72-22

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September 29, 2010

Ms. Vonna Ordaz
c/o U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

References: 1. Holtec Position Paper DS-348
2. Holtec Position Paper DS-349

Subject: Input to Region III Technical Assistance Request (TAR) on the Structural Qualification of Independent Spent Fuel Storage Installation (ISFSI) Pads

Dear Ms. Ordaz:

Holtec appreciates the conference call with the Spent Fuel Storage and Transportation (SFST) Staff and other stakeholders on September 23, 2010 in which the SFST Staff explained their position on the Soil Structure Interaction (SSI) analysis of ISFSI pads using the computer code DYNAMO. A week prior to the call, Holtec had submitted two position papers, listed as references above, that provided the basis for designating the ISFSI pads as not important to safety (NITS) and summarized the status of pad qualification methodologies used at Holtec's sites and within the industry at large with reference to the TAR queries. We are most thankful as the September 23rd telephone consultation went a long way towards forging a clear path forward to close out this issue. This letter is intended to provide the substantiating information suggested by the SFST Staff as necessary to provide a proper closure of the TAR issues.

SFST Staff's Regulatory Position & Outline of our Effort to Comply

The SFST Staff's verbally articulated position, as we understand it, is that while it is appropriate to designate the pad as NITS, the structural analysis must be performed using a method (and computer code) that is well pedigreed and preferably tested for its veracity in an approved NRC docket. We trust that the information summarized in this letter and the appendices would fulfill what the SFST Staff termed as the criteria for an "adequate" analysis using the computer code DYNAMO in full measure.

We provide the necessary evidence under headings that address the two litmus tests for adequacy, namely:

1. Use in an NRC site specific docket for SSI analysis of an ISFSI pad (note that the SSI analyses to support 72.212 under general licenses are not reviewed and approved by the NRC).
2. Widespread application of the SSI code for safety analysis of non-linear dynamic problems in NRC dockets.

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SSI analysis precedence in an NRC docket

The Private Fuel Storage (PFS), LLC docket (USNRC Docket No. 72-0022) provides the ultimate confirmation of the application of DYNAMO in SSI analysis of ISFSI pads because the country's only proposed Away- From- Reactor (AFR) storage installation involved not only licensing of the facility by the NRC, but also a protracted litigation between the PFS, LLC (defendant) and the State of Utah (plaintiff) with the NRC and it's consultants serving as fact and expert witnesses. DYNAMO SSI analyses served as the vehicle for the initial licensing of the HI-STORM Systems (4000 storage systems), for the PFS facility, and later as the centerpiece for defendant's case in the subsequent Atomic Safety Licensing Board (ASLB) proceedings on the seismic adequacy of pad. The seismic qualification of the pad under the 1000, 2000, and 10,000-year return earthquakes, NRC's licensing reviews, pre-file testimonies by industry experts admitted by the Board, interrogatories, depositions, testimonies and cross examinations with participation from NRC Staff, experts from a U.S. National Laboratory, and Holtec, all centered on proving the veracity of DYNAMO's SSI solutions, provide a vast body of technical corroboration of the code for ISFSI pad qualification.

Appendix A to this letter contains an annotated bibliography of the pre-licensing and post-licensing material related to DYNAMO SSI analysis of the pad loaded with HI- STORM casks. As can be seen from this annotated bibliography, the amount of archival information on DYNAMO as an SSI analysis code is immense. All of this work dates back to the 1996 through 2003 period when the Licensing and ASLB proceedings on the plaintiff's seismic contention occurred.

All of the above material should be available in ADAMS. However, if SFST has difficulty in retrieving the information, we will extract the information from our configuration control system and provide it to the Commission (some of it is designated as proprietary) under a separate cover.

It is also instructive to peruse the pre-filed testimony from Holtec in order to gain appreciation of the extent to which DYNAMO was subject to plaintiff scrutiny during the ASLB hearings. Holtec believes the recent concern with regard to the competence of the DYNAMO SSI analysis has arisen because of the passage of several years since the PFS seismic hearings, during which time a gradual attrition in the ranks of NRC staff who directly participated in the PFS seismic matters has occurred. Holtec would be pleased supply the pre-filed testimony to the Commission should it be difficult to retrieve from ADAMS.

Industry Acceptance of the Code

DYNAMO is a non-linear dynamics code whose theoretical underpinnings are found in the 1976 book entitled "Component Element Method in Dynamics" by Levy and Wilkinson (McGraw-Hill). This university text book provides examples of use of this methodology in typical industrial problems such as vehicle collisions and impact scenarios. The earliest application of DYNAMO in the nuclear industry occurred at Fermi (1980), Quad Cities (1982), VC Summer (1983), and Oyster Creek (1984) wet storage applications involving free standing racks. In 1986,

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DYNAMO served as PG&E's sole computer code for the licensing of high density racks followed by a successful defense of the Diablo Canyon's license at the 1987 ASLB hearings on seismic contentions raised by the National Sierra Club. Experts from the USNRC, Franklin Institute Research Laboratories, the Brookhaven National Laboratory, and California Polytechnic Institute (expert for the plaintiff) provided written and oral testimony in the 1987 ASLB proceedings. The 1987 ASLB hearings on the seismic contentions admitted from the Sierra Club and from Mothers for Peace was a widely watched industry event in which opposing experts provided extensive testimonies and analyses to support their arguments. In the end, the plant's licensing basis, founded entirely on DYNAMO's non- linear solutions, was ruled to be technically sound by the ASLB. Equally important, no opposing expert contested the soundness for DYNAMO as the appropriate code for the required analyses. The documentation on the Diablo Canyon operating license amendment and ASLB hearings on seismic issues / DYNAMO is quite voluminous.

In Appendix B, we provide a list of US and foreign plants where DYNAMO has served as the licensing basis non-linear dynamic analysis code. As one can see, the list is extensive and covers 30 years of virtually continuous regulatory scrutiny on a multitude of dockets and regulatory jurisdictions. We estimate that each licensing application involved review by at least five independent specialists from the client utility, its consultant, and ultimately by the NRC staff. The licensing effort involved regulators in the U.S., Brazil, Mexico, South Korea, Taiwan, and the United Kingdom. To secure the concurrence from this diverse group of experts required a robust validation regimen for DYNAMO. This led us to validate the code against problems in dynamics that involve instability, bifurcation, and sub-harmonic resonance. The DYNAMO validation manual, containing the code's successful application to the particularly abstruse problems, was a subject of careful scrutiny by the plaintiff's experts during the above mentioned PFS hearings.

In summary, it may be appropriate to state that DYNAMO has a long and successful history of industry and regulator acceptance. The code has not been ascertained by any expert to be wanting in its technical efficacy and veracity in any forum including those involving adversarial and legally sensitive situations ("legal intervention"). Candidly, we don't know of any code that has been subject to the extent and intensity of critical appraisal in regulatory proceedings more than DYNAMO has. The code's use in licensing work is ubiquitous, forming the licensing basis for a majority of the nation's nuclear plants and over 20 plants abroad.

We should also observe that coordinate transformation carried out in the seismic problems using DYNAMO is a central feature in all of the hundreds of industry reports that support scores of plants' safety analyses. Reference 2 listed above provides a stand-alone proof of this standard formalism used to cast the Newtonian equations of motion in a matrix form which facilitates seismic analysis on DYNAMO.

The maturation of LS-DYNA as a finite element code with capability to treat material and geometric non-linearity now provides an alternative to DYNAMO. Prior to LS-DYNA, there was no viable alternative. The SSI analysis was performed by some on SASSII, even though the code

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is *prima facie* inappropriate for problems involving casks that are free to lift, rotate, and stagger on the pad under an earthquake. Even today, while LS-DYNA is unquestionably competent for analyzing the substrate/pad/cask assemblage, it is a cumbersome tool; the required size of the finite element model and the computation time required to perform the analysis limits its use as a parametric analysis vehicle for ISFSI pads. To study the effect of different number of casks and different cask layouts on a pad, we are still beholden to DYNAMO.

Finally, we should point out that every pad designed and analyzed using DYNAMO has at least 10% engineered margin which is a standard design requirement for reinforced concrete structures in the company's internal guidelines. The margins built into the LaSalle, Byron and Braidwood pads, as their respective reports show, are several times higher.

We trust the information transmitted with this letter would meet with the SFST Staff and Region III Staff needs to close out this issue. If you have any question please feel free to contact me at 856-797-0900 x687.

Sincerely,

Tammy S. Morin
Licensing Manager
Holtec International

Appendices:
A: Annotated Bibliography of Documents on DYNAMO's Use in the PFS Docket
B: Partial List of Fuel Rack Applications Using DYNAMO

cc: Mr. Doug Weaver Deputy Director, Licensing & Inspection Directorate, SFST, USNRC
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Mr. Rob Tindal, Project Manager, Holtec International
Mr. Jay Leff, Project Manager, Holtec International
Mr. Robert Byers, Exelon

APPENDIX A:
Annotated Bibliography of Documents on DYNAMO's Use in the PFS Docket

This appendix provides an annotated bibliography of Holtec International reports submitted in support of licensing the Private Fuel Storage (PFS), LLC Independent Spent Fuel Storage Installation (ISFSI), and in support of the subsequent Atomic Safety Licensing Board (ASLB) hearings. The seven reports listed below are all focused on the stability analysis of the spent fuel storage casks.

The first four reports used the DYNAMO computer program. The casks were each modeled as a 6-degree of freedom rigid bodies with compression-only contact elements plus two frictional elements at locations around the cask periphery. The pad was modeled as a rigid element with appropriate mass and inertia properties. The effect of the substrate was modeled by linear or rotational spring-mass-damper systems that tied each of the 6-degrees of freedom of the pad to ground. The properties of the substrate were developed by the geotechnical consultants to PFS and supplied as design data to Holtec. Similarly, the response spectra for the site was supplied to Holtec and one set of 3-D seismic events were developed that were statistically independent and bounded the supplied response spectra. The acceleration input was initially assumed to be applied at the base of the soil springs and then transferred to the centroid of the casks and pad as known inertia forces for the purpose of implementation in DYNAMO (the code at that time was identified by the title DYNARACK as it had originally been used for the analysis of spent fuel racks). An appendix in report HI-971631 documents the transformation of variables from an absolute system to a relative system, thus permitting the base of the soil column to be fixed, and the driving forces applied at the centroid of the bodies. This approach carries through all of the reports listed below. The differences between the reports were only slight changes in pad dimensions, and the characteristics of the seismic events. The results for the interface forces (cask-to-pad contact force) were archived for use by the PFS architect and engineering firm charged with the pad structural qualification.

In summary, the DYNAMO model simulated the casks as rigid bodies, modeled the pad as a rigid body, characterized the substrate by simple spring-mass-damper systems with the substrate mass/inertia attached to the pad, and transferred the base accelerations to known inertia forces at the centroids of the various bodies.

1. HI-971631 MULTI-CASK SEISMIC RESPONSE AT THE PFS ISFSI

This analysis used an initial deterministic response spectra set to develop the time histories. ZPA's were 0.67 (two horizontal components), and 0.69 (vertical component). This report contains the theoretical equations of motion and documents the transformation of variables.

2. HI-992242 MULTI CASK RESPONSE AT THE PFS ISFSI FROM 1000-YEAR RETURN EVENT

After a Probabilistic Hazards Analysis was undertaken, new response spectra were supplied, and the substrate properties modified. This report examined the 1000-year return earthquake, which was weaker than the original deterministic event. ZPA's of 0.4, 0.4, and 0.39 were used (two horizontal events and one vertical event). Sensitivity of results to variations in soil properties was considered.

3. HI-992277 MULTI-CASK RESPONSE AT THE PSFS ISFSI FROM 2000-YEAR SEISMIC EVENT

The design basis was changed to be a 2000-year return earthquake, and the report upgraded.

4. HI-2012640 MULTI-CASK RESPONSE AT PFS ISFSI FROM 2000-YEAR RETURN SEISMIC EVENT (REV. 2).

This report documents the response of the cask system to the revised 2000-year return earthquake. The ZPA's are 0.73, 0.71 (two horizontal directions), and 0.72 for the vertical direction. The dynamic model and the transformation of coordinates so that base excitation was replaced by known inertia forces, were unchanged. The sensitivity of the results to changes in substrate properties (lower bound, best estimate, and upper bound) was again considered. The results showed that substrate property variation had minimal effects on the magnitude of movement. An attachment to the report considered the effect of replacing the three linear springs at the soil/pad interface with compression and friction elements so that there could be relative motion between the pad and the substrate. As expected, cask response decreased as the relative motion at the interface increased.

5. HI-2012780 DYNAMIC RESPONSE OF FREE-STANDING HI-STORM EXCITED BY 10,000 YEAR EARTHQUAKE AT PFS

During the ASLB hearings, a 10,000-year return earthquake was examined. The ZPA's for this event were above 1.0. Because of the large rocking motion expected, the DYNAMO simulation model (which suffers a loss of accuracy if large geometry changes occur) was replaced by a VisualNastran model. SSI effects were ignored and the input excitation was assumed at the base of the ISFSI pad (although the excitation provided accounted for the substrate properties). A single cask was considered, and a transformation of coordinates used to replace the base excitation problem by a fixed pad with known inertia forces applied at the cask mass center.

6. HI-2022854 PFSF BEYOND DESIGN BASIS SCOPING ANALYSIS

This report considered multiple casks on the pad with the excitation being the 10,000 year-return earthquake. In this report, multiple casks were examined, the soil substrate model of sets of spring-mass-dampers reintroduced, and the input excitation assumed at the base of the linear soil springs. The application of the transformation of coordinates was put in place to change the simulation into one with a fixed base and inertia forces applied to each cask. One simulation was performed with the 2000-year event so that a solution could be developed with less severe cask rocking. This solution was compared with the results from DYNAMO and good agreement achieved. Therefore, confidence was established that either DYNAMO or VisualNastran (VN) would provide comparable results for low ZPA events.

7. HI-2022878 SUPPLEMENTAL SEISMIC STABILITY ANALYSES FOR THE PSFS

During the ASLB hearings, several issues were raised by the plaintiff. This report used the VN code to:

1. Refute the solutions obtained by the plaintiff's expert,
2. Evaluate the effect of soil cement between adjacent pads, and
3. Examine the sensitivity of the solution to changes in contact stiffness and damping inputs.

The VN models used were either extensions or simplifications of the model used in the previous report. The 2000-year return earthquake was used as input as that was the official design basis. The MPC was assumed to move with the HI-STORM; that is, rattling between the bodies was conservatively ignored.

Appendix B:
Partial Listing of Fuel Rack Applications Using DYNAMO

PLANT	Country	Nuclear Regulatory Body/USNRC Docket No.(s)	YEAR
Enrico Fermi Unit 2	U.S.	USNRC 50-341	1980
Quad Cities 1 & 2	U.S.	USNRC 50-254, 50-265	1981
Rancho Seco	U.S.	USNRC 50-312	1982
Grand Gulf Unit 1	U.S.	USNRC 50-416	1984
Oyster Creek	U.S.	USNRC 50-219	1984
Pilgrim	U.S.	USNRC 50-293	1985
V.C. Summer	U.S.	USNRC 50-395	1984
Diablo Canyon Units 1 & 2	U.S.	USNRC 50-275, 50-323	1986
Byron Units 1 & 2	U.S.	USNRC 50-454, 50-455	1987
Braidwood Units 1 & 2	U.S.	USNRC 50-456, 50-457	1987
Vogtle Unit 2	U.S.	USNRC 50-425	1988
St. Lucie Unit 1	U.S.	USNRC 50-335	1987
Millstone Point Unit 1	U.S.	USNRC 50-245	1989
D.C. Cook Units 1 & 2	U.S.	USNRC 50-315, 50-316	1992
Indian Point Unit 2	U.S.	USNRC 50-247	1990

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PLANT	Country	Nuclear Regulatory Body/USNRC Docket No.(s)	YEAR
Three Mile Island Unit 1	U.S.	USNRC 50-289	1991
James A. FitzPatrick	U.S.	USNRC 50-333	1990
Shearon Harris Unit 2	U.S.	USNRC 50-401	1991
Hope Creek	U.S.	USNRC 50-354	1990
NMP2 Units 1 & 2	Taiwan	Atomic Energy Council (AEC)	1990
Ulchin Unit 2	Korea	Korea Institute for Nuclear Safety (KINS)	1990
Laguna Verde Units 1 & 2	Mexico	Comision Federal de Electricidad	1991
Zion Station Units 1 & 2	U.S.	USNRC 50-295, 50-304	1992
Sequoyah	U.S.	USNRC 50-327, 50-328	1992
LaSalle Unit 1	U.S.	USNRC 50-373	1992
Duane Arnold Energy Center	U.S.	USNRC 50-331	1992
Fort Calhoun	U.S.	USNRC 50-285	1992
Nine Mile Point Unit 1	U.S.	USNRC 50-220	1993
Beaver Valley Unit 1	U.S.	USNRC 50-334	1992
Salem Units 1 & 2	U.S.	USNRC 50-272, 50-311	1993
Limerick	U.S.	USNRC 50-352, 50-353	1994

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PLANT	Country	Nuclear Regulatory Body/USNRC Docket No.(s)	YEAR
Ulchin Unit 1	Korea	Korea Institute for Nuclear Safety (KINS)	1995
Yonggwang Units 1 & 2	Korea	Korea Institute for Nuclear Safety (KINS)	1996
Kori-4	Korea	Korea Institute for Nuclear Safety (KINS)	1996
Connecticut Yankee	U.S.	USNRC 50-213	1996
Angra Unit 1	Brazil	Brazil	1996
Sizewell B	U.K.	Nuclear Safety Regulator (NSR)	1996
Waterford 3	U.S.	USNRC 50-382	1997
J.A. Fitzpatrick	U.S.	USNRC 50-333	1998
Callaway	U.S.	USNRC 50-483	1998
Nine Mile Unit 1	U.S.	USNRC 50-220	1998
Chin Shan	Taiwan	Atomic Energy Council (AEC)	1998
Vermont Yankee	U.S.	USNRC 50-271	1998
Millstone 3	U.S.	USNRC 50-423	1998
Byron/Braidwood	U.S.	USNRC 50-454, 50-455, 50-567, 50-457	1999
Wolf Creek	U.S.	USNRC 50-482	1999
Plant Hatch Units 1 & 2	U.S.	USNRC 50-321, 50-366	1999

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PLANT	Country	Nuclear Regulatory Body/USNRC Docket No.(s)	YEAR
Harris Pools C and D	U.S.	USNRC 50-401	1999
Davis-Besse	U.S.	USNRC 50-346	1999
Enrico Fermi Unit 2	U.S.	USNRC 50-341	2000
Kewaunee	U.S.	USNRC 50-305	2001
V.C. Summer	U.S.	USNRC 50-395	2001
St. Lucie	U.S.	USNRC 50-335, 50-389	2002
Turkey Point	U.S.	USNRC 50-250, 251	2002
Diablo Canyon Unit 1 Diablo Canyon Unit 2	U.S.	USNRC 50-275 USNRC 50-323	2005
Clinton Unit 1 Clinton Unit 2	U.S.	USNRC 50-461 USNRC 50-462	2006
Cooper	U.S.	USNRC 50-298	2007
Ulchin 3 & 4	Korea	Korea Institute for Nuclear Safety (KINS)	2008
AP-1000	U.S.	USNRC Generic Certification	Ongoing
Honghae units 1-4	China	National Nuclear Safety Administration (NNSA)	Ongoing
Nindge units 1-2	China	National Nuclear Safety Administration (NNSA)	Ongoing
Yangjiang Units 1 & 2	China	National Nuclear Safety Administration (NNSA)	Ongoing

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PLANT	Country	Nuclear Regulatory Body/USNRC Docket No.(s)	YEAR
Nindge units 3 & 4	China	National Nuclear Safety Administration (NNSA)	Ongoing
Yangjiang Units 3 & 4	China	National Nuclear Safety Administration (NNSA)	Ongoing
Fangchenggang Unit 1&2	China	National Nuclear Safety Administration (NNSA)	Ongoing
Sanmen Units 1&2	China	National Nuclear Safety Administration (NNSA)	Ongoing
Haiyang Units 1 & 2	China	National Nuclear Safety Administration (NNSA)	Ongoing
Mitsubishi USAPWR racks for North Anna & Comanche Peak sites	U.S.	USNRC Generic Certification	Ongoing