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August 7, 2001

**COMMITMENT RESOLUTION LETTER #37**
**DOCKET NO. 72-22 / TAC NO. L22462**
**PRIVATE FUEL STORAGE FACILITY**
**PRIVATE FUEL STORAGE L.L.C.**

In accordance with our July 31, 2001 conference call, Private Fuel Storage (PFS) submits the following resolution to NRC/CNWRA questions and comments regarding the stability analysis for the cask storage pads.

**NRC Question/Comment**

PFS should provide a basis for the conclusions contained within the SAR that the storage casks do not tip over, collide, nor slide off the storage pad during the seismic event, taking into consideration the potential movement of the cask storage pads of up to 6".

**PFS Response**

A formal evaluation has been performed for PFS by Holtec International to assess the impact of potential movement of the cask storage pads during a seismic event on the PFS Site Specific HI-STORM Drop/Tipover Analyses, (Holtec Report No. HI-2012653, Revision 1, dated May 7, 2001). The Holtec evaluation is attached for your use.

The results of the evaluation demonstrate that the current conclusions reached in the PFSF Safety Analysis Report remain valid and are bounding for the response of the casks relative to the pad.

Template = SECY-028

SECY-02

NUCLEAR REGULATORY COMMISSION

Docket No. 72-22 Official Exh. No. NN

In the matter of PFS

Staff ______ IDENTIFIED ✓

Applicant ✓ RECEIVED ✓

Intervenor ______ REJECTED ______

Other ______ WITHDRAWN ______

DATE 4/30/02 Witness ______

Clerk ~~4/30/0~~ AMP

If you have any questions regarding this response, please contact me at 303-741-7009.

Sincerely,

John L. Donnell
Project Director
Private Fuel Storage L.L.C.

Enclosure

Copy to:
- Mark Delligatti-1/1
- John Parkyn-1/1
- Jay Silberg-1/1
- Sherwin Turk-1/1
- Asadul Chowdhury-1/1
- Scott Northard-1/1
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- Utah Document file (D. Bird)-1/1

HOLTEC INTERNATIONAL

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August 6, 2001

Dr. Max DeLong
Executive Engineer
Xcel Energy
414 Nicollet Mall (RS-7)
Minneapolis, MN 55401

Reference: Holtec Project 70651

Dear Dr. DeLong:

In response to your request, we herewith provide the additional information related to the recent site-specific ISFSI pad sliding evaluations performed for Private Fuel Storage (PFS).

**SCOPE:**

Holtec International has previously performed a series of dynamic simulations of a PFSF ISFSI pad supporting from one to eight spent fuel storage casks and subject to various seismic excitations; these analyses were performed in support of the PFSF site-specific ISFSI licensing submittal. Using design input supplied by PFSF, soil-springs were included in the dynamic model to simulate the effect of the foundation between the base of the ISFSI pad and the top of competent rock driven by the design basis seismic excitation. In the previous Holtec analyses, no separation of the soil from the ISFSI pad lower surface, nor any relative motion (sliding) between the base of the ISFSI pad and the soil surface was assumed. Recent hypothetical bounding analysis (by others) has concluded that postulating loss of surface cohesion could result in as much as six inches of relative displacement of the pad with respect to the soil surface. Therefore, the effect of such relative movement on the response of the casks requires attention. In this letter report, Holtec provides the information needed to conclude that this potential sliding of the ISFSI pad relative to the underlying soil foundation has no significant effect on the conclusions based on the previous dynamic simulations that assumed no sliding.

**DISCUSSION:**

The loss of cohesion leading to pad movement, relative to the top layer of the soil, is well represented by assuming frictional behavior at the pad/soil interface. Therefore, at some limiting value of horizontal force, the pad begins to move, relative to the soil, and this movement may affect the response of the casks. relative to the pad. Whether the effect on the cask response is detrimental or beneficial is the subject of this letter report.

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We note that the simulation responses to date effectively assume an infinite value for the coefficient of friction between the pad and the soil as the horizontal soil resistance is modeled as a linear spring-damper that is always fully effective. The results from the various simulations predicted minimal movement of the pad and a combination of tipping and sliding of the casks relative to the pad (dependent upon the cask/pad coefficient of friction used). To address the issue at hand, we note that if we postulate the other extreme limit for the pad/soil coefficient of friction, namely zero, then the pad/cask system is fully isolated from the input seismic excitation and the casks experience no motion (either sliding or tipping) relative to the pad. The pad, however, experiences maximum relative movement relative to the soil. Based on this simple physical argument, we are led to the conclusion that any sliding of the pad relative to the soil serves to decrease the energy input to the casks and therefore decreases the motion of the casks relative to the pad. If our argument is valid, then the current FSAR statement (repeated below for completeness) remains valid and supplies bounding values for the response of the casks, relative to the pad.

> "In addition, the vendor performed a site specific analysis for HI-STORM storage casks subjected to the design basis ground motion associated with the probabilistic seismic hazard analysis with the 2,000-yr return period (0.711g horizontal, 0.695g vertical), and determined maximum displacement of the cask of less than 4 inches (Reference 61). The analyses concluded that the casks do not tip over, collide, nor slide off the storage pad for these earthquakes. Soil-structure interaction was considered in the site-specific analyses. The seismic cask stability analyses are fully described in Section 8.2.1."

Although the qualitative argument presented above is convincing in its simplicity, it must be backed by equally convincing confirmatory analyses. A series of dynamic simulations have been performed to confirm the applicability and correctness of the heuristic argument presented previously. Based on these confirmatory results, we conclude that the FSAR statements remain valid as they served to quantify the cask movements relative to the pad.

## CONFIRMATORY ANALYSES:

The dynamic simulation model used in all previous submittals on this matter is capable of simulating linear or non-linear behavior across and interface; specifically, the resisting normal force and in-plane forces at the pad/soil interface may be represented by linear springs or by a compression-only normal spring and two orthogonal friction springs. The

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characteristic of each set of two friction springs (FY1, FY2) associated with a compression only normal spring (FW) is as follows:

Let $FH = (FY1^2+FY2^2)^{1/2}$

Then, if the computed value of $FH < \mu FW$, the springs FY1 and FY2 behave as simple linear elements at this instant in time with a stiffness and damping associated with the soil.

If the computed value of FH exceeds $\mu$ FW, then the computed values of FY1 and FY2 are limited to the values that maintain $FH = \mu FW$ for the next time step.

Three dynamic analyses were performed using the Holtec QA validated simulation code DYNAMO to evaluate the effect of pad/soil relative motion. These analyses were performed using the following model parameters:

Pad/soil coefficient of friction = 0.306

Seismic input time histories – Latest 2000 Year Return Seismic Event

Cask/pad coefficient of friction = 0.8

Number of casks on ISFSI pad = 8 (2 x 4) array

The three analyses differ in only one aspect; the magnitude of the soil damping associated with the non-linear elements representing normal and in-plane resistance from the soil. For case 1, we assume that the previously computed values for soil resistance due to damping were maintained. For case 2, we assume that the soil damping forces are reduced to 10% of the values used in case 1. Finally, for case 3, we assume that the soil damping forces are reduced to 1% of the values used in case 1. The cases using reduced damping reflect the reality that the damping forces are not active while slip is occurring so that the net effect of the structural damping over the duration of the event must be reduced. The following table summarizes the results obtained for pad center in-plane movement.

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| CASE | % OF SOIL DAMPING VALUE PREVIOUSLY USED IN LINEAR ANALYSES | MAX. PAD MOVEMENT (inch) N-S | MAX. PAD MOVEMENT (inch) E-W |
|---|---|---|---|
| 1 | 100 | 0.537 | 0.537 |
| 2 | 10 | 3.989 | 2.692 |
| 3 | 1 | 8.808 | 5.178 |

As expected, the amount of pad sliding, as a rigid body is a strong function of the level of soil damping assumed to continuously act over the entire duration of the seismic event. Note that cases 2 and 3 bound from either side, the 6" result obtained from a static equivalent analysis using the 100%-40%-40% combination rule.

The results for cask movement relative to the pad from each of the simulations confirmed the initial assertion that as more pad/soil sliding occurred, the cask/pad relative movements decreased and the propensity for cask overturning was nonexistent. For example, for case 2, the maximum cask excursions, relative to the pad, did not exceed 0.02" at the top or bottom of the cask; i e., even though the cask/pad coefficient of friction was 0.8, the "redirection" of the input energy to moving the pad sufficed to eliminate all overturning cask motion.

Based on the confirming dynamic simulations, we conclude that the initial simulations of the soil/pad interface with linear springs results in the largest values for cask motion relative to the pad; any sliding of the pad relative to the underlying soil due to reduced cohesion has the beneficial effect of reducing or elimination cask movements relative to the pad.

Sincerely,

Brian Gutherman, P.E.
Project Manager

Document ID: 70651014

Emcc: J. Cooper, SWEC