HADCRT Results for Benchmark Exercise #2

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Presented to the:

International Collaborative Project to Evaluate Fire Models for Nuclear Power Plant Applications

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Background

- Nuclear fuel cycle facility source term analysis code, HADCRT (Hanford Double Contained Receiver Tanks).
- Logical to extend HADCRT explosion & accident capability by adding fire models to the validated baseline code.

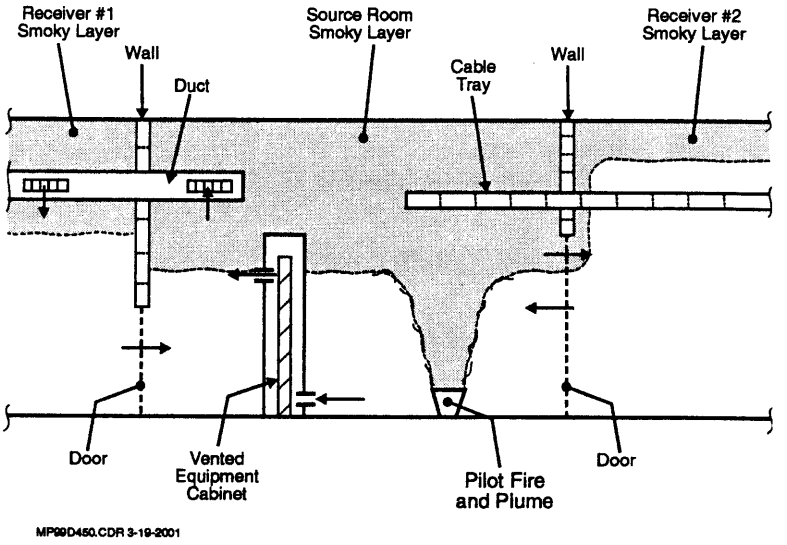
Background

- **Generic features:**
  - **Arbitrary topology**
  - **Arbitrary specification of chemical species & properties**
  - **Fog formation (vapor/aerosol equilibrium)**
  - **Density-driven counter-current gas flows between compartments**
  - **Aerosol agglomeration, settling, transport, & source models**
  - **Radiation networks**
  - **Multi-dimensional heat conduction**

Background

- **Fire features include:**
  - **Stratified layer composition and thickness per compartment**
  - **Pilot fire definitions (burn rates, yields, etc.)**
  - **Plume model**

HADCRT Fire Model Features

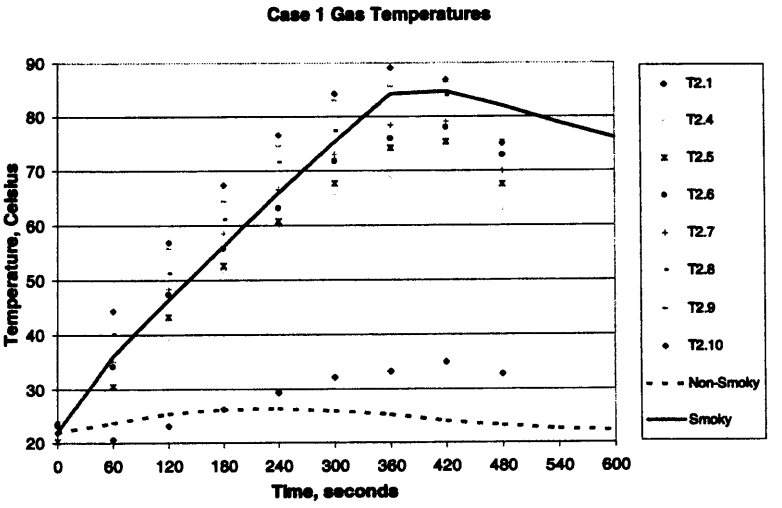


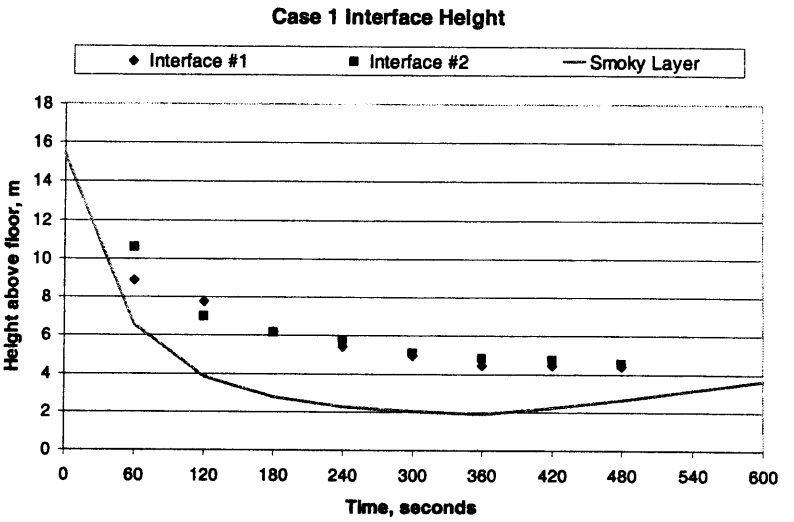
HADCRT Model for Benchmark Exercise #2

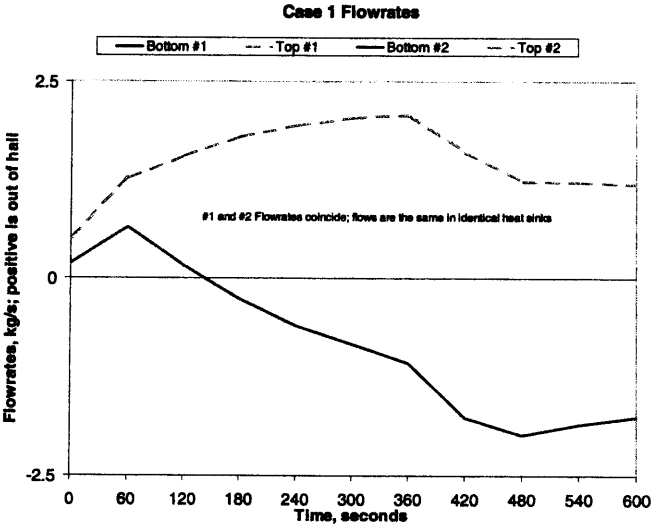
- **Two regions: hall and the environment**
  - **Hall: 5891 m^3, 378 m^2 floor area, 1800 m^2 wall HX area, parallelepiped, 22 C, 101350 Pa**
  - **Environment: 20 C, 101350 Pa**
- **Seven Heat Sinks**
  - **Floor 1 ft. thick concrete; adiabatic on the outside**
  - **Sheet metal is neglected**
  - **Walls and ceiling are 5 cm mineral wool**
  - **One HS for floor, six for walls**
  - **Wall HS model the wall as six panels**
  - **Material properties from Table 1 of the problem specification**

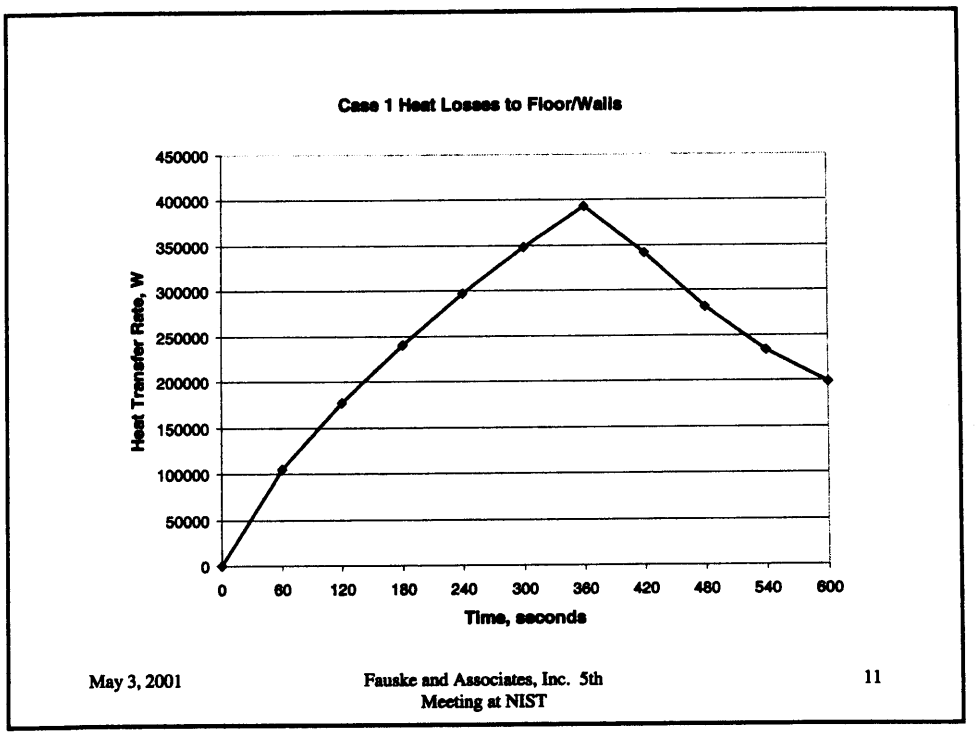
HADCRT Model for Benchmark Exercise #2

- **Junctions: depends on the case**
  - **Case 1: Four junctions, as shown in Table 2 of the problem specification, but only "z" coordinate matters**
  - **Case 2: Same as Case 1**
  - **Case 3: Two doors, one top junction has 11 m^3/s forced flow**
- **Code inputs for fires: region, area, burn flux, fuel properties, start time, fuel mass, yields for CO, CO2, CH, soot, H2O; limit of five fires**
- **Use handbook values for heptane; e.g., 44.6 MJ/kg**
- **As a first cut, skip radiation; fire is 100% convective**




Case 1 Interface Height
Interface #1
Interface #2
Smoky Layer
Height above floor, m
18
16
14
12
10
8
6
4
2
0
0
60
120
180
240
300
360
420
480
540
600
Time, seconds


Case 1 Flowrates
Bottom #1
Top #1
Bottom #2
Top #2
Flowrates, kg/s; positive is out of hall
2.5
0
-2.5
#1 and #2 Flowrates coincide; flows are the same in identical heat sinks
0
60
120
180
240
300
360
420
480
540
600
Time, seconds



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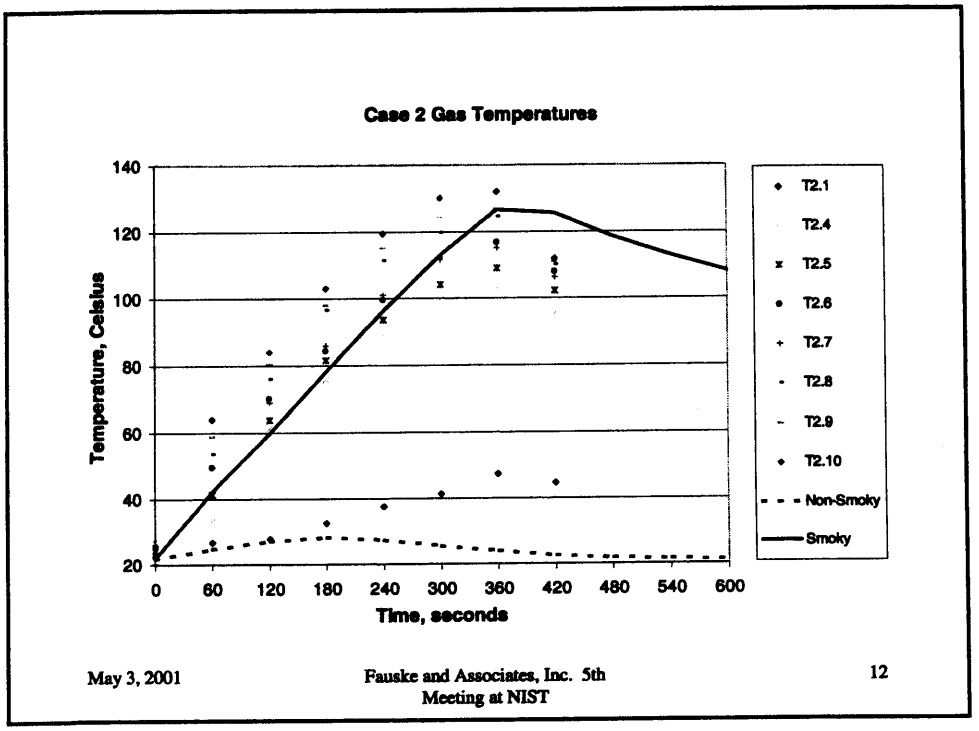

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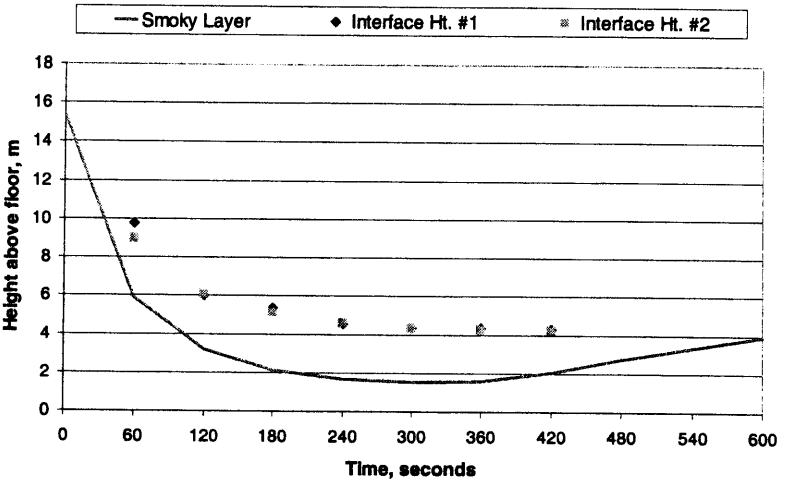
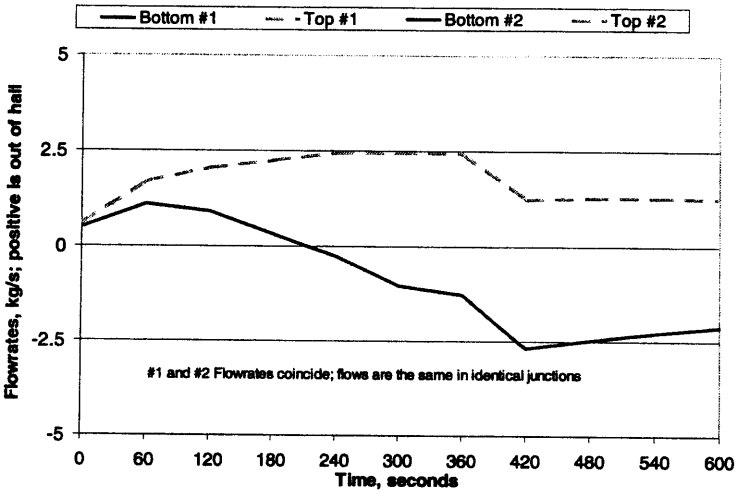
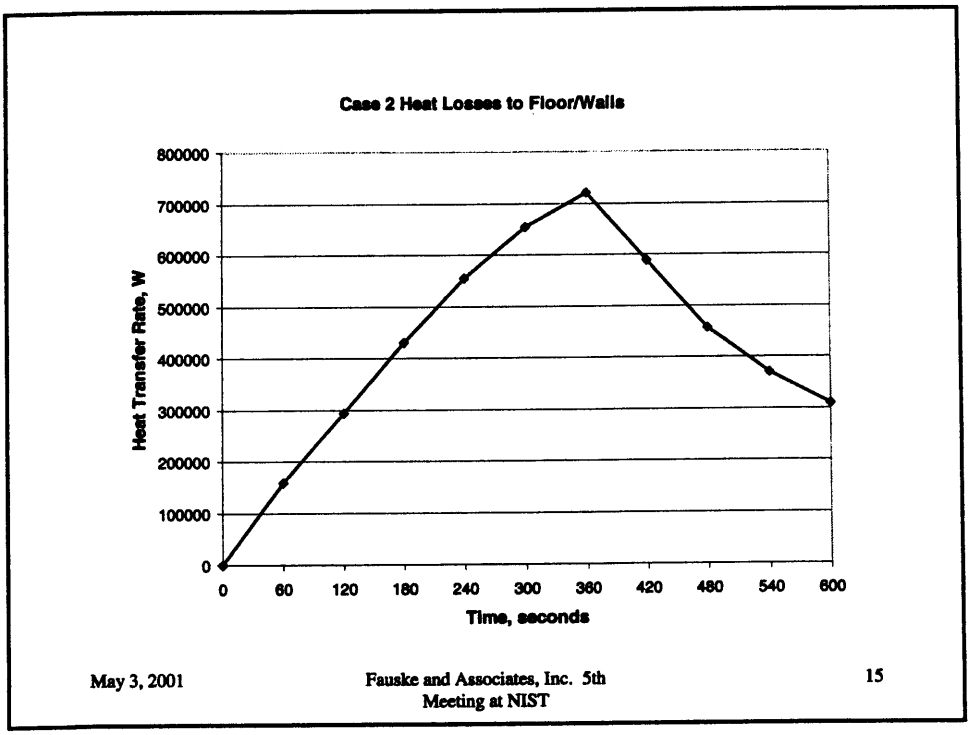
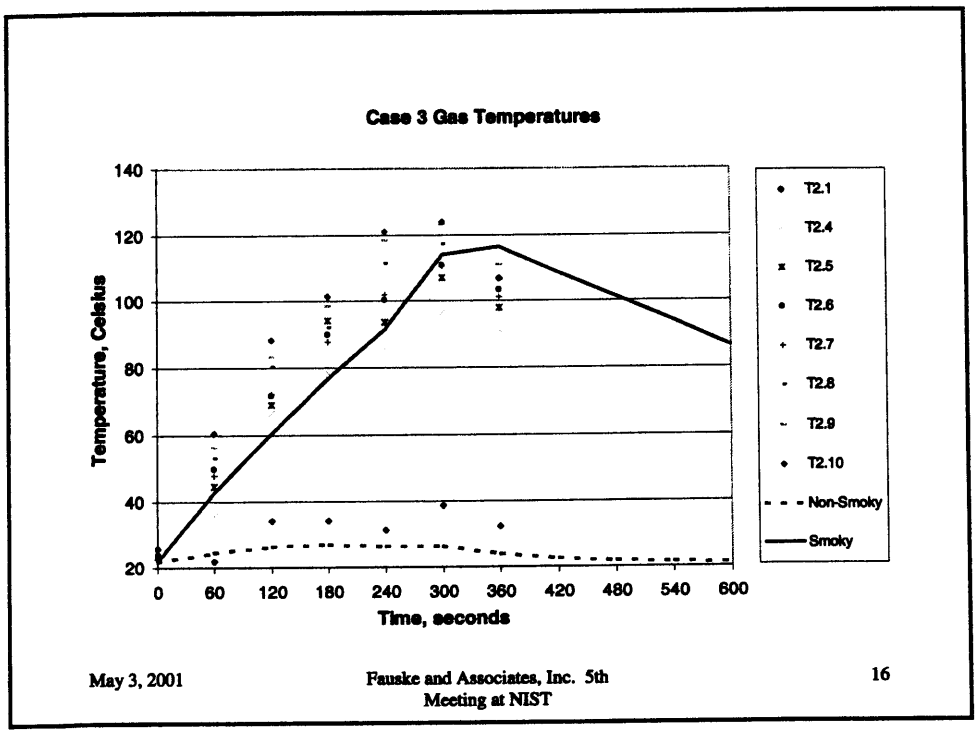
Case 2 Interface Height

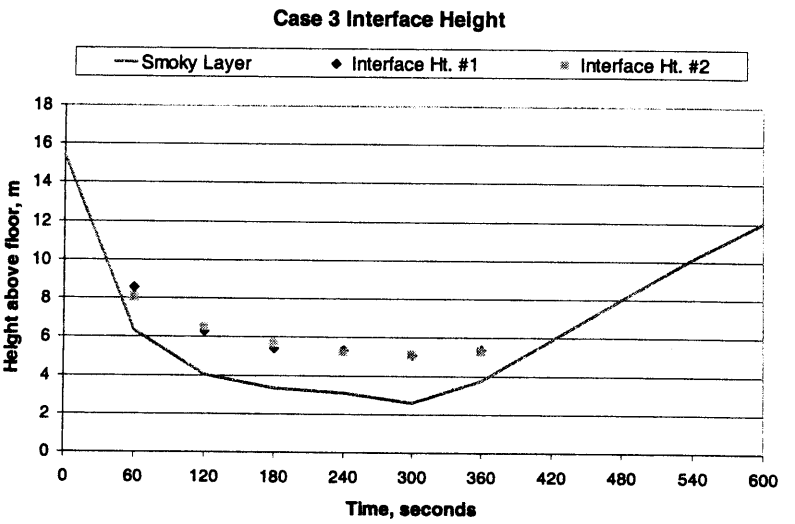


Case 2 Flowrates




Case 2 Heat Losses to Floor/Walls
Heat Transfer Rate, W
800000
700000
600000
500000
400000
300000
200000
100000
0
0
60
120
180
240
300
360
420
480
540
600
Time, seconds


Case 3 Gas Temperatures
Temperature, Celsius
140
120
100
80
60
40
20
0
60
120
180
240
300
360
420
480
540
600
Time, seconds
T2.1
T2.4
T2.5
T2.6
T2.7
T2.8
T2.9
T2.10
Non-Smoky
Smoky



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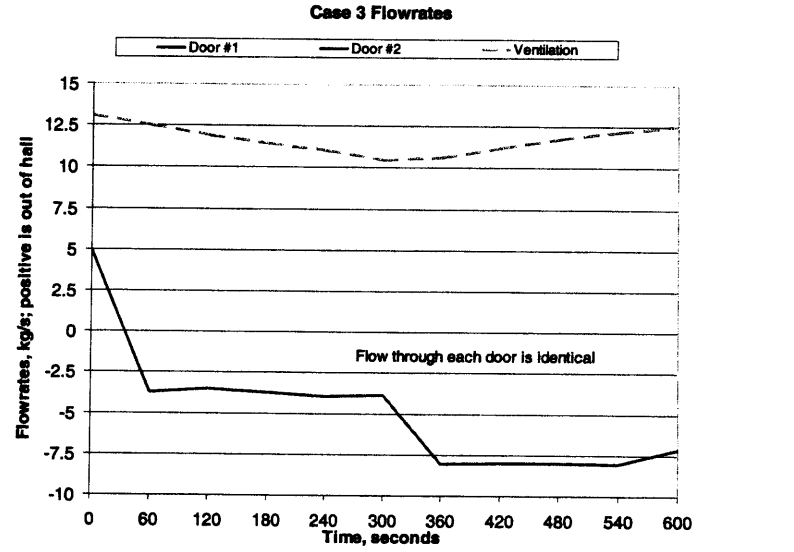

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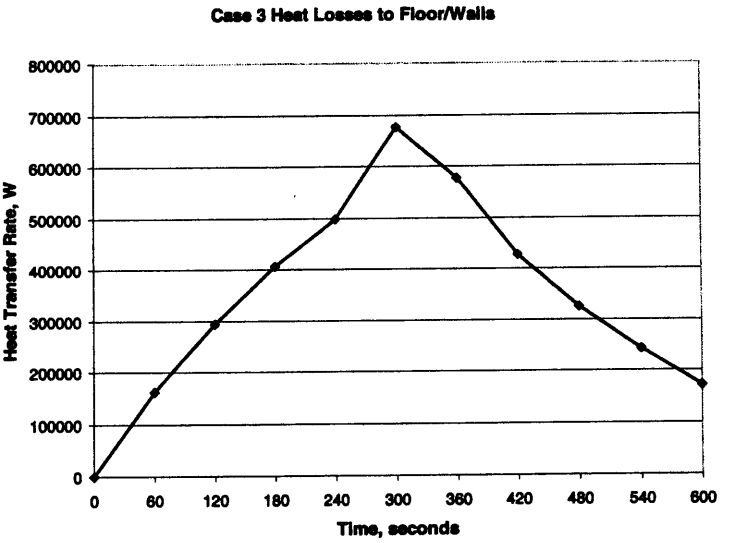

Results Summary

- **Non-smoky layer temperatures are low**
  - **Radiation neglected**
  - **Problem specification for junctions creates a chimney effect that brings cold air into the non-smoky layer**
- **Junction specification creates no pressure differential between the hall and the environment**
- **Parametric studies for leakage areas and infiltration are desirable**
- **Smoky layer temperatures are in good agreement**
  - **need to include the 80/20 split between convection and radiation and consider absorptivity**

Future Work

- **Parametric studies of leakage and infiltration**
- **Radiative aspects of the problem; set up radiation networks to better model gas and heat sink temperatures in the non-smoky layer, and target temperatures**
- **Smoky layer absorptivity**
- **Report plume temperatures**
- **Volume vs. height relationships for regions**