of neighboring soil cement layer. If the relative amount of concrete cement layer is the same as to the different degrees of vertical deflection of the pad, it will not change the results. Because the -- what we call is the constraint as provided by the neighboring elements represented by the presence of soil cement layer will not change its effectiveness in restraining the motions of the pad.

Q. Also going back to the question of a static case, for example, when you place a cask on the pad and a dynamic situation where you run the model with the -- with an earthquake with the cask on the pad, should an appropriate model be able to predict accurately what occurs both in the static condition as well as the dynamic condition? In other words, should your model be able to appropriately predict the results with respect to

both static and dynamic conditions?

DR. LUK: Can you repeat the whole question? Because it has everything to do with the first portion of your question.

MR. GAUKLER: Assuming a model --

JUDGE FARRAR: Mr. Gaukler, do you want us just to read it back?

MR. GAUKLER: Yeah, why don't you just read it back.

(The record was read as follows:

"Also going back to the question of a static case, for example, when you place a cask on the pad and a dynamic situation where you run the model with the -- with an earthquake with the cask on the pad, should an appropriate model be able to predict accurately what occurs both in the static condition as well as the dynamic condition? In other words, should your model be able to appropriately predict the results with respect to both static and dynamic conditions?")

DR. LUK: Yes. In the context of the question, the answer is yes. But I also would like to qualify a little bit, in trying to executing the dynamic run of the model, it is crucial to go

through the initial step of the static deadload initiations. But people can actually use the same model to conduct a static analysis instead of a dynamic analysis.

Q. So your model would be able to predict both the static condition as well as the dynamic condition?

DR. LUK: Yes.

Q. With respect to the models for the PFSF, you ran the model with respect to both the 2,000 and 10,000-year earthquakes for the PFSF site, correct?

DR. LUK: Yes.

Q. In addition, you also ran the model with all of the PFSF site characteristics, the soil characteristics, including the soil cement, with the time history for the 1971 San Fernando Pacoima Dam earthquake. Is that correct?

DR. LUK: Yes.

Q. And what was the reason for including that run with the San Fernando Pacoima Dam earthquake as part of your evaluation?

DR. LUK: Yes. As a part of our sensitivity evaluation of the dynamic behavior of Private Fuel Storage cask, we feel this is going

through the interaction with the Staff at NRC that we should also conduct the seismic analysis by using an actual earthquake record. Mainly because the time history for the seismic accelerations as far as the response spectra for the two events based on the 2,000-years return period as well as the 10,000-years return period are going through some vigorous methodology, but they are, in technical terms, artificial. So we have to use some actual earthquake results to either confirm or validate the analysis results that were in turn based on using artificial seismic loading.

Q. And did the --

MR. TURK: I'm sorry. Validated by using artificial or actual seismic loads?

DR. LUK: We tried to use actual earthquake records to validate the results when artificial seismic loading is used.

Q. (By Mr. Gaukler) And how do the results of the earthquake -- excuse me. How do the results of running the model with the 1971 San Fernando Pacoima Dam earthquake record compare to use of the model with the PFSF time histories?

DR. LUK: When we examined the analysis results based on the 1971 San Fernando earthquake

Pacoima Dam record and looked at the results from this case and compare to the results from the 2,000-years return period seismic event, our observation indicates that similar results were obtained with respect to the dynamic response of the cask on top of the pad.

Q. So the results of the 1971 San Fernando Pacoima Dam earthquake run confirms the results that you obtained using the 2,000-year time history for the PFSF?

DR. LUK: To be precise is not a technical term for confirmations, but since we use an input seismic loading quite similar to that of the seismic event based on 2,000-years return period, we feel very comfortable what we get for the results for the seismic event based on 2,000-years return period, More or less appropriate for the model that we use to perform the seismic analysis.

Q. And would the time history that you use for the 1971 San Fernando Pacoima Dam earthquake incorporate or take into account potential differences -- potential phasing differences that may exist in that earthquake record from the time history used for the 2,000-year PFSF run?

DR. LUK: In a technical sense, for each of those two sets of seismic loading we went through extensive investigation to examine the appropriateness of the response spectra and the time history of the seismic accelerations to make sure that they're appropriate before we use them to exercise the three-dimensional coupled model.

Q. Would the results of your analysis of the models for the PFSF site account for synergistic effects between various factors that were included in the model, such as pad flexibility and non-vertically incoming seismic waves?

MR. TURK: Just for clarification, the question is, if synergistic effects were present would they be reflected in the outcome?

MR. GAUKLER: Yes, better question.

DR. LUK: What we did is that we used the identical three-dimensional coupled finite elements model, and we only change the input seismic loading. One is based on the 2,000-years return period, the other one is based on 1971 San Fernando earthquake Pacoima Dam record.

Q. But my question is, just focusing in on the 2,000-year earthquake for the PFSF, assuming that there were some synergistic effect say between

non-vertically propagating waves and pad flexibility, would your model account for any such effect?

DR. LUK: Yes.

MR. TURK: And just for clarification again, when you say would his model account for it, you mean would the results show up in the outcome?

MR. GAUKLER: Yes.

MR. TURK: And I assume that's the answer that the witness intended?

DR. LUK: Yes.

Q. (By Mr. Gaukler) Would you summarize briefly what the results of your -- of Model 1 show with respect to the effect or seismic response of the cask to an earthquake at the PFSF?

DR. LUK: Yes. The summary of our analysis for the site-specific evaluation of the Private Fuel Storage cask is as follows. We feel when we use a lower-bound coefficient of friction which equals 0.2 at the interface between the bottom of the cask and the top of the pad, it actually provides the governing case for the sliding response of the pad with respect -- for the sliding response of the cask with respect to the pad, sorry; that the maximum displacement of Model

1 in our -- I'll have to ask you to go to -- go to Table 8 on page 30, which is the summary table for the seismic results for a Private Fuel Storage cask in a seismic event for 2,000-year return period. There we indicated that the maximum sliding displacement of the cask with respect to the pad is 3.98 inches.

MR. TURK: May I ask for a clarification? This was for best estimate soil or lower bound soil?

DR. LUK: This is for the best estimate.

Q. (By Mr. Gaukler) And would you please similarly summarize your results with respect to your evaluation of the seismic response for the casks using a 10,000-year earthquake at the PFSF?

DR. LUK: Yes. My response would follow the summary of the results that we include in the report in Table 10 on page 32. For the case when we use the lower bound soil profile data that was given to us by the Staff at NRC, the maximum horizontal sliding displacement of cask with respect to pad is 15.94 inches.

Q. And what does your analysis show with respect to potential for tipping of the cask?

DR. LUK: As we find out, in order to

evaluate the angular rotation of the cask with respect to the vertical axis, we have to use upper bound of the coefficient of friction at the interface between the cask and the pad, and the value that we use is 0.8 as the coefficient of friction. And in that case, as the results indicated that in Tables 8, which is for the 2,000-years return period seismic event, there is actually not much angular rotations at all. They are all fairly small, but if you want to look at the highest value on this table, which is actually, by using the best estimate soil profile data is also, for mu 1 equals to 0.8, for mu 2 equals 1.0. The highest or the maximum rotational angle is 0.4 degrees. And when you use the 10,000-years return period seismic event as the input seismic loading, with the choice of using the lower bound soil profile data, we will get a maximum rotational angle of the cask in numerical results as 1.16 degrees.

Q. And that latter result is using a coefficient of 0.80 between the cask and the pad, correct?

DR. LUK: Yes, sir.

Q. And the purpose of using that

coefficient of friction would be to enhance the likelihood of tipping as opposed to sliding?

DR. LUK: Yes, sir. In our accumulated experience in this project within the past three years we find out by using an upper bound of the coefficient of friction at the interface between the bottom of the cask and the top of the pad, that we will get a higher rotational angle of the cask with respect to the vertical axis.

Q. And you consider 0.80 to be such an upper bound?

DR. LUK: We were given a coefficient of friction equals to 0.8 by the Staff at NRC.

Q. Based upon what you know, would that be an upper bound for the coefficient of friction for steel and concrete?

DR. LUK: From the perspective of a practicing engineer, I will say yes.

MR. TURK: Sorry. That was as a practicing engineer?

DR. LUK: Yes.

Q. (By Mr. Gaukler) So in summary, for either the 2,000 or 10,000 year earthquake, there is no tip-over of the cask at the PSFS site, correct?

DR. LUK: Based on our results on the rotational angle of the cask with respect to the vertical axis, since the amount of angular rotations that we find from the model are very small, it is not our job to make any conclusions, but it's important for us to provide results to the Staff at NRC. But in that context it is not likely the cask would tip over.

Q. Mr. Guttman, I have a few questions for you. Dr. Luk testified that you performed a supervisory role with respect to his analysis for the PFSF. Could you please describe your role in that regard?

MR. Guttman: As chief of the technical review section, I have several structural people below me reporting to me. And through interactions with the Office of Research with our people, we -- I requested some technical assistance to perform some confirmatory calculations for the PFS site, and the information that Dr. Luk received was provided through my people at the spent fuel project's office.

Q. And how did your review or supervision of Dr. Luk compare to your review of the PFS license application, generally?

MR. Guttman: Generally shows that the Applicant's calculations are very conservative.

Q. There was some questions with respect -- question and answer 3, you address the NRC Staff review of the Applicant's analysis. A number of questions you remember were asked of Dr. Ofoegbu and Mr. Pomerening on Friday as to how the NRC performs its review and how it makes its decisions, for example, whether additional analysis or tests are necessary. Could you please describe for the Board how that process is carried out?

MR. Guttman: Could you please repeat that question?

Q. Yeah. On Friday there were several questions that were raised with respect to Dr. Ofoegbu and Mr. Pomerening on how the NRC conducts its review process or makes its decision, for example, as to whether additional tests are necessary or additional confirmation is necessary, or whether additional tests may be necessary prior to licensing.

MR. TURK: May I ask, is the question related to testing of material properties of the soil cement, or a need for a confirmatory analysis such as was conducted by Dr. Guttman?

MR. GAUKLER: I was trying to phrase the question in general terms and just was trying to give some examples.

MR. TURK: Could we focus first on the question pertaining to Dr. Luk's -- the need for evaluation by Dr. Luk?

MR. GAUKLER: Okay.

MR. Guttman: The question is?

Q. (By Mr. Gaukler) In terms of the -- say Dr. Luk's additional analysis, how does the NRC go about making its decision as to whether it believes additional analysis is necessary as part of its review, or, for example, as was done in this case, as a confirmatory analysis?

MR. Guttman: The Staff's technical licensing decisions on the acceptability of the Applicant's submittal was not at all based on any confirmatory calculations. They were based on detailed reviews performed by the Staff and the Center in accordance with standard practices and standard review plan, commission guidance and policies, and the regulations. Reason I requested confirmatory analysis was based on my experience when I was deposed by the State on Contention H. From that deposition it was clear that the

complexities of the issues resulted in quite a few -- quite a lot of confusion, particularly when it came into description of conservative assumptions.

When the Staff -- for Staff analyses, when they look at a certain procedure and analytic techniques and an Applicant states that it applies certain conservative bounding conditions, and the Staff has adequate experience, a technical decision with reasonable assurance can be achieved without analytical confirmatory calculations. But that doesn't always answer or convey to the other party the quantification of some of these conservatisms.

So as based on my experience with Contention H, and based on the changes in the seismic design at the PFS, the acceleration and the design, I thought it would help matters, since it was contested, if we had -- if we had confirmatory calculations from -- performed by the Staff.

So I requested both the Center and through the Office of Nuclear Regulatory Research, the Sandia National Laboratory, to provide some confirmatory calculations that will be different and more realistic or state of the art to help integrate the complexities of the systems and shed

some light with regard to the performance of the cask.

Q. If I understood you correctly, you said that in general, it's general practice of the Staff not to require the Applicant to go beyond the analyses and commitments made in its submittal. Is that correct, generally? Excuse me. I understood you -- assuming that the Staff finds the analysis in the Applicant's -- analysis and commitments in the Applicant's license application satisfactory, it normally does not require the Applicant to go forward and do additional work; is that correct?

MR. TURK: I think the witness was saying that the Staff can only make its own decision based on its review of the Applicant's calculations and analyses without the Staff performing additional --

Q. Okay. In terms of, say --

MR. TURK: If you'd like to have the witness confirm.

JUDGE FARRAR: Let me hear the last third of the previous answer. Or maybe I could just read it over your shoulder.

MR. TURK: It wasn't my intention to cut off counsel's question. I thought he had misheard

the answer.

JUDGE FARRAR: Let us just ask a clarifying question. After you had this confirmatory work done, can you say again or explain whether your licensing basis was the Applicant's submissions or included the confirmatory work, or both?

MR. Guttman: I didn't understand the question. Whether -- the intent was to confirm that there is ample margin for the licensing -- the Applicant's licensing calculations are adequate and that our independent analyses confirms the safety of the system.

JUDGE FARRAR: Okay. Off the record.

(Discussion off the record.)

JUDGE FARRAR: Go ahead, Mr. Turk, clarifying question.

MS. NAKAHARA: Your Honor, let me interject. I would request that counsel would ask clarifying questions rather than characterizing what the witnesses testify, and just allow the witness to clarify it as necessary. Thank you.

MR. TURK: I guess that's to the form of the question that I asked.

JUDGE FARRAR: Yeah. Go ahead and --

MR. TURK: I'll ask him the direct form. Mr. Guttman, are you aware of the date on which the Staff issued Revision 2 to its Safety Evaluation Report?

MR. Guttman: To tell you the truth, I do not remember dates. Following 9-11, I've been so busy that it's a blur, and it's been a very stressful and very busy time for me.

MR. TURK: Is it correct that Safety Evaluation Report Revision 2 was issued with the Staff's conclusions before you received the results of Dr. Luk's confirmatory analysis?

MR. Guttman: That is correct.

MR. TURK: And also for clarification, when you refer to the events of 9-11, are you referring to the Commission's evaluation in response to the terrorist events of September 11th?

MR. Guttman: That's correct.

MR. TURK: And you're involved in that process?

MR. Guttman: Extremely so.

MR. GAUKLER: I have no further questions.

JUDGE FARRAR: All right.

MR. TURK: I'm sorry. If I said Rev. 1,

I meant to say Rev. 2.

JUDGE FARRAR: Ms. Nakahara, do you want a couple minutes before you start?

MS. NAKAHARA: Yes, please.

JUDGE FARRAR: Why don't we just take a five-minute break kind of in the room here.

(A recess was taken.)

JUDGE FARRAR: Before we resume with the State's cross, Mr. Guttman, let me ask you the Board's question in a different fashion. Given the timing of your Safety Evaluation Report, Revision 2, and the timing of the Luk study, the Staff reached a conclusion that the Applicant's presentation passed muster before you had the Luk study in hand?

MR. Guttman: That is correct.

JUDGE FARRAR: And when was your deposition on H? It was sometime in 1999 or 2000?

MR. GAUKLER: It would have been spring of 2000.

MR. TURK: I'm sorry. What was the question?

JUDGE FARRAR: When was his deposition on Contention H, which was dismissed sometime in 2000. I mean, when was it generally compared to

now. It was a couple years ago.

MR. TURK: It was spring of 2000. And for the record, that was the contention that dealt with the thermal performance of the cask under ambient conditions in the desert.

JUDGE FARRAR: And that's one the State withdrew?

MR. TURK: Yes. Not to characterize it necessarily in this regard, but after the review was performed -- I'm sorry -- after the analysis was performed by Pacific Northwest Laboratories at Mr. Guttman's request, the State withdrew the contention.

MS. NAKAHARA: For the record, your Honor, we did not get the report until after prefiled testimony was filed. So once again, the Staff provided a report.

JUDGE FARRAR: You didn't get which report?

MS. NAKAHARA: The confirmatory analysis that Mr. Turk is referring to by the contractors.

MR. GAUKLER: On Contention H she's talking about.

MS. NAKAHARA: Yes.

MR. TURK: I don't think that's correct.

I don't think we had filed testimony at that time.

MS. NAKAHARA: We had filed testimony.

MR. TURK: I don't recall.

JUDGE FARRAR: This is just for background trying to understand how the Staff does its business when they have an applicant presentation in front of them and they have confirmatory work, and what their licensing basis is as a general matter.

MR. TURK: I would also note in terms of timing, your Honor, in response to Ms. Nakahara's last comment, until the Board admitted the portions of this contention concerning cask design and stability, which was in December of 2001, the only issues dealing with seismic matters for matters A and -- parts A and B of the contention which have been withdrawn, and part E, the granting of the seismic exemption. So . . .

MS. CHANCELLOR: That's incorrect, your Honor. We had part C of the contention as well as original Utah L, and we had a disagreement with the Staff as to the scope of that part of the contention.

JUDGE FARRAR: Before we go any further, this is not a relevant or productive to the simple

question the Board had, which is how the Staff goes about its business when they're looking for confirmation.

I guess one further question on that line, Mr. Guttman, I take it the Staff's practice if you thought the Applicant's presentation was facially defective and they hadn't remediated it, you don't do confirmatory work to fill the gaps, you send them home and tell them to come back another time, don't you?

MR. Guttman: Yes, sir.

JUDGE FARRAR: All right. Go ahead, Ms. Nakahara.

JUDGE LAM: Before that, let me follow up with Judge Farrar's question to Mr. Guttman.

Mr. Guttman, what triggered your effort to commission a large-scale study of this type? Can you elaborate a little bit more?

MR. Guttman: Are you talking about the generic analysis or the site-specific analysis?

JUDGE LAM: Both.

MR. Guttman: The generic analysis was initiated several years ago by K.C. Leu, who reports to me, to try -- as one of our activities to provide guidance with regards to analysis and

response to freestanding casks. In the past all research analyses were -- in regard to seismic events were concentrating on reactors; and Dr. Leu, L-e-u, recommended that that we request the Office of Nuclear Regulatory Research to perform some state-of-the-art calculations and see how casks perform under various seismic conditions, seismic loads.

With respect to this hearing, the application of PFS, again, based on my experience with Contention H, it appeared very useful if we had some confirmatory calculations using state-of-the-art analyses to confirm the Applicant's positions.

If you're not that familiar with seismic analyses and you hear people modeling earth as springs, it sounds strange. It's an acceptable method and it's a conservative method, as Dr. Luk's calculations using more realistic computer simulations demonstrated.

And that was the intent of this confirmatory calculation, to assist in people's understanding of the cask and seismic behaviors and provide potentially some broader understanding of how one -- how the casks would behave under

different types of modeling techniques, state-of-the-art modeling techniques.

JUDGE LAM: May I ask you, Mr. Guttman, how much resources has been consumed with this particular project, generic and site specific?

MR. Guttman: I don't know the number. When we request something from the Office of Nuclear Regulatory Research, they look at the resources and their priorities. At first this was on the back burner until some resources were provided or found, depending again on the priorities of what the pressing needs are on the agency and the Office of Nuclear Regulatory Research.

JUDGE LAM: Any reasonable estimate?

MR. Guttman: Perhaps Dr. Luk has a better idea. I don't have any estimates. I don't know.

DR. LUK: Yes. If you don't mind, I can provide additional information. But first let me say something to substantiate Dr. Guttman's description on the background for our generic analysis effort for this project that was requested by the Office of Regulatory Research at the NRC. To use a dry cask storage system to store a spent

fuel rod has been in existence for quite a few years, I think dating back maybe the late 80's or early 90's. But for the significant portion of those use of the dry cask system is in eastern region of the United States where the level of seismic loading is fairly low. The current Standard Review Plan is actually adequate to go through the licensing review efforts in regions with low seismic loading.

And it was my understanding that in the past few years there is an obvious trend, the same mode of using dry storage of spent fuel rods as going west. When it go west to regions where there's relatively much higher seismic loading, there is a concern to whether the current Standard Review Plan is adequate to support the Staff at NRC in going through their licensing review process. And in that background, Dr. K.C. Leu under the direction from Mr. Guttman wrote a need letter to the Office of Regulatory Research and requesting some research work be done to examine the dynamic response of a dry storage cask.

MR. Guttman: I need to interject here. The Staff's position, and still continues to be, is that the Standard Review Plan is also adequate for

western United States where high seismic conditions occurs. However, we continue to always seek better methods and science as we proceed in our licensing programs. So that's one of the reasons that we requested the Office of Nuclear Regulatory Research to review and basically assess, have we missed anything, what's the latest state of the art, and confirm that our existing Standard Review Plans are adequate; and if they happen to not be adequate, then we will look into those and make appropriate modifications. But at this point the Standard Review Plans are applicable to the entire country.

DR. LUK: Yes. Let me also repeat as an echo to --

JUDGE FARRAR: Wait, don't repeat things. We have a long hearing here. If it's something new, you may, but --

JUDGE LAM: I think you gentlemen answered my questions. Thank you.

JUDGE FARRAR: We could explore this and may at some greater length, but rather than pre-empt any of the State's cross-examination, Ms. Nakahara, why don't you go ahead.

MS. NAKAHARA: Actually, your Honor, thank you. I'm going to follow up a little bit

with Judge Farrar and Judge Lam's questions.

JUDGE FARRAR: Go ahead.

CROSS-EXAMINATION

BY MS. NAKAHARA:

Q. Mr. Guttman, when did you first request a site-specific analysis be conducted for the PFS site?

MR. Guttman: The initial thoughts, the first time the thought came into my mind is after we had a public meeting at the Center on PFS, I can't recall the date, when the PFS came in to discuss the seismic -- their new seismic design. Again, dates at this point to me are totally fuzzy. It must have been about a year ago, I'd guess.

Q. So this would be prior to when Dr. Luk said he initiated his site-specific analysis for PFS which, my recollection was May 2001?

MR. Guttman: That's correct.

Q. Following up on Judge Lam's question, what monetary limitations did you have in requesting a site-specific analysis for PFS?

MR. Guttman: We have no monetary limitations, as far as I'm aware.

Q. Dr. Luk could obtain any scientific

resources he needed, he could -- I'll stop there.

MR. Guttman: That is correct.

Q. Dr. Luk could run as many cases as he thought was necessary?

MR. Guttman: That would be up to the project manager in the Office of Research.

Q. And who would that be?

MR. Guttman: Shauket.

DR. LUK: Dr. Khalid Shauket. Spelling is, the first name is K-h-a-l-i-d; the last name is S-h-a-u-k-e-t.

Q. And Mr. Guttman, what input would you have in determining the number of cases Dr. Luk ran?

MR. Guttman: Through my reviewers, we came up with some questions with regards to the 2,000-year earthquake, and then the 10,000-year earthquakes to try to demonstrate some margins; or if there is a cliff and we haven't -- in terms of is there something past a certain amount, certain return frequency that will cause the cask to tip over, and we haven't seen that. We asked a question of what's the influence of soil cement. And those were basically the issues. And some sensitivity studies with regards to some of the

parameters that were in question.

Q. What scheduling constraints did you impose on Dr. Luk for the site-specific analysis, if any?

MR. Guttman: There were no scheduling constraints other than we would like to have the analyses as soon as possible in support of this hearing. We requested the Office of Research, since it takes a while to perform these type of calculations, to do it as soon as possible.

Q. Did you have a target completion time frame for Dr. Luk's report?

MR. Guttman: As far as I'm aware, we did not specify any date because we were not aware of how quickly the analyses could be performed. All we asked is that it be prepared as soon as possible to support this hearing.

Q. And you had mentioned that the report would support this hearing a couple times, and that you did not need Dr. Luk's report to make a decision on the Safety Evaluation Report. Is that correct?

MR. Guttman: That is correct.

Q. So in other words, Dr. Luk's report was prepared solely for litigation?

MR. Guttman: No. It was prepared for answering -- confirming -- basically it was performed for answering highly complex information -- highly complex mathematical and scientific theories which I thought would be of interest in conveying to the state what the real performances for the cask -- well, I guess in a sense the answer is yes. It was not as a regulatory tool to confirm our regulatory decisions, but to assist the State in understanding the complexities of the analyses just as we performed with Contention H. That was a success path that I thought may be useful for this contention as well.

Q. Mr. Guttman, you requested a site-specific analysis from Dr. Luk approximately a year ago. Is that about the time frame in which PFS had revised its seismic ground motions to increase approximately 35 percent?

MR. Guttman: It was following that. As I mentioned, we had a public meeting on that.

Q. Given that PFS had recently increased their seismic ground motions, and you had not made a determination on the acceptability of PFS's reports, help me understand why you would not wait

for Dr. Luk's conclusions prior to making a decision in the Safety Evaluation Report.

MR. Guttman: As I mentioned before, we have a Standard Review Plan, and the Applicant followed the Standard Review Plan. The analyses are those who are familiar with the -- excuse me. The analytic methods used for seismic analyses are well-known to the experts, particularly the ones at the Center and my people, and they were well within the bounds of the equations that are identified in the methodologies used.

Q. So Mr. Guttman, are you familiar with the multicask response at PFS ISFSI from the 2,000-year seismic event, Revision 2 to State's Exhibit -- sorry, your Honor -- Exhibit 173. Are you familiar with that document?

MR. Guttman: No.

Q. This document, if you'll accept my characterization, is PFS's analysis conducted by Holtec International which predicts the cask response under a 2,000-year return period. This document was submitted August 20th, 2001. So is it correct that although you -- although your Staff had not received PFS's analysis on cask response, their request to Dr. Luk to do a site-specific

analysis was solely for litigation purposes?

MR. TURK: I object to the question, your Honor. First of all, counsel is implying that this report constitutes the first information the Staff had as to the seismic acceleration and performance at the PFSF facility. If that's the representation, I'd like for some substantiation of it.

JUDGE FARRAR: Mr. Gaukler?

MR. GAUKLER: I object for the same reason. Revision 0 of this document is actually dated March 29th, 2001.

JUDGE FARRAR: Objection is overruled. The witness can answer. This is a legitimate subject to test.

MR. Guttman: Could you please repeat the question?

MS. NAKAHARA: Could you re-read the question?

(The record was read as follows: "This document, if you'll accept my characterization, is PFS's analysis conducted by Holtec International which predicts the cask response under a 2,000-year return period. This document was submitted August 20th, 2001. So

is it correct that although you -- although your Staff had not received PFS's analysis on cask response, their request to Dr. Luk to do a site-specific analysis was solely for litigation purposes?")

MR. TURK: I object to the question, your Honor. I don't think it's understandable.

JUDGE FARRAR: I understand it. Does the witness understand it?

MR. Guttman: (Shaking head side to side.)

JUDGE FARRAR: It goes to the order in which you made management decisions about asking for confirmatory work or making staff decisions.

MR. Guttman: I can tell you the order. After the meeting that we had, a public meeting with the Center and PFS on their seismic analyses.

JUDGE FARRAR: Do you know when that was?

MR. Guttman: At that point I recognized the complexities of the issues and believed that it would assist the State to understand, to understand the true behavior of the system under postulated accidents. This was solely based on my experience of Contention H, and I was hoping that this would

be an acceptable resolution to assist the State in understanding the performance.

JUDGE FARRAR: But it wouldn't assist just the state, it would assist you all?

MR. Guttman: We expected it to be confirmatory, and that we were fairly -- we were very confident that the Applicant's analyses had followed the Standard Review Plan and thorough review of their inputs to ensure conservatisms would bound any kind of -- I'm sorry -- result in conservative results.

JUDGE FARRAR: Go ahead, Ms. Nakahara.

MS. NAKAHARA: Thank you.

Q. (By Ms. Nakahara) Mr. Guttman, based on your recollection of when this initiating public meeting took place where you first see the idea to ask for a confirmatory analysis, given Mr. Turk's statement or his concern that the Revision 0 of this Holtec analysis is March 29th, 2001, would your staff have had adequate time to evaluate a report dated March 29th, 2001 prior to your meeting with PFS at this public meeting that you're referring to? I'm sorry; it's a confusing question, because we don't have a time frame for your public meeting. Let me take this -- try and

take this in a shorter step.

You refer to a public meeting approximately a year ago from now in which you first conceived the idea to ask for a site-specific analysis for the PFS site, correct?

MR. Guttman: Correct.

Q. During this public meeting approximately a year ago, would your staff have completed their analysis of the PFS cask stability analysis dated March 29th, 2001 by the time you had this meeting?

MR. Guttman: When we had that meeting, the Staff had not completed its assessment of the new design.

Q. Okay, thank you. And is it fair to characterize the purpose of the site-specific analysis requested by Dr. Luk as to confirm PFS's analysis to the State? Is that what I heard you say?

MR. Guttman: A confirmatory analysis confirms that the Applicant's analyses are acceptable. That was not the intent, my intent for requesting this calculation, even though it is confirmatory. If the analyses showed something totally different, then as a confirmatory analysis we would reassess our position. But, as I stated

before, based on my experience on Contention H, I thought this would be helpful to all parties, particularly the State, to perform an independent calculation.

Q. If Dr. Luk's analysis had shown something different, it would have come after Staff made their decision in the final SER; is that correct?

MR. Guttman: That's correct.

Q. Thank you. Dr. Luk, Mr. Gaukler asked you some questions this morning about other cask stability analyses --

JUDGE FARRAR: Ms. Nakahara, is this a new subject?

MS. NAKAHARA: Yes.

JUDGE FARRAR: Let me interrupt you, if I could.

Mr. Guttman, you gave a couple of answers ten and twenty minutes ago that I'm trying to reconcile if I heard them correctly. One was whether you commissioned this extra work depended on priorities in another division of the NRC and how it meshed in with all the other work the Commission has to do; then later I thought I heard you say that there were no monetary or resource

restrictions on the work, and they're sounding inconsistent. Can you help us with that?

MR. Guttman: When I refer to the initial user need letter to research that on a generic analysis, that is when the Office of Research looks at its priorities. That was way before the PFS analysis was requested. So at that time research looks at all of its priorities and determines when to perform these type of calculations. This was ongoing, and we took advantage of that and requested them to perform the site-specific calculation.

JUDGE FARRAR: But does the site-specific calculation then also run into resource allocation management budget issues?

MR. Guttman: Yes, it does. And because of this, research requested to expand its final due date on the generic analysis by approximately a year.

JUDGE FARRAR: Is what you just said, you said the generic analysis or the site specific?

MR. Guttman: The generic analysis.

JUDGE FARRAR: But the site specific was driven by -- would have been influenced to some extent by both resource availability and the need

to meet the proposed hearing schedule for this proceeding?

MR. Guttman: I'm sorry?

JUDGE FARRAR: Yeah, re-read that.

(The record was read as follows: "But the site specific was driven by -- would have been influenced to some extent by both resource availability and the need to meet the proposed hearing schedule for this proceeding?")

MR. Guttman: The resources were there for the generic analysis, and they applied those resources on the site-specific calculations. As a consequence, we had to extend the time period for the generic calculations. So the resources were there.

JUDGE FARRAR: Okay, thank you.

Q. (By Ms. Nakahara) Dr. Luk, are you aware of the amount of the contract for the site-specific analysis for PFS with your company?

MR. TURK: Could I hear the question again?

Q. Dr. Luk, are you aware of the amount of the contract for the site-specific analysis for the PFS site with your company?

MR. TURK: Just for clarification:

Dr. Luk works for the Sandia National Laboratory, not for a private company. I have no objection about the question of about how much the contract is for.

JUDGE FARRAR: Right. With that understanding, Dr. Luk.

DR. LUK: Yes. All of our funding is directly from the Office of the Nuclear Regulatory Research. We do not have to break down to partition the level of support for any site-specific analysis for the following reasons. When we do the generic analysis, we feel that we need a starting point. The starting point means if there's a way that we can start the seismic analysis of the structural behavior of the cask by following a site-specific event, we'll make a focus. Because otherwise we'll have to select a set of soil profile data, for example.

JUDGE FARRAR: Let me short circuit this. Then I take it you can't break down the generic from the site specific, but do you have a total figure for both?

DR. LUK: Yes. I'll have to ask Mr. Guttman, is that appropriate to release the information on the funding from the NRC? Because

they are the sponsor.

MR. TURK: May we go off the record for a moment, your Honor?

JUDGE FARRAR: Yes.

(Discussion off the record.)

JUDGE FARRAR: Back on the record after some off-the-record discussions about what we're looking for here.

MR. TURK: Let me introduce this first by saying, your Honor, I don't know if this is the kind of information that is normally made public or not. I don't know if this is included in budgets presented to Congress or not. But for the sake of moving this proceeding along, I would not object to the question. I can't give you an answer whether this is publicly available or not publicly available information.

JUDGE FARRAR: Well, even in the -- we appreciate your not interposing an objection. We certainly don't want to put on the public record something that's not on the public record, but my -- or the Board's expectation is that the Commission's budget --

MR. TURK: It should be scrutable.

JUDGE FARRAR: -- is largely available

for public scrutiny.

MR. TURK: It's in that sense that I lean towards saying let the answer come on the record.

JUDGE FARRAR: Unless there's some national security interest where people wouldn't want to know details of the Commission's budget or Sandia's budget, but I'm not aware of anything like that.

MR. TURK: Nor am I, your Honor.

JUDGE FARRAR: Maybe I wouldn't be aware.

MR. TURK: It doesn't sound like a national security interest issue, so I wouldn't have a problem with that disclosure. If we're talking about national security, I'd feel different.

JUDGE FARRAR: All right. Can either of you, against that background and the lack of an objection, can you give us a ballpark number?

DR. LUK: Yes, sir. To the best of my recollection, starting from March of 1999, and we either have spent or will project to spend, up to November of 2002, the rough budget in the paperwork is about a million dollars. That includes every

part of effort, including the generic as well as three site-specific analyses.

Q. (By Ms. Nakahara) Dr. Luk, can you give a rough estimate of the percentage that you have spent on the PFS site-specific analysis?

DR. LUK: We first were tasked to look into.

JUDGE FARRAR: Wait, wait. That's a simple question. Can you give a rough estimate?

MR. TURK: And your Honor, I think before we get that answer we have to establish the background for this site-specific project, because I don't think the questioner may be aware of how the modeling has progressed starting from its initiation through the three different site-specific projects. Maybe as a preliminary matter, can we ask the witness to identify what are other site-specific projects and then how the modeling progressed?

JUDGE FARRAR: Okay. But what we need to start doing is getting shorter answers, and then if we want an explanation, we'll ask for it. So this is a fairly simple question that Mr. Turk is right, it will be useful to mention other site specific.

DR. LUK: So what's your question do you want me to answer?

JUDGE FARRAR: The question is, Ms. Nakahara's question is what percentage of that million dollars went into the site-specific analysis as opposed to the -- site-specific analysis for PFS as opposed to the generic analysis; and recognizing, I think she'd be willing to recognize there may be some overlap, it may not be easy to draw a hard-and-fast line; and, as Mr. Turk suggests, there may be other site-specific analyses, but to which if the people with authority over your budget were looking at this, they might ask some very detailed questions. This is not a very -- this is not looking for the detailed answer that congressional budget people or internal budget people would be looking for, but just a fairly simple --

DR. LUK: Yes, your Honor. In this perspective, my estimate is that the specific effort related to the seismic analysis of the Private Fuel Storage cask is under $200,000.

Q. (By Ms. Nakahara) Dr. Luk, if you know, does your contract with NRC --

MR. TURK: Your Honor, may I get a

clarifying question?

JUDGE FARRAR: Sure.

MR. TURK: Dr. Luk, would that include monies that are proportional with respect to any modeling that had existed previously which may have been incorporated into this modeling, or is that just the additional money spent on the PFS site-specific question after all the preliminary work before it had been done?

DR. LUK: Yes. Let me try to be precise that the dollar figure that I just mentioned is solely on the analysis effort. I don't know how much it actually cost the budget for me to be present and participate in the public hearing. That is not part of the budget.

MR. TURK: I'll follow up later, your Honor.

Q. (By Ms. Nakahara) Dr. Luk, if you know, is the contract between Sandia and NRC for your analyses for freestanding casks, is it a cost plus contract? Do you understand the term? Or let me ask it a different way. Dr. Luk, if you know, is the contract with Sandia and NRC for the -- for your analysis of freestanding cask, are you paid by tasks plus you get some type of fee on top of that,

or is there some limitation to the amount of a contract in which you need to complete your tasks?

DR. LUK: Our budget for the NRC contracts are based upon the mutual established of the task. And then the budget -- well, the NRC will be built according to the level of effort.

Q. And do you base your level of effort on the tasks that you have in front of you, or based a monetary level, or both?

DR. LUK: It's on both.

JUDGE FARRAR: Is there a maximum on that monetary level? You know, here's the work we have planned, do it and charge us but don't go over $250,000?

DR. LUK: If you took a snapshot anytime, yes, there is a maximum. But that's based on the current knowledge, the content of the task.

Q. (By Ms. Nakahara) Dr. Luk, Mr. Guttman just testified that there was no --

MR. TURK: Your Honor, can I just get one more clarifying on that? When the witness says it's based on the current knowledge of the scope of the task, could that expand, if you find that you needed to do additional work with the maximum dollar limit, then be increased?

DR. LUK: Yes. As it happened quite a few different times within this project, the scope of the work changed. And from the change of the scope of the work, there is corresponding adjustment on the budget.

MS. NAKAHARA: Is Mr. Turk finished?

Q. (By Ms. Nakahara) Dr. Luk, Mr. Guttman testified --

JUDGE FARRAR: Let me interject there. We try to when we have a level of interest in a particular subject make sure we get all the information on the table at the same time. Thus far I've found Mr. Turk's questions to be clarifying. If we sense that he's trying to interfere with any questions you're asking, we'll be sure to see that that doesn't happen.

MR. TURK: Thank you.

MS. NAKAHARA: Thank you, your Honor.

Q. (By Ms. Nakahara) I'll try this one more time. Dr. Luk, Mr. Guttman testified that there was essentially no scheduling constraints to your finalizing your site-specific analysis for the PFS facility. Did you have an internal time frame in which you sought to finalize your analyses?

DR. LUK: Yes.

Q. And what time frame was that?

DR. LUK: That -- my answer is time dependent. When we first started this task, we were only given one set of seismic input. And with that information given by the Staff at NRC, we'd go ahead and estimate the completion date. But then as the project progresses, we find out there's additional information requested by the Staff, and then we again look at the schedule and readjust it.

Q. With the initial one set of seismic input, was that for a 2,000-year return interval earthquake?

DR. LUK: Yes.

Q. And what was the initial completion date target?

DR. LUK: That completion date was the end of October 2001.

Q. Then with the addition of the other seismic inputs, is it correct that the additional seismic input is for the 10,000-year return interval earthquake at the PFS site and the Pocoima Dam ground motions?

DR. LUK: A minor correction. The sequence of the seismic input to our model is the 1971 San Fernando earthquake Pacoima Dam record,

and then followed by the 10,000-years return seismic.

Q. If you recall, when did the Staff request that you also consider a 10,000-year return earthquake -- or return interval earthquake at the PFS site?

DR. LUK: The formal request to perform the seismic analysis based on the 10,000-years return seismic event is sometime in January 2002.

Q. Given the difference, approximately six to seven months difference between the requests from the Staff to consider a 2,000-year return earthquake and a 1,0000-year return earthquake, did you have preliminary results for the 2,000 -- for the 2,000-year return earthquake prior to January 2002?

DR. LUK: Yes.

Q. When did you have your preliminary results?

DR. LUK: We have the results for the seismic analysis based on a 2,000-years return seismic at the end of October 2001.

MS. NAKAHARA: Thank you.

JUDGE FARRAR: Ms. Nakahara, let us know when there's a convenient break point.

MS. NAKAHARA: This is actually it.

JUDGE FARRAR: Okay. It's just about 12:30. We'll see everyone back at 1:30.

(A recess was taken.)

JUDGE FARRAR: All right. Let's start the afternoon session. We had the State ready to continue its cross-examination.

MS. NAKAHARA: Thank you, Your Honor.

CROSS EXAMINATION (Resumed)

BY MS. NAKAHARA:

Q. Dr. Luk, I have one follow-up question to the morning session. You indicated that you had preliminary results on the 2,000-year return interval earthquake for the PFS facility approximately October 2001; correct?

DR. LUK: Yes, the end of October 2001.

Q. Did those results change from your final report, those that are in your final report dated March 31st, 2002, for the 2,000-year return earthquake interval?

DR. LUK: No, it did not change.

MS. NAKAHARA: Your Honor, at the risk of sounding repetitious or irritating the Board, the State would like to renew its objection to the

admission of Staff Exhibit P, and Dr. Luk's testimony. Mr. Guttman testified that this document was not a document that was generated in the course of a license determination or determination to support the Safety Evaluation Report, that it was for litigation purposes only. The Staff had preliminary results that had not changed at the end of October, and yet the first we have seen the results was approximately March 10th with the first version of Dr. Luk's report, and subsequently, a day after prefile testimony was issued when we received the March 31st, 2002 report.

JUDGE FARRAR: At this point, your concern does not go to the difference between March 8th and March 31st, it deals with larger concepts?

MS. NAKAHARA: Yes, Your Honor.

JUDGE FARRAR: Let me just ask that one clarification. Is there any essential difference between the March 8th and the March 31st versions?

MR. TURK: With respect to the 2,000-year earthquake?

JUDGE FARRAR: With respect to anything. In other words, at some point, we saw Dr. Luk's report dated March 8th and then we saw one dated

March 31st, and it may not matter a whole lot, but I just wanted to find out before we hear argument on this whether there's any difference between March 8th and March 31st?

DR. LUK: Can I ask for permission to look at the March 8 report?

JUDGE FARRAR: Sure.

MR. TURK: And I think I'll need to ask some clarifying questions from Mr. Guttman before we present legal argument.

JUDGE FARRAR: That's fair. Go ahead, Dr. Luk.

DR. LUK: Yes, Your Honor. There is a difference in the two reports. One is dated March 8, the other one is dated March 31st. In essence, if you want to return to Tables 9 and 10 of the March 31st report and compare to the same table in the report data on March 8. Two additional analysis --

JUDGE FARRAR: Wait, which page are you on?

DR. LUK: Okay. For the report dated March 31st, is Pages 31 and 32.

JUDGE FARRAR: Okay.

DR. LUK: Then for the report dated

March 8, it's on Page 31.

JUDGE FARRAR: You're saying those two tables are slightly different?

DR. LUK: Yes. The report dated March 31st actually have two additional analysis performed. One for each of the two tables involved.

JUDGE FARRAR: But other than the additional analyses, no previous analyses changed or reached different results?

DR. LUK: Yes, sir.

JUDGE FARRAR: Okay. Mr. Turk, you wanted to ask some questions before we get into legal argument on the State's motion?

MR. TURK: Yes, and, Your Honor, as I begin to ask these questions, it's with the understanding that the State somehow feels that we should have disclosed the 2,000-year case to them sooner than we did. Is that the gist of the motion?

JUDGE FARRAR: I thought there were two parts to it. One, that some of this work was underway earlier and should have been disclosed earlier, but that second and a more far reaching objection, this is not part of the Staff's -- part

of the material on which the Staff arrived at its basic licensing conclusion. And therefore, it's in that sense surplusage which shouldn't be considered. Did I state that correctly, Ms. Nakahara?

MS. NAKAHARA: Yes.

MR. TURK: That's an interesting second issue. The questions I'll ask -- I guess I can explore both of those for a few moments, Your Honor.

JUDGE FARRAR: Yeah, and get whatever you need from the witness that would be factual background for that, and then we'll hear legal arguments.

MR. TURK: Mr. Guttman, I'd like to ask you some questions about the history, if you recall, with respect to your request that Sandia perform this independent analysis.

First of all, when you asked that this effort be conducted with respect to the PFS site specific conditions, was that based on any request by counsel?

MR. Guttman: No.

MR. TURK: Were you aware at that time whether or not there was a contention in the case

that dealt with the issue of cask stability at the PFS site?

MR. Guttman: No.

MR. TURK: So your request was independent of any knowledge of your part as to whether or not there was an issue in the case on this issue?

MR. Guttman: That is correct.

MR. TURK: Did you ask that this analysis be conducted for litigation purposes or for litigation purposes only?

MR. Guttman: No.

MR. TURK: So if your testimony previously had made that sort of a statement, that would be incorrect.

MR. Guttman: It's incorrect.

JUDGE FARRAR: Did you misunderstand the previous question or -- in other words, Ms. Nakahara is sitting there thinking that she got you to concede it was for litigation. Now, your counsel has gotten you to state that it wasn't. Can you reconcile the --

MR. Guttman: As a manager, it's my duty to try to anticipate certain activities, so as to provide timely responses. In addition, there

really are other uses or needs for these type of calculations, and that's to provide input into the generic analysis that's being performed by research.

JUDGE FARRAR: Then would it be fair to reconcile the two answers by saying yeah, you knew it would be used in litigation, but that wasn't precisely why you did it?

MR. TURK: Well, Your Honor, I don't hear him saying that yeah, he knew it would be used in litigation. If you would have asked him that question first, I would have objected.

JUDGE FARRAR: Well, I thought he triggered -- that at one point, a lot of this was triggered by an old state contention which he was aware was part of litigation. But feel free to put all this in your own words rather than ours.

MR. Guttman: I anticipated that given the complexities of these issues, that this would probably be raised in litigation. At that time, I don't believe it was.

JUDGE FARRAR: Ms. Nakahara, would you like to --

MR. TURK: Oh, I have more, Your Honor.

JUDGE FARRAR: Okay.

MR. TURK: When the preliminary results were obtained in October of 2001, do you recall whether you discussed that with counsel or not?

MR. Guttman: It was not discussed with counsel.

MR. TURK: Dr. Luk, do you recall having conversations with counsel, meaning myself or anyone else at the office of general counsel NRC, in the October 2001 time frame?

DR. LUK: No.

MR. TURK: You did not have those kinds of conversations?

DR. LUK: Correct.

MR. TURK: Do you recall when you first began having any communications with myself or other members of OGC with respect to your report?

DR. LUK: I think my first interactions with you, Mr. Turk, is sometime late January 2002.

MR. TURK: Mr. Guttman, if the results of Dr. Luk's analysis for the 2,000-year case had shown that the casks would tip over or would slide excessively under 2,000-year return period ground motions, would you have communicated that information to the NRC Staff licensing group in the spent fuel project office?

MR. Guttman: Yes, I would have.

MR. TURK: And would you expect that the SER Revision 2 would have been issued in December 2001 if Dr. Luk's report had shown -- if Dr. Luk's preliminary reports had shown cask tipover or excessive sliding for the 2,000-year return ground motion?

MR. Guttman: It would not have.

MR. TURK: You would have communicated concern to the licensing group?

MR. Guttman: Yes, I would.

MR. TURK: And would you expect that that concern would be resolved before the Staff's SER Revision 2 would have issued?

MR. Guttman: No question about it, yes.

MR. TURK: Also just so the record is clear at this one point, Mr. Guttman, did you or anyone else from the NRC Staff request that any particular outcome be obtained through Dr. Luk's analysis?

MR. Guttman: No.

MR. TURK: Was he totally free, in your mind, to reach whatever result the model predicted?

MR. Guttman: Yes.

MR. TURK: And that's whether it would

have predicted cask tipover or no cask tipover?

MR. Guttman: Yes.

MR. TURK: And that's true with respect to the 2,000-year earthquake motion as well as the Pacoima Dam record as well as the 10,000-year earthquake?

MR. Guttman: Yes.

MR. TURK: Mr. Guttman, for clarification, also you mention that you've been involved extensively in the Commission's response to the September 11th terrorist attack; correct?

MR. Guttman: Correct.

MR. TURK: Has that consumed a lot of your time and energy in the past six months?

MR. Guttman: I got burned out. It consumed a lot of my energy and time.

MR. TURK: As you sit here today, is your recollection of the precise timing of your -- when you requested Dr. Luk's assistance, can you be sure there's an absolutely perfect recollection?

MR. Guttman: No.

MR. TURK: But to the best of your ability, as you sit here today, that's your recollection?

MR. Guttman: That's correct.

MR. TURK: Also a few more questions of Dr. Luk.

Dr. Luk, there were other sites involved, other site specific cases involved in your study; is that correct?

DR. LUK: Yes.

MR. TURK: One of them was for the Hatch plant?

DR. LUK: Yes.

MR. TURK: And another one for San Onofre?

DR. LUK: Yes.

MR. TURK: And those two were completed before you did your work on the PFS -- I'm sorry, you issued reports with respect to each of those site specific cases?

DR. LUK: Yes, I issued progress status reports for each of those two site specific analysis.

MR. TURK: And do you recall the date of the issuance of your report with respect to the Hatch site specific case?

DR. LUK: For the Hatch analysis report, it was issued June 28, 2001.

MR. TURK: And with respect to San

Onofre, when was that report issued?

DR. LUK: The analysis report for San Onofre site is issued December 21st, 2001.

MR. TURK: And did there come a time in either -- after December of 2001, in which the Staff requested that you issue a single report which addressed both the 10,000-year and the 2,000-year earthquake?

DR. LUK: Could you repeat the question.

MR. TURK: Did the Staff ask that you issue a single report for the PFS case that dealt with both the 2,000-year earthquake and the 10,000-year earthquake?

DR. LUK: This request was made, I think at the time of late January 2002.

MR. TURK: And do you recall if there was any reason expressed at that time for the issuance of the single report that included both of those return period events? Do you recall, for instance, if it was related to the litigation in the PFS proceeding?

DR. LUK: I was informed that it would probably be better for documentation purpose to reduce confusions, and is not explicitly related to any litigation.

MR. TURK: I think those are the questions I need to ask at this time, Your Honor.

JUDGE FARRAR: Ms. Nakahara, did you have any questions you'd want to ask along those same lines before we hear legal argument?

MS. NAKAHARA: Yes, thank you, Your Honor.

Q. (By Ms. Nakahara) Mr. Guttman, clarify, if you will, it's my recollection this morning that you testified that you conceived the idea to ask Dr. Luk to prepare a site specific analysis for the PFS facility to help the State -- and I can't recall your exact words, but it was with respect to assisting the State in understanding the issues, is that not correct?

MR. Guttman: That's correct.

Q. With what respect were you inferring that you wanted to assist the State if it wasn't with respect to a specific contention?

MR. Guttman: This was again anticipatory on my part. I, after having -- attending the meeting, the public meeting with PFS and the center, I recognized the complexities of the issues and I saw a tremendous amount of similarities between that and Contention H.

Q. And you anticipated that the state would, in fact, file Contention Utah QQ?

MR. Guttman: No. What I anticipated is that there is a potential that issues could be raised and that we had some calculations that are realistic, the best estimate state-of-the-art, we may even be able to prevent these contentions from going to hearings as occurred with the Contention H potentially.

Q. And NRC has an adequate budget to allow site specific analyses in anticipation of concerns that may be raised by an intervenor?

MR. Guttman: That was not the only factor that went into the decision of doing the PFS site specific analysis.

Q. Were you aware of the State's contention, Utah Contention L which dealt with seismic and geotechnical issues?

MR. Guttman: I'm not familiar with those.

Q. Were you aware of the State's Contention L Part B which dealt with the seismic exemption request from PFS to allow a 2000-year return period?

MR. Guttman: I'm aware that PFS

requested the exemption, but I've not been involved with that exemption.

Q. And you were unaware of the State's contention with respect to that seismic exemption request; is that correct?

MR. Guttman: I'm aware that the State is contesting the exemption request, but that's as far as my knowledge of it.

Q. And when did you first become aware that the State was contesting the seismic exemption request?

MR. Guttman: That, I don't even recall.

Q. Would it have been before this public meeting you held approximately a year ago?

MR. Guttman: No?

Q. And when did you become aware of the State's Contention QQ, if at all, which deals with the ability of PFS's design to withstand seismic ground motions and geotechnical conditions at the site?

MR. Guttman: I don't recall.

Q. When were you first named as a witness in this proceeding?

MR. Guttman: I don't recall.

Q. And with what respect were you requested

to testify in this proceeding? On what issues?

MR. Guttman: Basically to introduce the results from Sandia.

Q. But you don't recall when you were named as a witness?

MR. Guttman: Not the date, no.

Q. Approximately?

MR. TURK: It would be a matter of record, I'm sure in the discovery response in which he's named.

MS. NAKAHARA: Well, that would have been when you named him as a witness.

JUDGE FARRAR: Mr. Turk, this is a fair question. If he remembers the answer. If he doesn't, you can supply him the information.

MR. Guttman: I really don't remember. I'm telling you the truth. I really don't remember. I just don't, the time line is gone.

Q. (By Ms. Nakahara) And Dr. Luk, you remind me when the Staff requested that you evaluate a 10,000-year return period at the PFS site?

DR. LUK: To my best recollection, it's sometime January 2002.

Q. If you know, why were your results for

the 2000-year return period that were effectively final the end of October 2001, why was that report not final pending the request you include the 10,000-year return period in January 2002?

DR. LUK: The reason for that is that according to our deliverable milestone chart, we have to give a status report to the Staff at NRC according to that deliverable schedule. But that does not mean that the work is finished. A very typical example is that we first start the site specific analysis for San Onofre and they keep on asking for newer things in our -- the latest submittal -- the latest status report related to San Onofre was issued December 21st, 2001, but we actually started this at the end of 1999. So since this is within the project is an ongoing effort.

Q. Will you clarify what a status report is?

DR. LUK: Status report is to provide our analysis, methodology and analysis results in a comprehensive manner in a report format and submit it to the Staff at NRC.

Q. Not knowing that the Staff would request you to include a 10,000-year return period analysis for the PFS site in January 2002, when did you

anticipate the final, the 2000 -- the 2,000-year return interval earthquake analysis for the PFS site given that you've had results at the end of October 2001?

DR. LUK: Would you mind repeating the question.

Q. Given that you had results for a 2,000-year return period earthquake at the PFS site at the end of October 2001, when were you scheduled to final that report? I'll just stop there.

DR. LUK: We filed a status report on our findings on the Private Fuel Storage cask based on the 2,000-year return seismic event. We finished the analysis by the end of October, and we filed our status report on that.

Q. So when you're saying a status report -- did I understand you correctly when you were referring to the completion date for a status report for San Onofre with December 21st, 2001; is that correct?

DR. LUK: Can you repeat the question.

Q. Did I correctly understand you in response to a question from Mr. Turk that the status report date for San Onofre was December 21st, 2001?

DR. LUK: The last version of the San Onofre status report was issued on December 21st, 2001?

Q. Now, is that a status report? Do you consider that a status report?

DR. LUK: Yes.

Q. So essentially what you gave to NRC is a document similar to the March 31st, 2002 document which included three ground motion return cases; is that correct?

DR. LUK: My recollection is that we finished all the execution of the model before that, and we accumulate the results and examine the results and report what we find.

MS. NAKAHARA: I have no more questions, Your Honor.

JUDGE FARRAR: Mr. Gaukler, did you want to ask any clarifying questions?

MR. GAUKLER: No.

JUDGE FARRAR: All right. We have Ms. Nakahara's motion in front of us. Let me try to frame it with what's on the Board's mind, and if any of these concepts that I throw out on behalf of the Board are things you disagree with, feel free to do so in your arguments. There's I think a line

of Licensing Board or Appeal Board or Commission cases where intervenors attacked the job the Staff did in reviewing something on safety matters, and the Applicants argued successfully what's at issue is not what the Staff did. The Staff could have done a terrible job. It's whether the Applicant's filings justify giving them the license. I think there's a line of cases that say what's at issue here, in other words, is the Applicant's presentation not the Staff's work.

In this case, I think the witness has answered our question that if the Applicant's presentation had fallen short, the Staff practices -- sometimes you ask for additional information, but if they lose, they lose and you don't spend Commission or Government money bolstering their case.

On the other hand, here you have some Staff work that was done that's confirmatory that would seem to be probative of the issue in front of us. In other words, is the Applicant's presentation sufficient, and this is, in effect, the Staff saying, well, we looked at that and we think that's okay and then we did this other work and that confirms it. So it's probative in that

sense.

On the other hand, Ms. Nakahara points out that the Staff, without this document, had reached a licensing decision that the Applicant past muster. So given that, Mr. Turk, we'd like to hear -- here's where the relevance and materiality and probative value all kind of blend together. So feel free to challenge anything I just said as being an incorrect appreciation of Commission juris prudence or to argue -- well, and to argue against her motion.

MR. TURK: Thank you.

Your Honor, I'd like to address your last point first and then I'd like to come back to the question of timing and perhaps an implied accusation of unfair litigation procedure.

First of all, it's very clear from the witness's testimony that the basis for our review of this application was the Standard Review Plan consistent with standard NRC Staff practice. An application comes in, they reference the appropriate standards and codes, we review it. You had the testimony as a separate panel, I think structurally that's the proper way to do this. We presented the testimony of our witnesses on Friday,

who indicated that based on their review of the application, the Applicant had demonstrated that it had met regulatory guidance, and on the basis of their review, the SER was issued and the SER concludes, as does their testimony, that the facility may be licensed without undue harm -- undue risk to public health and safety.

So that is the basis for the Staff's licensing decision which we reached in our December 2001 SER supplement or revision. Now, is that all we did? Obviously, no. As the witnesses have indicated, there was a generic study underway, which we think is highly probative to the issue of how do casks behave? How do these freestanding HI-STORM 100 casks behave in seismic acceleration, such as the 2,000-year earthquake and more, the way beyond design basis for the 10,000-year return earthquake. And incidentally, you will hear testimony during Part E of the contention, that nuclear power plants typically use something equivalent to a 10,000-year earthquake return period in their deterministic analyses.

This confirmatory or maybe for -- to choose a better word, this independent analysis by Sandia, which didn't seek to confirm the

Applicant's result, but rather to confirm how do the casks behave in seismic events, is highly probative to the issue of, is the public health and safety protected upon issuance of a license to this facility. I don't think you could exclude the evidence without doing harm to have to ensuring that there is an adequate record with respect to how safe is this facility going to be.

Some questions have been raised by the State with respect to particular nuances or second orders of magnitude or other issues within the Applicant's analysis, and most of the testimony that you'll hear deals with whether the Applicant's analysis and the Staff's review of that analysis, which is represented in our SER, reaches the correct conclusion. That's one issue. But this analysis by Sandia presents independent confirmation that the casks will behave in a seismic event in a manner that does not present undue risk to the public health and safety. That's an important piece of evidence.

Dr. Luk has indicated that approximately $200,000 went into the site specific analysis for the PFS case. That's a significant amount of money. I think it's useful.

We have not had questioning yet with respect to the -- I'm sorry, we have not had a complete record yet as to the nature of the generic study, and I would bring that out later during redirect. And that has to do with what uses could be put to site specific information that's contained in the direct analysis report. We'll get to that. That would have to do with the generic uses of this information. But in this proceeding, I think the information presented by Dr. Luk is highly probative, and in that regard should be accepted.

Now, the second issue that I'd like to address, unless you have questions on that, I would proceed to the second issue which is the timing and litigative approach taken by the Staff.

JUDGE FARRAR: Go ahead.

MR. TURK: Your Honors, as you've heard during my brief questioning of the witnesses, the decision to go ahead with the site specific analysis with regard to the PFS case was not based upon any knowledge of a contention proceeding, it was not based upon discussions with counsel. It was undertaken by a member of NRC management because, as he stated, he wanted to obtain a

confirmation or an independent assessment of the cask's stability. There's nothing unfair about the Staff doing its business that way. I think the public health and safety is well served when the Staff decides independently to conduct an analysis. And Your Honors may not have been present during various depositions, but there was a comment made by the State at one time that the Staff never does independent analysis. Well, here's an example where the Staff did, and I think it's a valuable contribution.

When should we have presented the results of that analysis? The proper time is once there is a contention admitted. Until a contention is admitted there is no obligation on the Staff to produce preliminary results or to share them with any party. Those are simply matters that are within the Staff's purview for their own information.

In December 2001, the Board admitted Contention QQ and indicated that it should be consolidated with Contention L. It was at that time that we suddenly had an issue in this case that dealt with cask stability. Now, the State had argued before that, that when they -- that they had

raised these issues in their response to discovery on Contention L. Both the Applicant and we took a very strong position that said, no, those issues have never been raised as part of Contention L, but rather constitute a new manner. And, in fact, the State incorporated those matters specifically in Contention QQ which it filed in May 2001. It was only in December that the Board reached its decision on whether to accept the issue and to recognize it explicitly in the Contention. At the point that the Board issued that decision, which was LBP01-39, we had an issue in the case that specifically dealt with how does the cask perform under seismic accelerations.

Your Honors heard testimony from the witnesses that it was in January of 2002 that they first had communications with counsel, meaning me, with respect to the development of testimony, or maybe they weren't that specific. With respect to the presentation of evidence concerning cask stability. There was some discussion about how best to present that. Dr. Luk indicated that the Staff had indicated to him that they felt it would be best to have the results of the 2,000-year and the 10,000-year return period investigations

reported in a single document, and we did that. We provided a summary to the State in February, we provided our first attempt at a final report in March 8th, and then we issued the final report March 31st.

I don't think there's been any unfair tactic on behalf of the Staff. I can tell you personally, and this is a representation be me as counsel, that I was not aware of the October 2001 results until we sit here today. What I was aware was that in January 2002, we had work that had been performed by Sandia that might be relevant to the contention that the board had admitted in December, and it was then moving forward that we consolidated the evidence and presented the information in Dr. Luk's report which is before us now, and the earlier March 8th version of it.

So I don't think there's been any unfair tactical advantage sought by the Staff. I think the timing of the filing of the contention -- and by the way, there have been several modifications of the contention since it was initially filed in May 2001. It's been a sliding target. But only when the Board issued a decision which said, this is part of this contention and it will be litigated

in this proceeding, that we suddenly have recognition that this is an issue that we have to address in evidence.

JUDGE FARRAR: Then under that view, we don't get into the classic moving target problem that intervenors run into that they may think they have a valid contention, but the Staff, for whatever reason, not necessarily related to the litigation, does additional work. From the Staff's point of view, that improves public health and safety. From an intervenor's point of view, it's wait a minute, here's some -- you know, just when we thought we had our attack mounted, we -- you know, here's some new stuff. You're saying that in the peculiar circumstances of this case, given the Board's December ruling, admitting the late-filed contention, that what might look superficially like a moving target case here, was not really a moving target case.

MR. TURK: That's our view. And incidentally, with respect to the late filing contention, the cask has been the same cask since the application was filed in 1997. The pads have changed slightly, but the concept of a concrete pad roughly 30 by 67 -- I believe is the exact

dimensions were 30 by 64 previously, the general contours of the facility have been known since the beginning. The concept of how casks would behave under seismic events is a concept that could have raised from the beginning. But it's only when the Board explicitly admitted that issue in December, which we argued against on the grounds that it was untimely, only when you admitted that contention did we suddenly have an issue that we had to address in testimony and evidence. And I think we've acted responsibly in trying to get you the evidence and the report and the testimony of witnesses as promptly as we could from that time forward.

JUDGE FARRAR: Mr. Gaukler.

MR. GAUKLER: Yes.

JUDGE FARRAR: Thank you, Mr. Turk.

MR. TURK: Thank you.

MR. GAUKLER: I'd like to add several points, Your Honor. I think there's two issues here. The first one really is the admissibility of the report in and of itself, wholly or in part, the time issues, et cetera. And I think on that, the NRC Rules of Procedure are quite clear. 243(c) says --

JUDGE FARRAR: Wait.

MR. GAUKLER: 2.743(c).

JUDGE FARRAR: Go ahead.

MR. GAUKLER: Says that "only relevant material and reliable evidence which is not unduly repetitious will be admitted." Here I think quite clearly the material is relevant and material to the issues that are before this Board. You've heard the testimony of Dr. Luk. We believe that the evidence is reliable, and the State is entitled to obviously cross-examine Dr. Luk with respect to the reliability of the evidence.

JUDGE FARRAR: Although, would it not be material if the only issue in front of us, going back to my concepts I stated at the beginning, is how good is the Applicant's -- the Applicant's have been in a position of saying, don't worry about what the Staff did, just look at what we did. Now you're saying look at what we did, and by the way, here's some neat stuff the Staff did, look at that, too.

MR. GAUKLER: The important thing will be the decision of this Board and the decision of the Commission. The administrative record will be comprised of the licensing basis of the Staff and

what the Applicant submitted as it is supplemented in this hearing. And in this hearing, you may -- the parties may supplement the record or actually basically produce additional evidence. It is most clearly seen, for example, with respect to the cases involving the final Environmental Impact Statement --

JUDGE FARRAR: But I've always viewed those as different notes. In other words, the impact statement is by law ours and then the Commission's where safety has been -- and, in fact, with regard to Environmental Impact Statements, what's at issue is the Staff's work, to some extent, whereas in safety, all this theory and issue is the Applicant's work.

MR. GAUKLER: But in both instances the final decision is that of the Licensing Board and the Commission, and in both instances, the Licensing Board is free to supplement the record beyond that which is provided for in the license application with respect to health and safety issues or beyond that which is provided in the FEIS with respect to environmental issues.

JUDGE FARRAR: Let's focus on this issue, Mr. Gaukler. Suppose at the end of the

hearing, we said -- and let me again speak colloquially and no insult meant to your witnesses, one of them whom just walked in the room. If we were to say at the end of the case, boy, the Applicant's stuff was no good. You know, they never -- you know, that was scientifically deficient, but we have in front of us Dr. Luk's work and if we were to say, you know, that does a good job, would you say you could get a license on that basis? The Staff would have sent you home if they believed that. But our role is different from the Staff, so we could give you a license based on Dr. Luk's report even if we rejected Dr. Soler's report.

MR. GAULKLER: Yes, that's correct, Your Honor. That would be the evidence of the administrative record, which would be subject to review by the Commission and then by the Court of Appeals. The same way, just by analogy, if you found something the Staff had done in the FEIS that was insufficient, but some party supplemented the record in the hearing, that also would go up the chain of review to the Commission and to the Court of Appeals, and the record would be both the official FEIS as developed by the Staff, plus the

evidence submitted with respect to the hearing.

The same thing applies here with respect to health and safety issues. The license application and the Staff's review can be supplemented by evidence in the record. The issue -- the only difference is that in the one case -- it's not the SER that is the subject here to dispute. In other words, they can't say the NRC Staff, SER is inadequate because they didn't have the Luk report and handle the issue. That would not be an issue they could raise in that case, in accordance with the line of cases that Your Honor just cited. So I don't think that line is relevant to the issue as to what extent the evidence in the record -- evidentiary record can supplemented to support a decision by this Board and by the Commission, either whether it's in health and safety issues or in environmental issues.

JUDGE FARRAR: Thank you, Mr. Gaukler. Ms. Nakahara.

MS. NAKAHARA: Thank you, Your Honor.

The first thing contrary to Mr. Gaukler's opinion, I don't believe you can bifurcate the timeliness issue with the admissibility issue. It's the State's position

because of lack of timeliness and the purpose of this document, which contrary to Mr. Turk's representation, Mr. Guttman did say it was to -- his idea was to develop a site specific analysis for the benefit of the State. The State is intervenor in this process and has raised litigation issues with respect to seismic issues.

JUDGE FARRAR: Are you saying, in essence, that an issue of this complexity, a document that comes in on March 31st for an April hearing is almost by definition too late?

MS. NAKAHARA: No. A document in which -- at the risk I'm going to be reprimanded by co-counsel here.

JUDGE FARRAR: I mean --

MS. NAKAHARA: I would distinguish between --

JUDGE FARRAR: That was a serious question.

MS. NAKAHARA: No, I understand.

JUDGE FARRAR: Take a moment and talk to each other, if you want. I mean this is a serious matter and that's a serious question.

(A discussion was held off the record.)

JUDGE FARRAR: Go ahead.

MS. NAKAHARA: A qualified no. That in this instance, yes, a report that's filed on March 31st is too late.

As I was going to distinguish, this is different than an analysis that PFS submitted because PFS's analysis of the beyond design-basis report essentially relied on the same model, the same concepts that we've had an opportunity to probe in discovery.

JUDGE FARRAR: Let me interrupt you. Mr. Gaukler, Mr. Turk, suppose on April 1st, the State had filed a motion saying, wait a minute, we just got this document, let's put off the hearing four months?

MR. TURK: I would have supported a one-month extension if the State had shown reason to need it. I would point out that -- one month, not four months. But I would point out that they had the report March 8th with respect to the 2,000-return period. And even with respect to the 10,000-return period, there was just two additional cases that were modeled in the March 31 report. And that had to do with using a factor of coefficient of .8. The March 8th report did study the Pacoima Dam and 10,000-year return period

earthquakes. So I would use the .2 -- I'm sorry use the .2 coefficient of friction between the cask and the pad which maximize sliding but didn't maximize tipover.

JUDGE FARRAR: So for practical purposes, in your mind, it was the March 8th report?

MR. TURK: They had March 8th. And, you know, as I think about it, Your Honor, I have to ask the witness one additional question.

JUDGE FARRAR: We're on Ms. Nakahara's time right now. I don't want to interrupt. Mr. Gaukler.

MR. GAUKLER: I would agree with Mr. Turk. The March 8th report sets forth the methodology that was used in the report. The only difference was the running of two additional cases with respect to the 10,000-year earthquake and the Pacoima Dam earthquake. And so I think that we would have argued that, that the State had enough time to prepare for the hearing. They didn't show any response in their testimony filed April 1 that they were addressing the March 8th report in terms of what they did have available for three weeks prior to that point in time. And so we would have

argued that the State had sufficient time to prepare and to the extent they needed a deposition, which is what they had, there would be time for that, as well.

JUDGE FARRAR: Ms. Nakahara, go ahead.

MS. NAKAHARA: Your Honor, we received the March 8th report with representation that it was going to be revised. In addition, that Dr. Luk was going out of town, would be out of the country starting March 10th, would not return until March 20th. Given that the report was going to be revised, we did not request our experts -- I know, budget isn't a litigation concern, but it's a reality for us -- to ask our experts to review the report until we have the final report.

With respect to a moving target --

JUDGE FARRAR: Let me interject there. I think given what the Staff has said today, there's no reason why you can't -- why you cannot point to budget concerns, also. So that's all right.

MS. NAKAHARA: Thank you, Your Honor.

With respect to a moving target, the State is well aware of this entire process as a moving target. This contention represents our

growing awareness of how the licensing procedure moves. As Mr. Turk alluded to, we filed Contention QQ May of 2001. Based on revised reports submitted by the Applicant, we filed an amendment to QQ on June 19th, 2001, and based on again -- yet again revised reports, we filed an amendment to QQ on August 23rd 2001.

Similarly, with respect to the seismic exemption portion of this contention, which has been referred to as Part B, L Part B, we initially filed, I believe May of 2000, we were told we were too early, we subsequently filed again after -- I can't remember the dates. But we subsequently filed three times until the Board admitted the contention.

This is not the same nature of a moving target as an Applicant revising its reports in response to the Staff's request. In this case, the moving target arose as an attempt to satisfy the State's -- or to nullify the State's concerns that it's raised with respect to this contention. And it seems unfair that the State can attack the Staff's work with a reasonable amount of discovery period, but the Staff can rely on it.

And I'd like to point out that the

reason we're in this predicament is in part because of how QQ was formulated and the State's agreement, although it's not in our interest to move this proceeding forward, that we didn't want to appear as a obstructionist, and we agreed to go through an abbreviated QQ process. And as you heard, as we argued our motions in limine, we feel we've already been penalized by that agreement, and this is yet another example of a potential to penalize the State in its opportunity to put on its case.

And the final thing I'd like to say is although we were given the opportunity to depose Dr. Luk -- and we do appreciate the Board's willingness to grant us the deposition, it did occur Saturday and our experts have not had time to consider what Dr. Luk -- the information that Dr. Luk provided in that deposition. And to consider it in the context of his report, in particular to assist me today with my cross-examination.

And that's all I have. Thank you, Your Honor.

MR. TURK: May I say a little bit more about the discovery period that led up to where we are today?