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BY FAX

December 13, 1999

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Reference: Holtec Project No. 70651

Subject: Private Fuel Storage, LLC
Docket 72-22

Dear Sir:

As committed in our phone conversation of December 6, 1999 with PFS and NRC project management personnel, we are pleased to provide the results of several sensitivity studies of the thermal model for the HI-STORM 100 cask system as it relates to the PFS, LLC license application. A description of these sensitivity studies, including the results and conclusions, is provided as Attachment 1 to this letter.

The expanded thermal model where we examined the effects of radiant heating from adjacent casks and the effect of ISFSI pad insolation are shown in the attached to be second order effects. We stand ready to assist the State of Utah's representatives in understanding the technical nuances of the HI-STORM cask's thermal-hydraulic simulation. We would also be most pleased to explain the implementation of the HI-STORM model on FLUENT.

If it would make for a more efficient resolution to this issue, we would be willing to receive the technical representatives from the State at our offices to help explain the soundness of our mathematical solutions. As the NRC is aware, we have previously provided the complete data files for the HI-STORM FLUENT model to the State of Utah in a similar spirit of openness and cooperation. We invite the State's representatives to visit with us and acquire a full understanding of the large margins of safety embedded in the thermal design of the HI-STORM 100 System.

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Please contact me at 856-797-0900, ext. 668 if you have questions or require additional information.

Sincerely,

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Licensing Manager

Approved

K.P. Singh, Ph.D, P.E.
President and CEO

Technical Approvals:

Preparer

Concurrence

Attachment: PFS EHT Thermal Modeling Features Sensitivity Study (7 pages)

Document ID: PFS023

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Mr. Jerry Cooper, SWEC (w/attach.)
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Mr. Mark Delligatti, USNRC (w/attach.)

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Attn: Document Control Desk
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Attachment 1

PFS EHT THERMAL MODELING FEATURES SENSITIVITY STUDY

1.0 INTRODUCTION

Holtec Report HI-992134 [1] presents the solution of the HI-STORM 100 thermal hydraulic problem using a mathematical model which was termed the EHT (Expanded HI-STORM Thermal) model. This model was devised to establish a conservative mathematical solution to the physical problem sought to be modeled in response to an NRC Request for Additional Information (RAI) to PFS. Specifically, the RAI required that the model incorporate three features, namely:

i) Include the heat transmission to the sub-grade soil due to contact between the base of the HI-STORM and the ISFSI pad.

ii) Consider the effect of heating of a cask by neighboring casks.

iii) Incorporate the effect of solar heating of the exposed surface of the ISFSI pad.

Including the heat loss to the sub-grade soil is a straightforward process. The second feature, namely the effect of heating by neighboring casks is a more tedious problem, because the number of casks in an array and their geometric arrangement must be included to obtain a solution. To bound the physical problem of a finite number of casks interchanging heat with each other, included in the EHT model is a most conservative mathematical simulation. The mathematical model treats the bounding problem of an infinite array of casks, each loaded with fuel at the maximum design basis heat load. In this limiting case, every cask is thermally identical, i.e. each cask would be at the same temperature. Therefore, the aggregate effect of the thermal interchange between a cask and all other casks can be represented by surrounding the cask with a co-axial "tank" with a reflecting inner surface. Figures 1 and 2 (attached) help illustrate this feature of the EHT model. In Figure 1, the subject cask (shown "hatched"), located in the interior of a 5x5 aray radiates heat, much of which leaves the cask without coming back. In the concentric tank simulation (Figure 2), all of the horizontally emitted radiant heat from the subject cask is reflected back to itself; i.e. the tank's inner surface behaves as a 100% efficient reflector. The concentric tank simulation is the essence of the EHT model.

The third feature, namely incorporation of solar heating of the exposed surface of the concrete pad is readily included in the thermal model without the need for additional theoretical considerations. In contrast, the concentric tank model seeks to bound the physical problem of finite casks by an infinite array of casks. This expansion of the physical problem to a much more severe problem (of an infinite number of casks is necessitated to ensure that, regardless of the size of the ISFSI, the EHT solution would produce an upper bound solution.

The thermal model constructed in said manner was run, temperature fields obtained, and results summarized in a Holtec calculation report [1]. In this attachment, sensitivity analyses are performed to assess the influence of certain modeling features on the HI-STORM temperature field. Specifically, a sensitivity study was performed on two features of the EHT model, namely:

(A) Effect of distance between the concentric tank (reflecting boundary) and the surface of the subject cask.

(B) The effect of insolation on the exposed surface of the pad.

This attachment documents the results of the above sensitivity analyses.

2.0 SENSITIVITY STUDY MODELING

The hypothetical cylindrical tank employed in the EHT model is defined by its characteristic dimension R obtained from the tributary area (A_o) associated with a HI-STORM cask as described in the PFS calculation [1]. For conservatism, the smaller tributary area stipulated in the HI-STORM generic licensing basis [2] was adopted for analysis even though the PFS ISFSI is arrayed with a more generous (wider) cask spacing than is required by HI-STORM TSAR. The concentric cylindrical boundary around a reference cask was modeled as a reflecting surface with an insulating boundary condition to include the effect of radiant heating by adjacent casks (lateral cask cooling *completely* neglected). The influence of this cylindrical tank on the cask temperature field is considerably reduced when the location of the interacting boundary is moved away from the cask surface. To numerically simulate an elimination of radiant heating on the PFS model, the radius of the cylindrical tank is arbitrarily increased by a large factor (5 times R). A thermal model is constructed in which the cylindrical tank boundary is moved away to 5R (all other modeling parameters held same as the EHT model) and the surface of the concrete pad extended to complete the model geometry. To ensure that the thermal solution sensitivity properly reflects elimination of Feature A, the concrete surface extension introduced for geometric continuity is modeled as an athermal boundary (insulated & no solar heating).

For performing a sensitivity run in which Feature B of the EHT model is eliminated, a separate thermal model is developed in which the pad extension outside the HI-STORM footprint below the concrete surface is removed. The exposed concrete surface is retained in the model for geometric continuity as an athermal boundary (i.e. insulated and no solar heating).

3.0 SENSITIVITY RESULTS

As discussed earlier, two additional thermal models were constructed in which modeling Features A and B were selectively removed from the EHT model. These models are referenced as EHT-A (i.e. without Feature A) and EHT-B (i.e. without Feature B) respectively. These models were solved on the FLUENT computer code and temperature fields in the HI-STORM system obtained. Three thermal parameters are identified for comparison of sensitivity run cases with base case (EHT model) solution. These are the peak cask surface temperature (T_s) in the active fuel zone, peak canister shell temperature (T_c) and peak cladding temperature (T_f). Model EHT-A was run at the two ambient temperatures 100°F (off normal) and 125°F (extreme hot). Table 1 provides a comparison of results at the off normal and extreme hot conditions. The EHT-B model was run at the higher ambient temperature (extreme hot 125°F). The results of this run are compared with EHT model in Table 2. The temperature limits for concrete, canister and cladding are also shown in these tables.

The results of modeling Feature A show that inclusion of radiant heating from adjacent casks increases the cask temperature (about 17°F). The magnitude of the change is progressively diminished for interior locations (11°F for the canister shell and 8°F for the fuel cladding). The results of modeling Feature B show that inclusion of concrete solar heating increases the cask surface temperature by about 10°F. The magnitude of change is much smaller for interior locations (8°F for the canister and 6°F for the fuel cladding).

4.0 CONCLUSIONS

Thermal solution perturbations to modeling features are presented in this sensitivity study. It is noted that the solution variations are dwarfed by the large safety margins inherent in the HI-STORM temperature field (approximately 200°F). Therefore these effects can be characterized as second order effects. Temperature perturbations introduced at the cask surface are attenuated in the cask interior. The primary means of heat dissipation engineered into the HI-STORM cask is via convective airflow in the canister-to-overpack annulus. About 80% of the decay heat is removed by the ventilation action in the HI-STORM cask and the balance, propelled by temperature gradients, readily finds its way out from the sides, the top and the bottom of the concrete shell by conduction and radiation.

TABLE 1: COMPARISON OF EHT-A SENSITIVITY RUN RESULTS WITH EHT MODEL

MODEL DESCRIPTOR	Cask Surface Temperature (active fuel zone) [°F]	Canister Shell Temperature [°F]	Peak Cladding Temperature [°F]
EHT Model[1] (off normal ambient)	144	324	765
EHT-A Model (off normal ambient)	128	314	759
EHT Model (extreme hot ambient)	169	351	784
EHT-A Model (extreme hot ambient)	152	340	776
Temperature Limit	350	775	1058

[1] From reference [1].

TABLE 2: COMPARISON OF EHT-B SENSITIVITY RUN RESULTS WITH EHT MODEL

MODEL DESCRIPTOR	Cask Surface Temperature (active fuel zone) [°F]	Canister Shell Temperature [°F]	Peak Cladding Temperature [°F]
EHT Model (extreme hot ambient)	169	351	784
EHT-B Model (extreme hot ambient)	159	343	778
Temperature Limit	350	775	1058

5.0 REFERENCES

[1] "HI-STORM Thermal Analysis for PFS RAI", Holtec Report HI-992134.
[2] "Topical Safety Analysis report for the HI-STORM 100 Cask System", Holtec Report HI-951312.

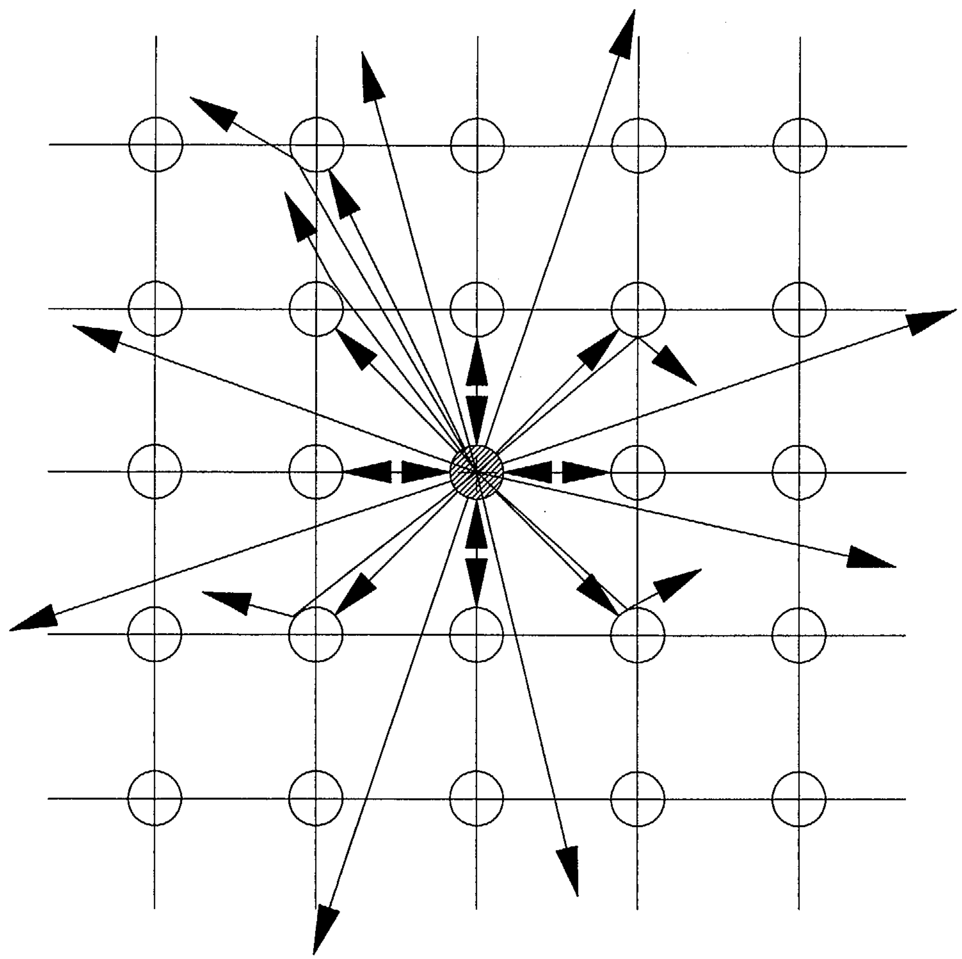

FIGURE 1; IN-PLANE RADIATIVE COOLING OF A HI-STORM CASK IN AN ARRAY

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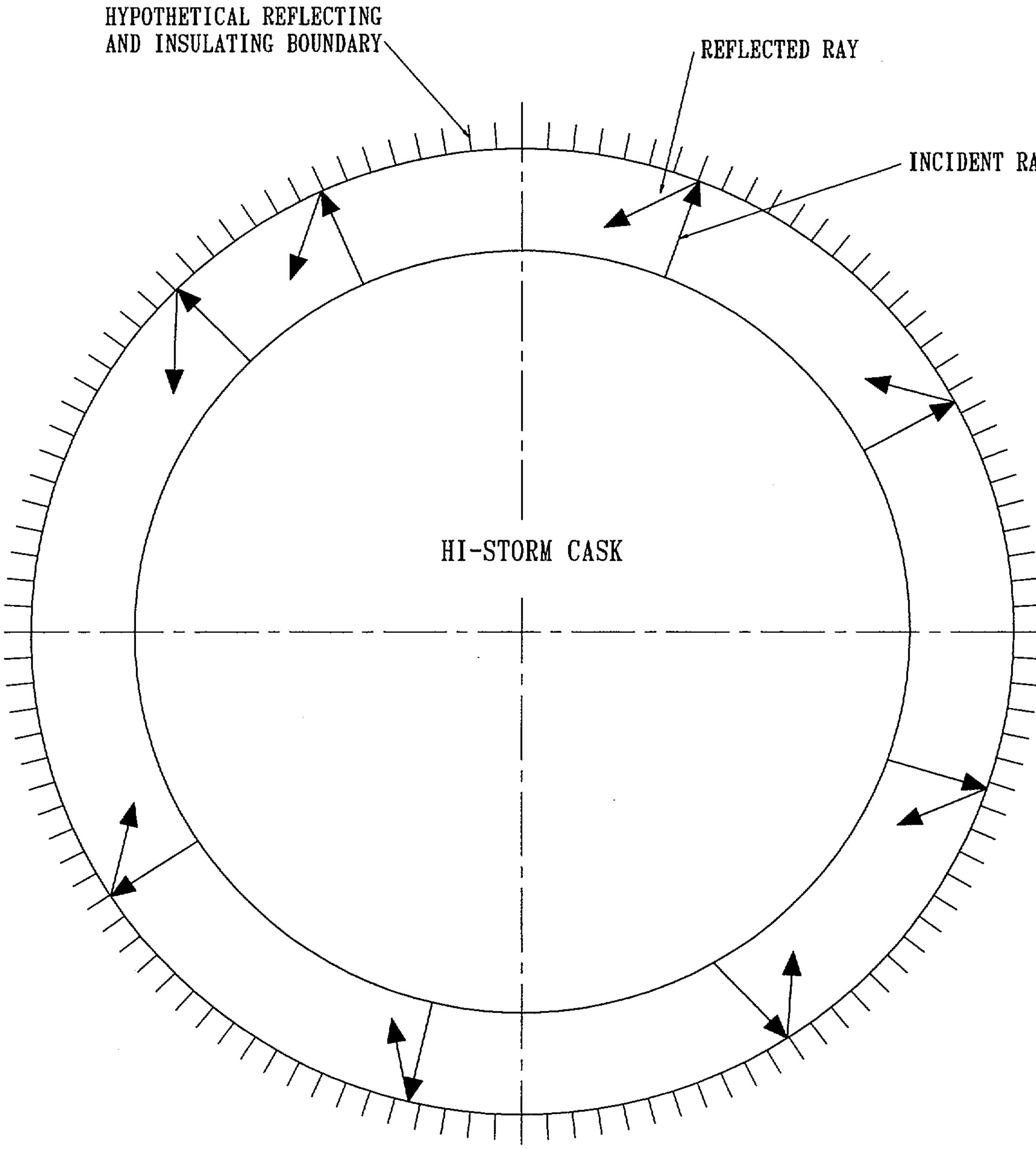

FIGURE 2; IN-PLANE RADIATIVE COOLING OF A HI-STORM CASK COMPLETELY ELIMINATED BY HYPOTHETICAL BOUNDARY