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COBRA-SFS Analysis of the Holtec Hi-Storm 100 Storage System Following a Tip-Over

INTRODUCTION

Pacific Northwest National Laboratory (PNNL) staff have analyzed the thermal performance of the Holtec Hi-Storm 100 cask system using the COBRA-SFS (Spent Fuel Storage) thermal hydraulic computer software, providing an independent best-estimate analysis of the system in normal storage mode. In addition, an analysis of the cask was performed for a horizontal orientation with all of the vent blocks, representing the worst case scenario following a tip-over incident. In actuality there will be convection through the vents providing additional cooling of the system. A short description of the approaches taken and the results from each effort is provided below.

COBRA-SFS MODEL

The Holtec Hi-Storm 100 spent fuel storage system was modeled using the COBRA-SFS computer code. The Hi-Storm system uses a canister in concrete overpack approach. COBRA-SFS has the capability of modeling in detail the flow field in the canister portion of the system, treating conduction, convection, and thermal radiation. The code has been rigorously validated against experimental data for many different geometries, including ventilated concrete casks similar to the Hi-Storm design. The code also has the validated capability of modeling the flow in the annulus formed between the cask canister and the concrete overpack. Using these capabilities, we modeled the heat transfer through 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. For the tip-over case the number of concrete nodes was increased to provide a more accurate description of the temperature distribution in the overpack region. In both models assembly #1 is the center most fuel assembly and assembly #3 is the outer fuel assembly.

Summary of Results

The COBRA-SFS results were intended to confirm or refute Holtec's reliance on the use of pressurized helium gas (5 atm) to enhance the thermal performance of the system. The COBRA-SFS independent analysis matched the Holtec SAR peak clad temperature predictions within 5°C. The COBRA-SFS results for this case are presented in Figure 1.0.

We also modeled the thermal performance of the cask system in a horizontal orientation. In actuality, there will be some flow (although reduced) through the annulus when the cask is tipped over, however, it is not possible to model the resultant complex flow field in the annulus with COBRA-SFS. As a first try at approximating the thermal impact of a tip-over incident, the internal flow within the fuel region was shut off in the COBRA-SFS model, as was the flow through the annulus. This definitely provides a good estimate of the worst possible case. The resultant temperature profile is provided in Figure 2.0.

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For the tip-over case we predicted concrete temperature ranging from a high of 507 °F (264°C) down to107 °F (42°C) at the outer radius.

Future Analyses

We are working on a detailed model of the heat transfer from the fuel canister wall on outward using the Star-CD commercial CFD software. Although this approach does not treat the details inside the fuel canister, it will provide a detailed prediction for the flow field through the annulus and resultant temperature distribution in the overpack. In this case the total decay heat will be uniformly assigned as a boundary condition on the fuel canister shell. This work is expected to be completed before May, 2002.

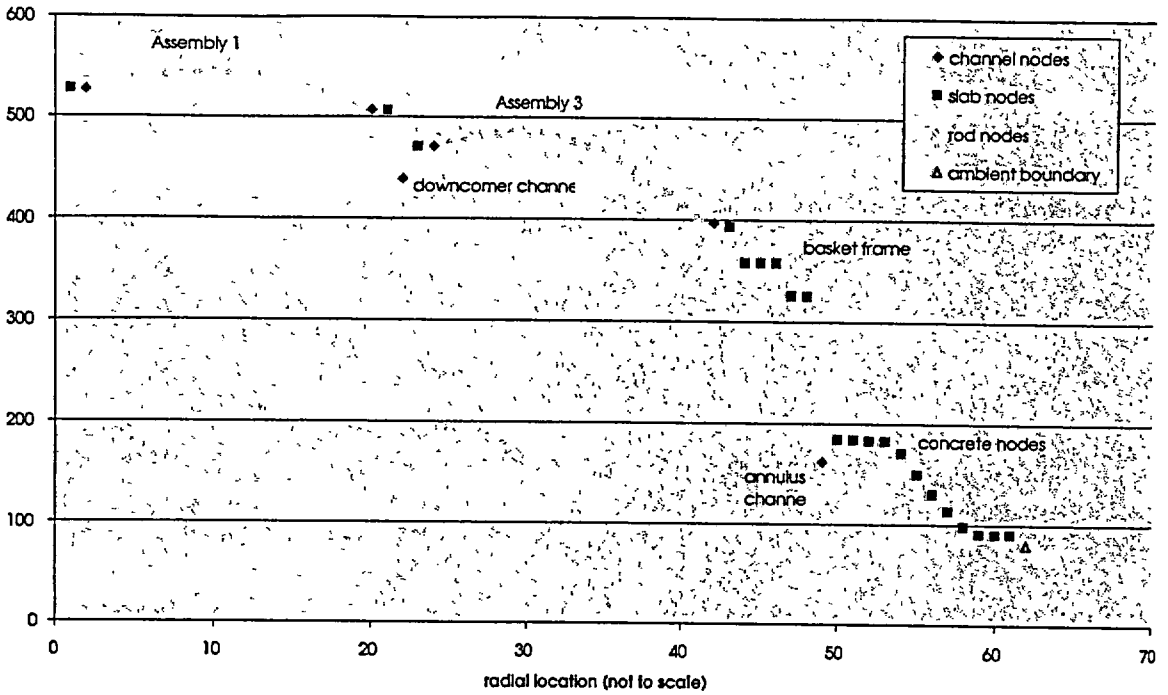

Figure 1.0 – COBRA-SFS Temperature Predictions, Normal Storage, Hi-Storm Cask

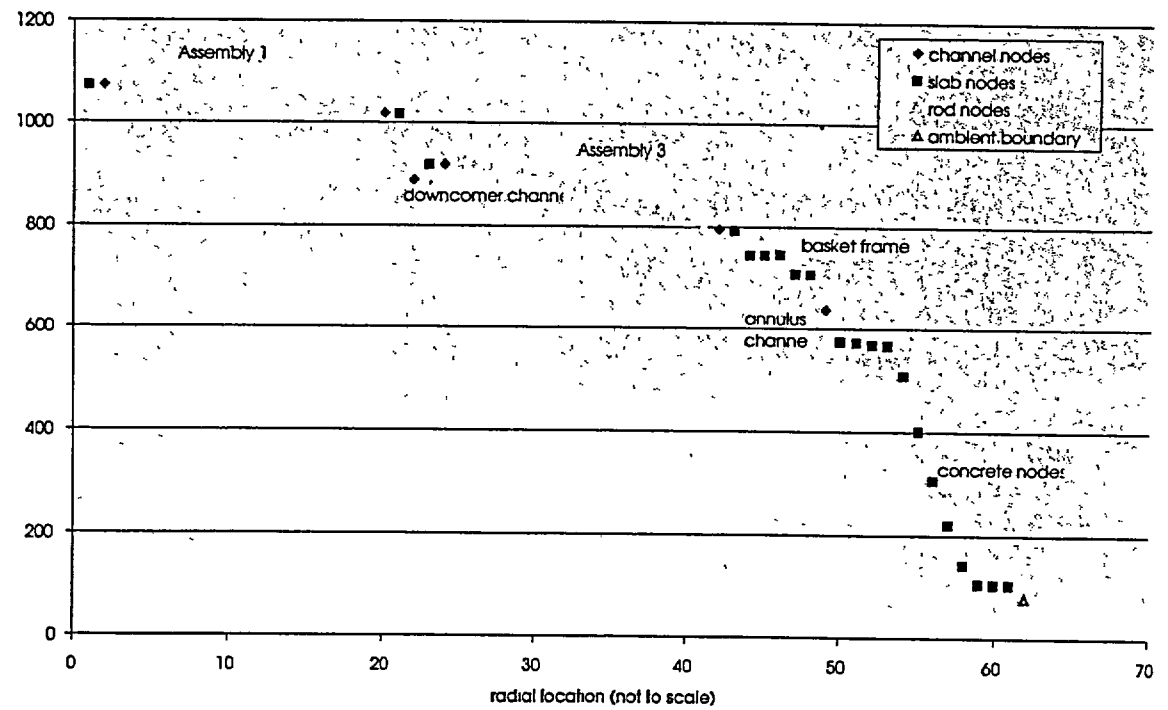

Figure 2.0 – COBRA-SFS Temperature Predictions, Tip-Over Case, All Vents Blocked,Hi-Storm Cask