Spent Fuel Transportation Cask
Response to a Tunnel Fire Scenario

Christopher S. Bajwa, PE
Harold S. Adkins
Judith M. Cuta

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Introduction

- Baltimore Tunnel Fire Event
- Howard Street Tunnel Fire Model
- Spent Fuel Transportation Cask Analyses
- Results/Conclusions
Baltimore Tunnel Fire, July 18, 2001
NIST Howard Street Tunnel Fire Model

- Fire Dynamics Simulator (FDS)
  - Computational Fluid Dynamics (CFD)
- Validated Against Test Data
  - Memorial Tunnel Fire Test Program
- Full 3D Tunnel Model
  - Included Railcars
NIST Howard Street Tunnel
Fire Model
FDS Temperature Results

Tunnel Temperatures

7 hour fire

- Floor
- Bottom
- Side
- Wall
- Top
- Ceiling

Upward Slope ➺

Distance in Meters (Fire at 0)

Degrees Fahrenheit

-40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40

2100 2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0
HOLTEC HI-STAR 100 Cask
HI-STAR 100 Rail Cask

Image Courtesy of HOLTEC International
TN-68 Spent Fuel Cask
HI-STAR 100 Spent Fuel Cask
- Model Developed in ANSYS®
- 3D half symmetry
- Explicit geometry representation
- Fuel assemblies homogenized
- Conduction, convection, and radiation
- Cask transport cradle included
- Tunnel walls included
- Model contains over 149,000 elements
Cask Analysis Model Details, cont.

- TransNuclear (TN) 68 Spent Fuel Cask
  - Model Developed in COBRA-SFS
  - 3D half symmetry
  - Explicit geometry representation
  - Fuel assemblies explicitly modeled
  - Conduction, convection, and radiation
  - Tunnel walls included
  - Model contains approximately 139,000 nodes
HI-STAR 100 model with Impact Limiter Shells
COBRA-SFS Node map for TN-68
Pre-Fire Analysis Conditions

- Equivalent to Normal Conditions of Transportation (NCT) in 10 CFR 71.71
  - Ambient Temperature 38°C (100°F)
  - Full Solar Insolation
  - Cask Surface Emmissivities: 0.3 for Stainless Steel, 0.85 for painted surfaces

- Maximum decay heat applied
  - TN-68 - 21.2 kW
  - HI-STAR 100 - 20 kW

- Steady state temperature solution obtained
HI-STAR 100 Temperature Plot (Pre-Fire Conditions)
Fire Boundary Conditions

- Applied NIST Calculated Temperature and Flow Conditions
- Center of Cask Located 20 Meters from Fire Source
- 7 Hour Fire plus 23 Hour Cooldown (30 Hours total)
- Temperatures Extrapolated Using Power Function (30<t<300 hours)
HI-STAR 100 Cask Component Temperature Plot

- Fuel (Global Peak)
- Canister
- Cask Inner Shell
- Cask Outer Surface
- Lid/Drain/Vent Port Seals

Time (hours)

Component Temperature (°F)

- Fire Duration
- NIST 30 hour data set
- Extrapolated Boundary Conditions
Results from Cask Analysis

- Maximum Spent Fuel Cladding Temperatures:
  - HI-STAR 100: 887°F
  - TN-68: 845°F
- No Fuel Cladding Failure Expected
- No Failure of the Multi-Purpose Canister (MPC) Expected for HI-STAR 100
- No Seal Failure Expected for the TN-68 (Max seal Temperature 811°F)
Conclusions

- Robust Nature of Rail Casks is Evident
- Fire Exposure Results in No Release of Radioactive Material
- Health and Safety of the Public is Protected