UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

OFFICE OF THE
GENERAL COUNSEL

June 1, 2000

G. Paul Bollwerk, III, Chairman
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dr. Peter S. Lam
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dr. Jerry Kline
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, DC 20555

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

Dear Administrative Judges:

In my letter of May 26, 2000, I indicated that the Staff was expecting to receive the final results of the computer analyses being performed for the Staff by our consultants at Pacific Northwest National Laboratory ("PNL"), which were referred to in Mr. Guttmann's prefiled testimony of May 15, 2000. A report summarizing the final results of those analyses has now been provided to the Staff by PNL, a copy of which is enclosed herewith as proposed Staff Exhibit E. As stated in my letter of May 26, the Staff intends to proffer this exhibit during the upcoming hearings on Contention Utah H ("Thermal Design").

Staff Exhibit E consists of a report from Thomas Michener (PNL) to Jack Guttmann (NRC), dated May 31, 2000, providing the final results of PNL's TEMPEST and COBRA-SFS computer analyses related to the PFS facility. The report indicates that 3-dimensional modeling of the PFS cask array with the TEMPEST code, assuming a "far-field" average ambient temperature of 52°F and considering the effects of cask and pad heating of air, predicts an average temperature of air entering the inlet vents of the hottest cask at the PFS site to be 60.44°F -- *i.e.*, 8.44°F higher than the far-field ambient temperature of 52°F. Further, assuming a 60°F average air temperature, the COBRA-SFS computer code analysis predicts a peak cladding temperature (PCT) of 531°F for the HI-STORM MPC-24 cask -- well below its long-term PCT limit of 692°F. In addition, the report indicates that an average ambient temperature of approximately 225°F would be required for the long-term PCT limit of 692°F to be exceeded.

SECY 040

The final results reported in Staff Exhibit E are bounded by the preliminary results that were reported in Mr. Guttmann's prefiled testimony on Contention Utah H. As stated in my letter of May 26, 2000, the Staff's written testimony will be revised to reflect the final results of these analyses, and the Staff will prepare an appropriate errata sheet for presentation upon Mr. Guttmann's appearance as a witness in the proceeding.

Sincerely,

Sherwin E Turk

Sherwin E. Turk
Counsel for NRC Staff

Enclosure: As stated

cc w/encl.: Service List

Pacific Northwest National Laboratory
Operated by Battelle for the
U.S. Department of Energy

EXHIBIT
STAFF - "E"

May 31, 2000

Jack Guttmann
U.S. Nuclear Regulatory Commission
NMSS/SFPO/TRD, 13 D13
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Dear Jack:

Please find attached a copy of the summary letter report "TEMPEST Analysis of the Utah ISFSI Private Fuel Storage Facility And COBRA-SFS Analysis of the Holtec Hi-Storm 100 Storage system."

If you have further questions or comments, please contact me.

Sincerely,

Thomas E. Michener

Thomas E. Michener
Sr. Research Engineer

TEM:crn

cc: File/lb

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Summary Report:

TEMPEST Analysis of the Utah ISFSI Private Fuel Storage Facility
And
COBRA-SFS Analysis of the Holtec Hi-Storm 100 Storage system

Background:

At the request of the U.S. Nuclear Regulatory Commission, the staff at the Pacific Northwest National Laboratory (PNNL) analyzed the thermal performance of the Private Fuel Storage Facility in Utah (PFS) using the TEMPEST computational fluid dynamics software. A 3-dimensional section of PFS with a total of 20 casks was modeled, using conservative assumptions, to estimate the flow field and temperature distributions surrounding the casks. The results from this model were then extracted and used as the boundary temperature for a detailed analysis of an individual Holtec Hi-Storm 100 cask system. The Holtec cask was modeled using the COBRA-SFS (Spent Fuel Storage) thermal hydraulic computer software. The analyses assumed bounding fuel and solar energy (insolation) conditions and natural circulation (convection) cooling inside the multi-purpose canister (MPC). A summary description of the approaches taken and the results from each effort are provided below.

TEMPEST PFS Site Calculation:

A 3-dimensional TEMPEST model was developed to simulate a strip of twenty casks, which is believed to represent the hottest row of casks in the proposed PFS array. The TEMPEST code has been extensively used by US Government agencies to model near and far field plumes, among many other 3-D applications. The modeled region is shown in a planar view in Figure 1. The 3-D computational model consisted of a strip 30 ft wide, 443 ft long and 200 ft in elevation. As shown in Figure 1, the modeled region extends from the array center (hottest point) to about 110 ft beyond the edge of the array. Adiabatic boundaries were assumed at three of the four sides surrounding the strip. The source of ambient air available to the casks in this model is from above or from the end of the row of casks.

The insolation load was assumed to be 123 Btu/ft^2-hr (388 W/m^2) on the flat surfaces such as the gravel roadway, concrete pads, and cask lids. Absorptivities were obtained from the book: "Thermal Radiation Heat Transfer" by Siegel and Howell. The values were 0.29 for the gravel roadway, 0.73 for the concrete pads, and 0.75 for the steel cask lids. The design base fuel load used in the TEMPEST calculation was 21.5 kW per cask. This heat load corresponds to the hotter MPC-68 design, which may be located at the PFS facility.

The TEMPEST model was executed until steady-state 3-dimensional velocity, temperature, and pressure fields were achieved. Results of this simulation revealed a complex 3-dimensional flow and temperature field typical of interacting thermal plumes in the open environment. One noteworthy conclusion is that a large amount of "far field" ambient air is induced into the system. The ambient air is entrained into the cask array by the rising thermal plume. This can be seen by referring to Figures 2a and 2b. Also, the volume of air drawn into the cask inlet vents and ejected out the exit vents is relatively negligible compared to the volume of air entrained into the rapidly rising plume flow.

The results also show that there is a significant downward and lateral circulation of ambient air in the vicinity of the gravel roadway center along the row of casks. This circulation is caused by air inducted into the turbulent plume, which is rapidly flowing above the row of casks. A fresh supply of cool ambient air travels down the path formed by the gravel roadway . This cool flow prevents a build-up of high temperature air just above the surface of the gravel roadway.

To ensure that the calculated heat transfer from the insolated surfaces (gravel roadway, etc) was conservative, heat transfer coefficients were chosen that are greater than one order of magnitude larger than best estimate values. The TEMPEST results show that greater than 90% of the insolation heat load is transported to the air that flows adjacent to heated surface. Radiation heat loss from the horizontal surfaces was not considered, thereby maximizing the heat that is convected to the air.

Computed results show that the average hottest air (mixed-mean temperature per cask) entering into any cask's inlet vents is 60.44 °F, an increase of approximately 8°F above the far field ambient temperature.

__COBRA-SFS Cask Calculation:__

A 1/8 symmetry section (Figure 3) of the Holtec Hi-Storm 100 spent fuel storage system was modeled using the COBRA-SFS computer code. The Hi-Storm system consists of a canister surrounded by a concrete overpack. The COBRA-SFS code modeled in detail the flow field in the canister, accounting for conduction, convection, and thermal radiation heat transfer mechanisms. The code has been rigorously validated against full scale experimental data for various cask designs, including ventilated concrete casks similar to the Hi-Storm design. Therefore the code has been validated to model flow in the annulus formed between the cask canister and the concrete overpack. Using these capabilities, the calculations treated the heat transfer throughout the cask internals, (fuel assemblies, basket, and flow channels) into and across the annulus, out the vents to ambient, through the concrete overpack and out to ambient. All of the COBRA-SFS simulations included insolation heat input on the cask sides and lid.

Cases 1-8 (Table 1) were investigated for a cask loaded with 24 PWR spent fuel assemblies with 0.896 Kilowatts (kW) per assembly, for a total of 21.5 kW of decay heat. This total decay heat is actually higher than the design limit of 20.88 kW. Therefore, the calculated PCT for Cases 1-8 are conservatively high. Two additional cases quantified the impact of using the correct decay heat. Case 9 repeats Case 2 with the a decay heat load of 20.88 kW and Case 10 repeats Case 8 with the corrected decay heat load.

Given the margin for the air temperature at the cask inlet vent, a similar margin exists for the calculated maximum fuel rod temperature. A minimum of 161 °F (692-531) margin exists between the calculated PCT and the HI-STORM approved maximum allowable temperature limit. From these calculations, it is concluded that the HI-STORM 100 system meets the thermal regulatory requirements set in 10CFR Part 72 with ample margin.

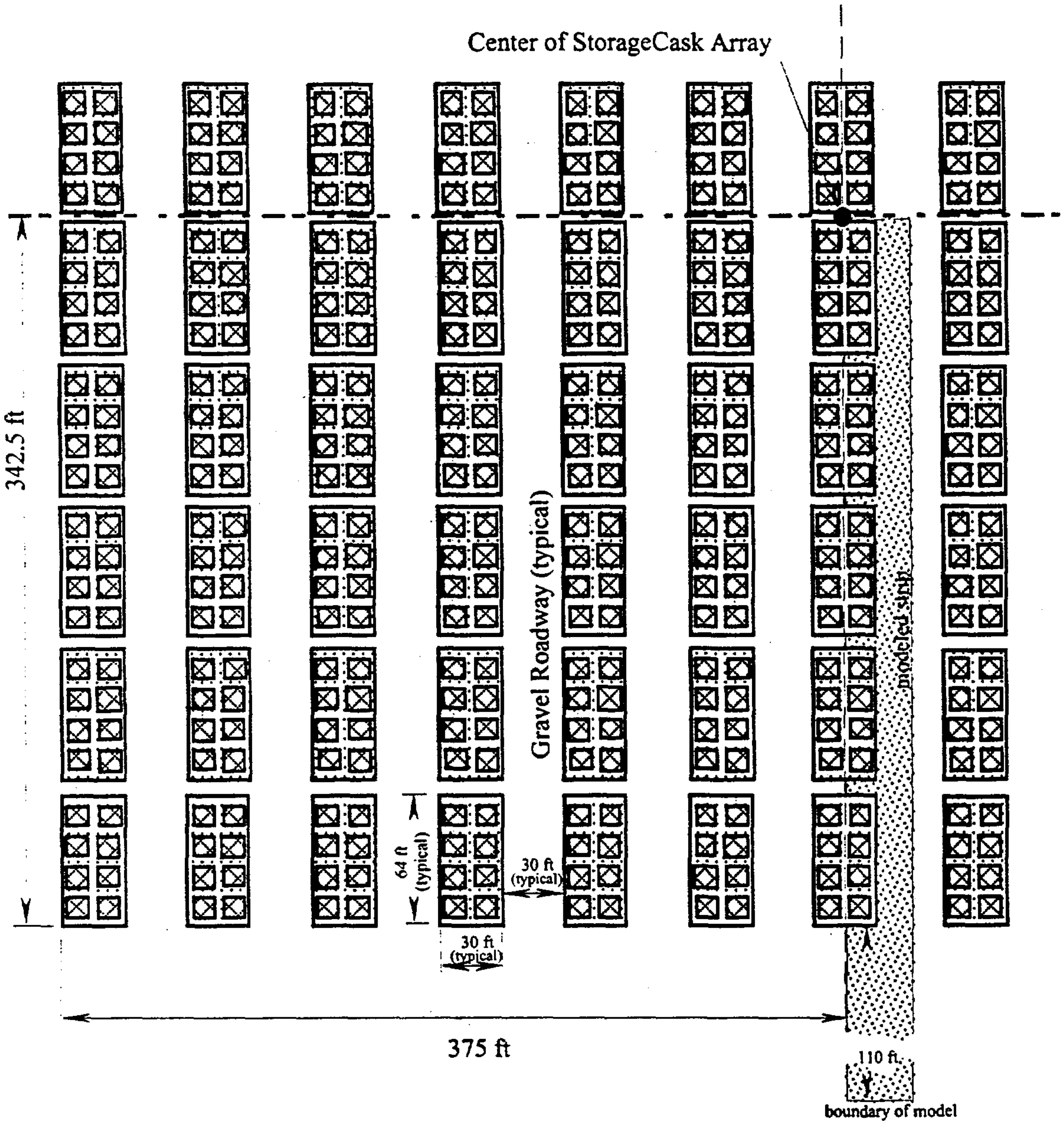

Figure 1. Planar Schematic: TEMPEST model of Utah PFS

COBRA-SFS Predicted		Peak Clad Temperature
Case#	Internal pressure of Helium at 5 ATM	
	(21.5 kW decay heat)	
1	Ambient air at 52°F	534 °F
2	Ambient air at 60°F	543 °F
3	Ambient air at 67°F	550 °F
4	Ambient air at 80°F	563 °F
5	Ambient air at 125°F	608 °F
6	Ambient air at 150°F	631 °F
7	Ambient air at 200°F	680 °F
8	Ambient air at 250°F	724 °F
	(20.88 kW decay heat)	
9	**Ambient air at 60°F**	**531 °F**
10	Ambient air at 250°F	713 °F

Table 1. Summary of COBRA-SFS simulations

A plot of the COBRA-SFS predicted Peak Clad Temperature (PCT) vs. ambient temperature at inlet vents is shown in Figure 4 for Cases 1-10. The calculation that simulates the long term conditions for the PFS facility case is Case 9, which uses results from the TEMPEST simulation (60°F) as the ambient temperature boundary condition and the corrected decay heat load of 20.88 kW.

Conclusions:

The impact of neighboring casks on the average air temperature entering the limiting HI-STORM cask at the PFS facility is negligible (approximately 8 °F above the "far field" ambient temperature) given the extensive margin in the cask design. The HI-STORM 100 system is designed to take advantage of convection cooling inside the MPC. This design leads to a calculated margin that permits approximately 173 °F increase in the "far field" ambient temperature (or an air temperature of 225 °F) to enter the inlet vents of the MPC before exceeding the NRC approved maximum allowable temperature limit of 692°F. In reality, a larger margin exists if the applicant credited a less conservative, but bounding, fuel rod pressure when evaluating the maximum allowable temperature limit. The margin is also increased if site-specific insolation values and view factors were used. An additional conservatism used in the analysis is the use of design basis fuel for every assembly in the MPC.

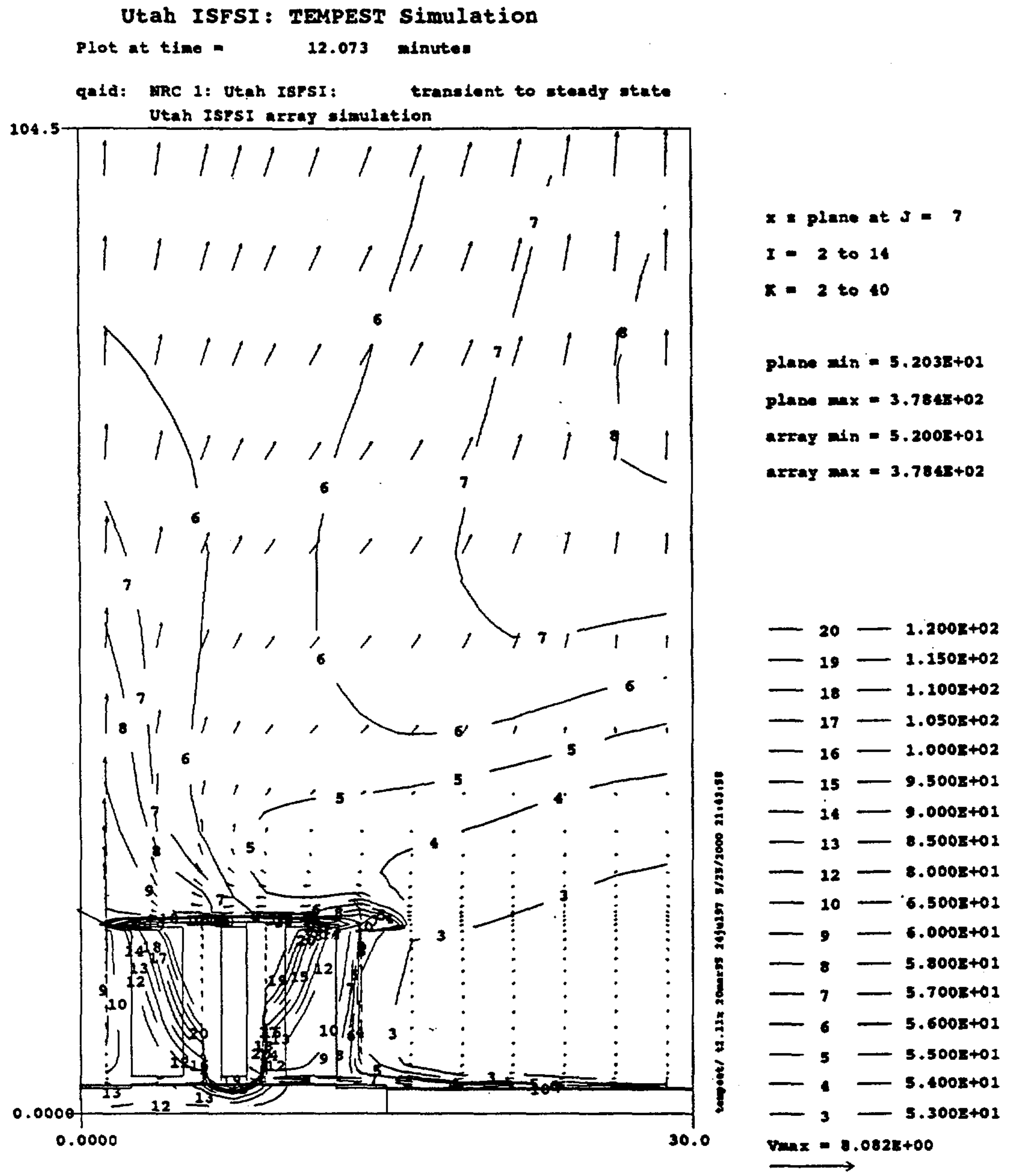

Figure 2a. Temperature Contours and Velocity Vectors in Vertical Plane Though Center Cask Centerline

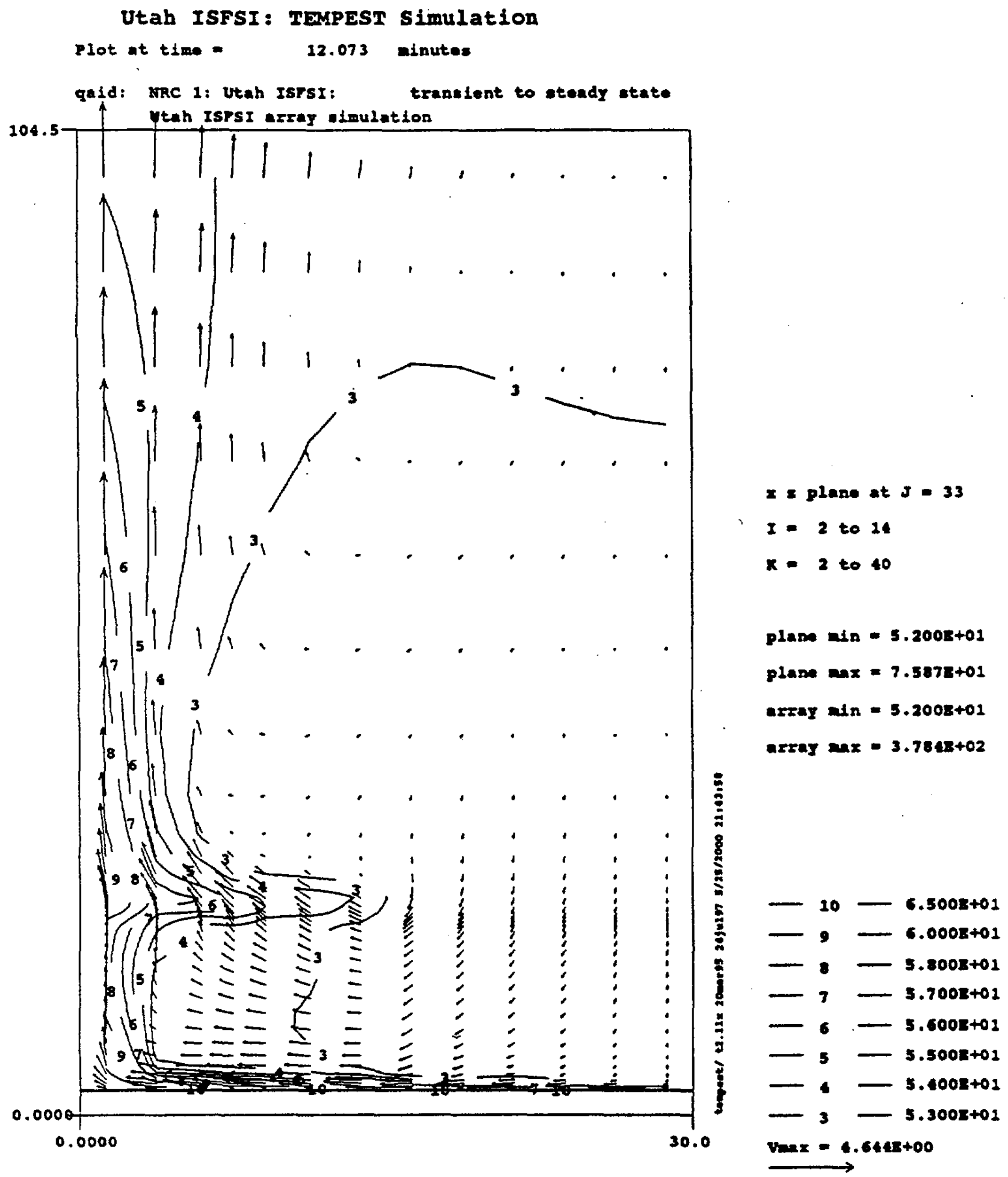

Figure 2b Temperature Contours and Velocity Vectors in Vertical Plane Between Two Pads

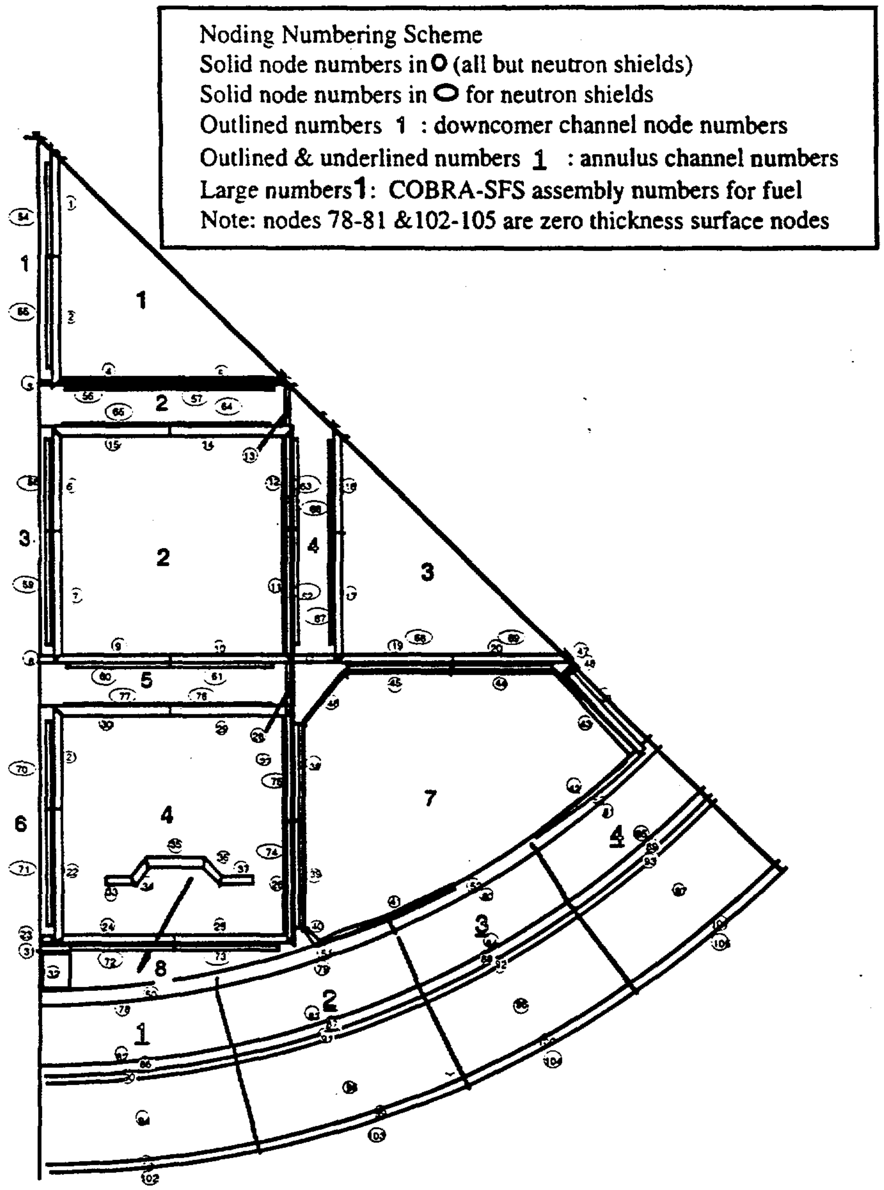

Figure 3. COBRA-SFS 1/8 Symmetry Hi-Storm Cask Node Map

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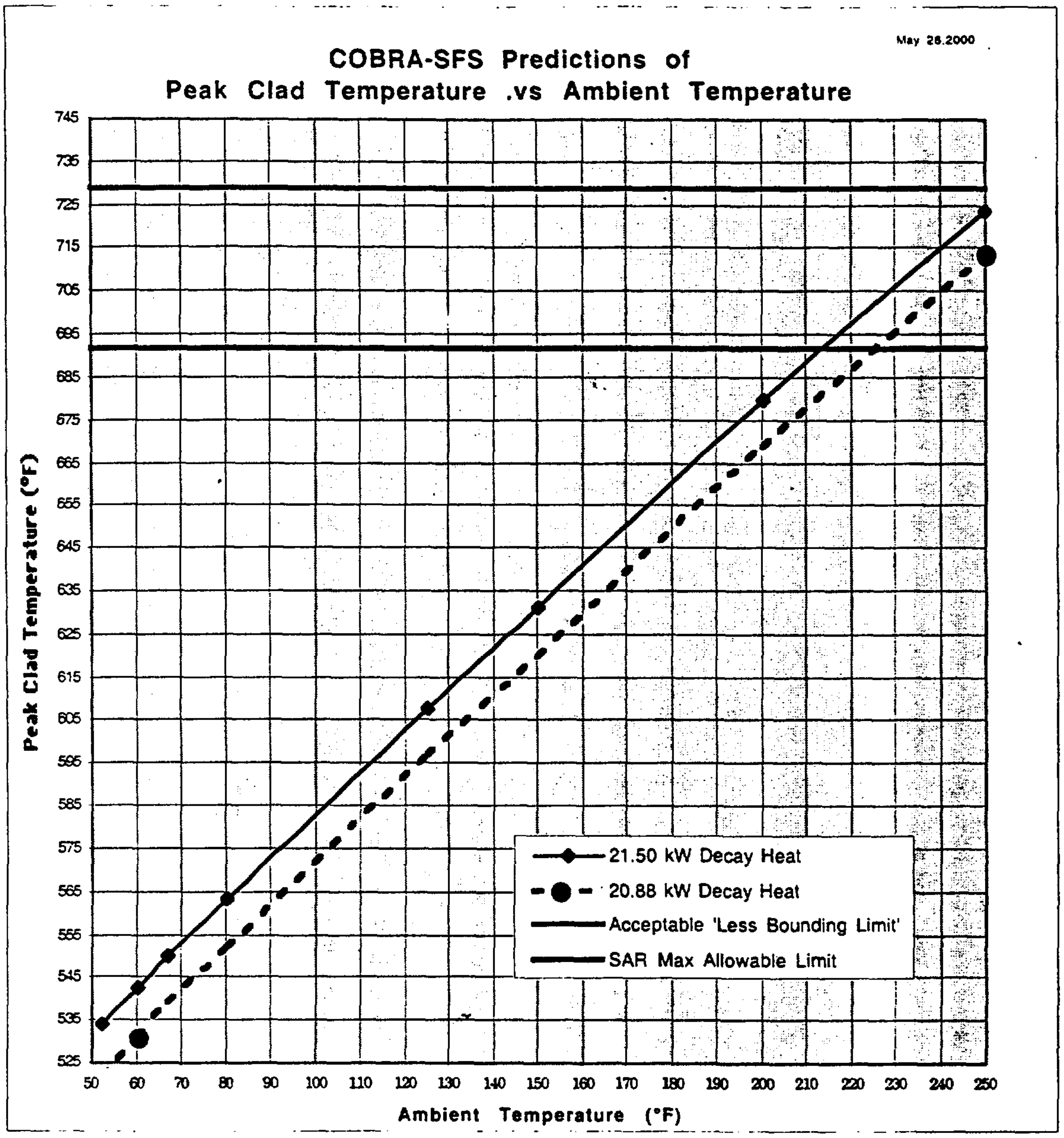

Figure 4. COBRA-SFS PCT vs Ambient Temperature