June 28, 2013

MEMORANDUM TO: Anthony H. Hsia, Deputy Director
Division of Spent Fuel Storage and Transportation
Office of Nuclear Materials Safety
and Safeguards

FROM: Daniel Huang **/RA/**
Rules, Inspections, & Operations Branch
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Office of Nuclear Materials Safety
and Safeguards

SUBJECT: SUMMARY OF MAY 30, 2013, MEETING WITH HOLTEC INTERNATIONAL, POTENTIAL RE- SUBMITTAL OF THE TOPICAL REPORT ON A FREESTANDING STACK-UP (DOCKET NO. 72-1014)

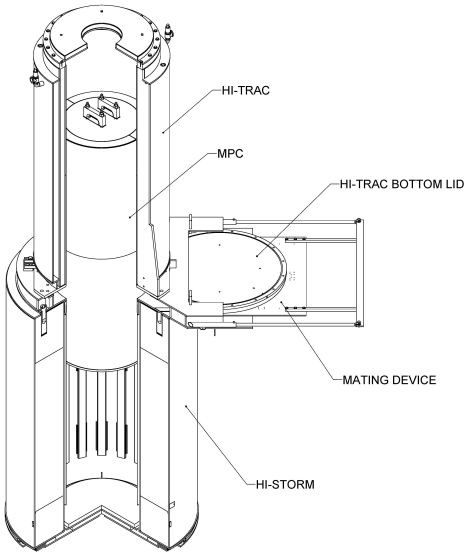
Background

The meeting with Holtec International (Holtec) was noticed on May 13, 2013. The Agency-wide Documents Access and Management System (ADAMS) accession number for the meeting notice is ML13130A034. The meeting agenda is provided as Enclosure 1. The meeting attendance list is provided as Enclosure 2. The handout from the public meeting is provided as Enclosure 3.

The purpose of the meeting was to allow Holtec International to discuss issues regarding the dynamic stability analysis of the stack-up configuration for the HI-STORM spent fuel storage system. The stack-up configuration refers to when the HI-TRAC transfer overpack is "stacked-up" on the HI-STORM storage overpack, and the two are joined with a mating device. The purpose of the stack-up configuration is to allow lowering of a multi-purpose canister containing spent fuel from the HI-TRAC transfer overpack (which is used to transfer fuel from a spent fuel pool) to the HI-STORM storage overpack (which is used for storage).

The analysis had been submitted as a topical report for NRC review and approval on January 24, 2013 (Holtec Topical Report HI-2125263R0, "Dynamic Analysis of a Freestanding Stack Subject to a Postulated Earthquake"). An acceptance review was performed on the topical report by U.S. Nuclear Regulatory Commission (NRC) staff. The topical report was subsequently withdrawn by Holtec on April 26, 2013. The intent of the meeting was to facilitate an open dialog between Holtec International and NRC staff on the results of the staff's

acceptance review regarding Holtec's methodology and approach for stack-up analysis. For clarity, a diagram of that stack-up configuration is included below:



Discussion

The staff had identified five general subject areas in the topical report in need of additional information as a result of the acceptance review. They are as follows:

1. Treatment of Damping
2. Design Basis for the Mating Device Connections
3. Use of the Finite Element Model
4. Calculation of Mean Sliding Response
5. Acceptance Criteria for Sliding of a Freestanding Stack-up

Holtec's presentation discussed issues in the same general subject areas plus other stack-up related topics. The bulleted items listed below provide a summary of the discussions between the NRC and Holtec International.

- **Computer Codes:** NRC considers both ANSYS and LS-DYNA as acceptable structural analysis codes that can be used for the Stack stability analysis. The code and the element types used in the finite element model, however, should be validated in accordance with Spent Fuel Storage and Transportation (SFST) Interim Staff Guidance (ISG) 21, "Use of Computational Modeling Software."

- **Low intensity earthquake sites:** If the spectral accelerations at the staging surface, considering the effect of floor flexibility on frequency responses, are so low that the Stack does not pivot about the cask's edge (no incipient tipping) from static equilibrium considerations; a non-linear time history analysis is not required to establish rocking stability of the stack-up configuration. Similarly, if the same spectral accelerations show that from static equilibrium considerations the Stack does not slide for the range of coefficient of friction applicable to the sliding surface; a non-linear time history analysis is not required to establish sliding stability. For such cases, NRC considers static equilibrium provides acceptable demonstration of kinematic stability.

- **Non-linear time history analysis:** Non-linear time history analysis should be performed if the spectral acceleration values at the staging surface do not support a static demonstration provided for in the foregoing. To perform the required dynamic stability analysis, five statistically independent earthquakes should be generated that meet the criteria for non-linear analysis in NUREG-0800. The input time histories should be baseline corrected such that they yield zero final displacement and zero final velocity. In generating the earthquake time histories, the phasing of the Fourier components associated with the real seed motions should be maintained to the maximum extent practical (i.e., minor distortion of the phase angle spectrum due to baseline correction is permissible).

- **Permissible angle of rotation:** The value of the permissible angle of rotation is equal to one third of the critical angle of rotation of the stack-up configuration, (i.e., the angle of tilt at which the center of gravity of the stack-up configuration (with the multi-purpose canister assumed to be at the highest elevation in the stack-up configuration) is directly over the stack-up configuration's edge).

- **Simulation of damping at the stack-up configuration / support surface interface:** The support interface may be simulated by a set of discrete viscous dampers. The damping assigned to the interface dampers should be equal to the value necessary to provide the same (or lesser) rate of decay of the rocking amplitude of the stack-up configuration when subject to an initial tilt as that predicted by Housner's classical solution. The initial tilt assumed in the calibration effort should be equal to the maximum permissible angle of tipping, and 50% of the maximum permissible angle of tipping. The lower of the two values of viscous damping thus determined should be used in the dynamic analysis.

- **Coefficient of friction:** When relying on friction to restrict relative movement of the components of the stack-up configuration (the HI-STORM storage overpack, the HI-TRAC transfer overpack and the mating device which joins the HI-STORM and the HI-

TRAC), the interface friction coefficient, between interfacing should be the lowest value noted in Mark's Machinery Handbook (for steel surfaces with oxide layer, this value is given as 0.27).

- **Manufacturer's catalog data:** NRC considers that test data provided by the material manufacturer to be admissible as input data for commercially sold products used in the stack-up configuration.

- **Multiple simulations:** The three dimensional seismic (time history) analysis of the stack-up configuration should be performed under each of the (minimum of) five time history sets generated in accordance with NRC NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 3.7.1 to identify a maximum rocking angle. In addition, for each generated earthquake, the friction coefficient at the stack-up configuration's base should be varied within its lower and upper bound range. The response of the stack-up configuration should be obtained for greater than two discrete values of the friction coefficients. The mean plus one standard deviation value of the maximum responses (viz., maximum rocking angle, maximum vertical load and shear load) from the simulations should be defined as the “computed” response for the stack-up configuration under the specified earthquake.

- **Acceptance criterion for tipping:** The computed maximum rocking angle of the stack-up configuration should be less than the permissible angle of rotation.

- **Acceptance criterion for sliding:** For support dollies that provide no restraint to lateral sliding, the maximum permissible lateral migration of the stack-up configuration's base should be limited to one third of the value at which the outer edge of the HI-STORM base reaches the edge of the support surface. Sliding criterion is not applicable to support dollies that are equipped with a physical barrier at their periphery that would prevent uncontrolled sliding. Such physical barriers should be included in the non-linear rocking analysis.

- **Essential Features of the Finite Element Model:** To reduce the zero energy modes and minimize the hourglass energy, fully integrated solid elements should be used in the regions of large deformation (such as the components that are directly in the line of impact). In addition, the elements in these regions shall be reasonably articulated with a finer mesh density. More rigorous hourglass control strategy (e.g., Flanagan Belytschko stiffness formulation) should be used to suppress the hourglass deformation modes that accompany under-integrated elements. Thick shell elements in the critical load path (e.g., mating device top plate, mating device bottom plate, HI-TRAC bottom flange) should use higher order element formulations with at least five integration points through the thickness. Mating device bolted connections should be represented by higher order beam-type elements (e.g., Hughes-Liu beams using higher order 3x3 Lobatto quadrature integration). All contact interfaces should be modeled using standard “part-to-part” contact. The sliding energy should be tracked to insure that all contact interfaces are numerically stable. The mating device bolted bottom plate connections should be modeled using a combination of beam elements (to simulate the bolts) and one dimensional spring elements (to simulate the interface between the bolt and the bolt hole) as suggested in the technical paper by S. Narkhede, et al. (11th International LSDYNA Users Conference).

- **Qualification of internal bolted joints**: The bolts joining the mating device to the HI-TRAC and HI-STORM should meet American Society of Mechanical Engineers (ASME) Subsection NF Level D stress limits. The joint moment and shear should be taken as the mean plus one standard deviation value of the maximum moments and shear forces recorded for the simulations.

NRC staff made no regulatory commitments at the meeting but acknowledges agreement with the discussions summarized above. The NRC will determine how best to incorporate this information into regulatory guidance. TAC No. L24715 has been closed.

Docket No. 72-1014
TAC No. L24715

Enclosures:
1. Meeting Agenda
2. List of Meeting Attendees
3. Presentation Slides

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Distribution: SFST r/f NRC Attendees

ADAMS Package No.: ML13178A240, Memo ML13178A263, Slides ML13178A264

OFC	SFST	E	SFST	E	SFST	E	SFST	E
NAME	DTHuang		WWheatley/DDamiano		GBjorkman (via e-mail)		EBenner	
DATE	6/27/2013		6/27/2013		6/28/2013		6/28/2013	

C=Without attachment/enclosure E=With attachment/enclosure N=No copy
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Meeting Agenda

Meeting with Holtec International
May 30, 2013
Room 3WFN 3A28

Purpose: To allow Holtec to discuss potential re-submittal of the topical report on stack up with the NRC staff.

Agenda:

- Introduction – NRC
- Opening comments - NRC and Holtec
- Holtec Discussion of outstanding issues
- Discussion – NRC and Holtec
- Opportunity for Public Comment – Public
- Adjourn

Enclosure 1

Meeting Between Holtec International and the Nuclear Regulatory Commission
May 30, 2013
Meeting Attendees (and Affiliation)

Huang, Daniel	NRC/NMSS/SFST
Tang, David	NRC/NMSS/SFST
Bjorkman, Gordon	NRC/NMSS/SFST
Hsia, Tony	NRC/NMSS/SFST
Benner, Eric	NRC/NMSS/SFST
Tripathi, Bob	NRC/NMSS/SFST
Prabhala, Venkat	Holtec International
Bullard, Chuck	Holtec International
Singh, Kris	Holtec International
Schrage, John	Exelon

Participation by phone

Ferguson, Gregory	Entergy/Waterford 3
McCullum, Rod	NEI
Tindal, Robert	Holtec International
Koski, Kevin	FirstEnergy
Spiesman, Ben	FirstEnergy
Haviland, Donna	FirstEnergy
Day, Shari	Structural Integrity Associates
Green, Carlyn	Backend Publications Ux Consulting