SAND2008-0423P

Large Calorimeter Fire Testing

KHNP Training Program
Module 13: Transportation of Nuclear Materials

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Sandia National Laboratories

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.

Introduction

- A calorimeter the size of a SNF rail transport cask was designed to study the thermal response of a large object in a 10CFR71 regulatory fire
- Three large fire tests were recently performed at Sandia
  - July 12, August 1, and September 13, 2007

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Purpose of the Tests

- To acquire thermal data for the benchmarking of computer models and techniques currently being used for assessing the thermal effects of regulatory and extra-regulatory fires on transportation packages

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Casks vs. Calorimeters

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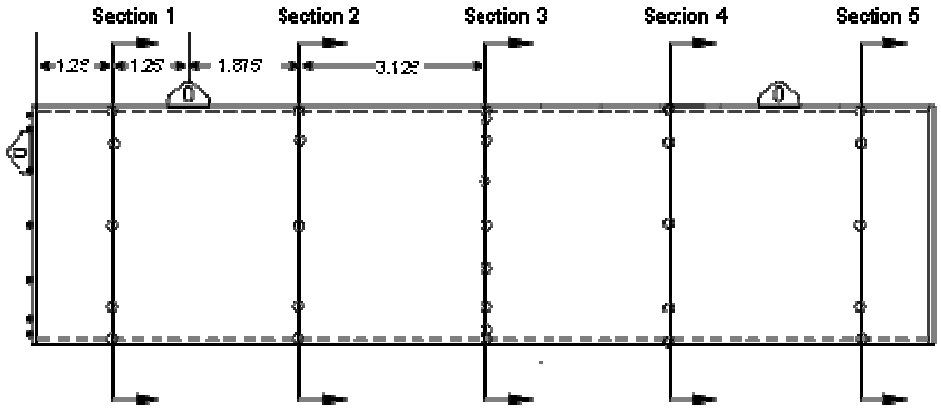
A Different Test…

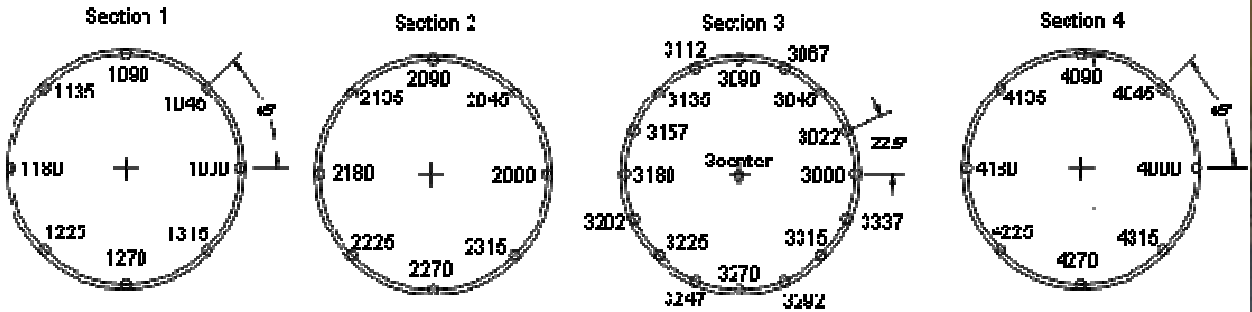
- Largest diameter calorimeter tested at Sandia
  - Typical calorimeters used at the burn site are about 18 inches in diameter or smaller
- Heavily instrumented Test – over 150 data channels
  - 71 internal TCs, 16 HFG, 3 DFP, 20+ external TCs, 12 three-dimensional ultrasonic anemometers, …
    - Some TCs embedded into the calorimeter wall
- In 2000 Sandia and UNR performed two fire tests with a calorimeter the size of a truck cask
- The new tests were performed with a larger calorimeter representing a rail cask.
  - The larger calorimeter:
    - Obstructs more the buoyant flow of hot gases
    - It acts as a heat sink for longer duration than the smaller calorimeters

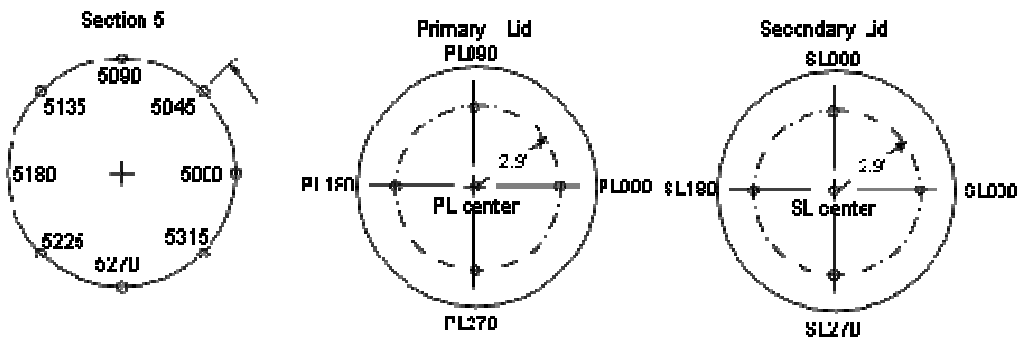
Calorimeter Design

- **Size**
  - **8 feet in diameter**
  - **15 feet long**
  - **1 inch thick wall**
- **One inch thick carbon steel wall allowed to measure variable heat absorption rate for about 30 minutes**
  - **After 30 minutes the wall temperature would be in quasi-steady state if the fire thermal environment doesn't change**

Calorimeter Design (cont.)







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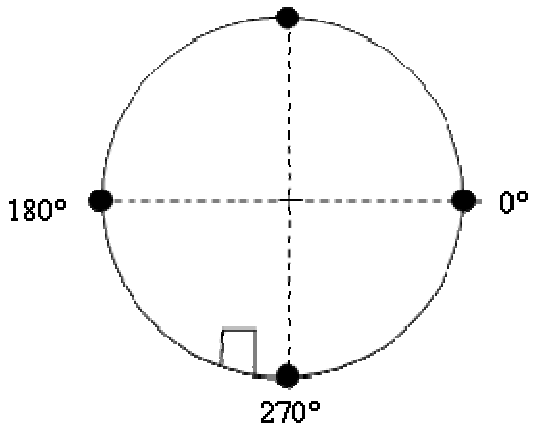
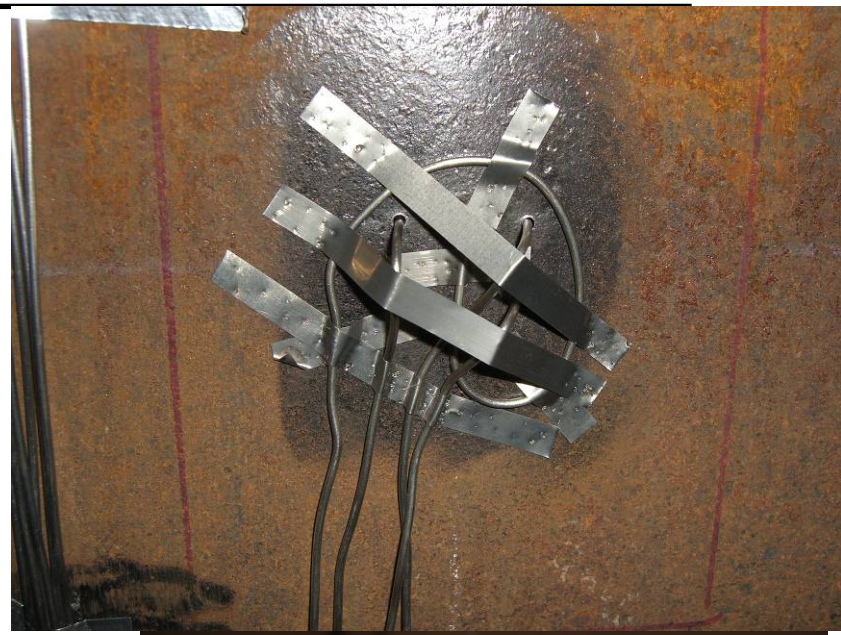
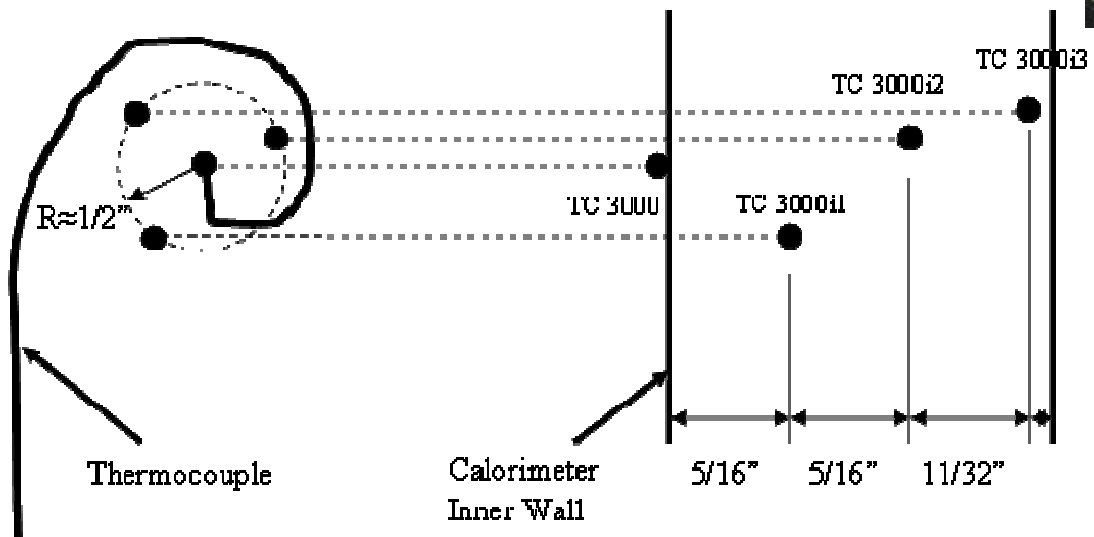
Calorimeter Design (cont.)

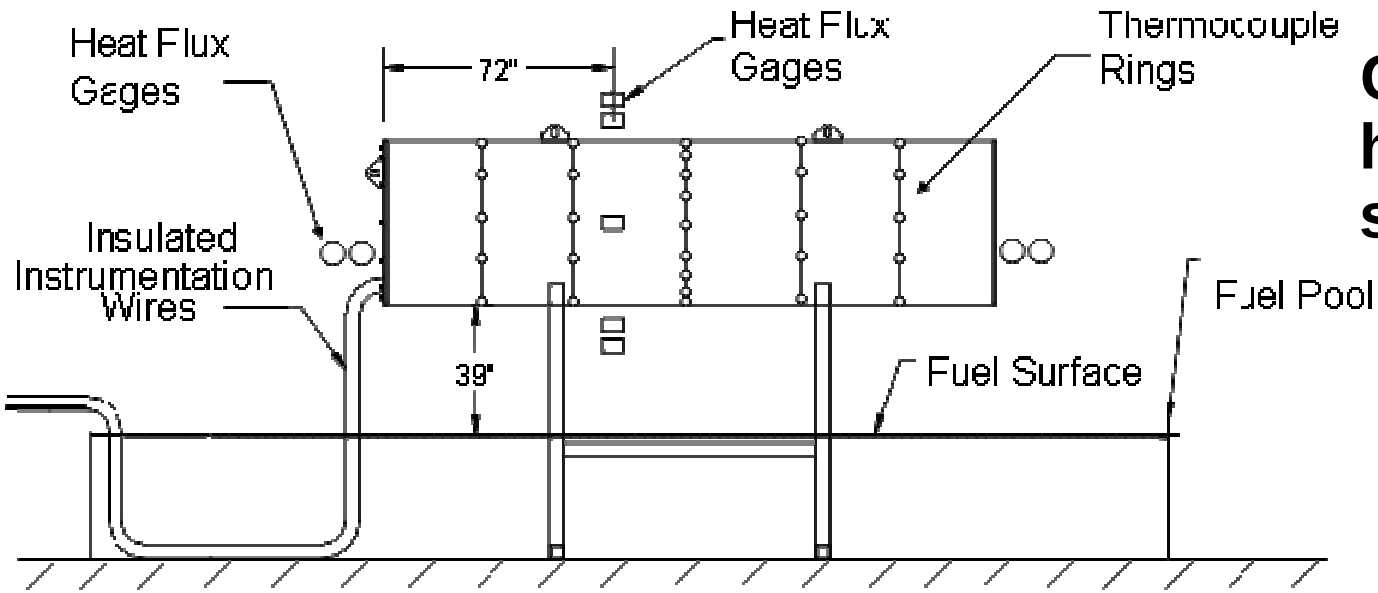


Section 3

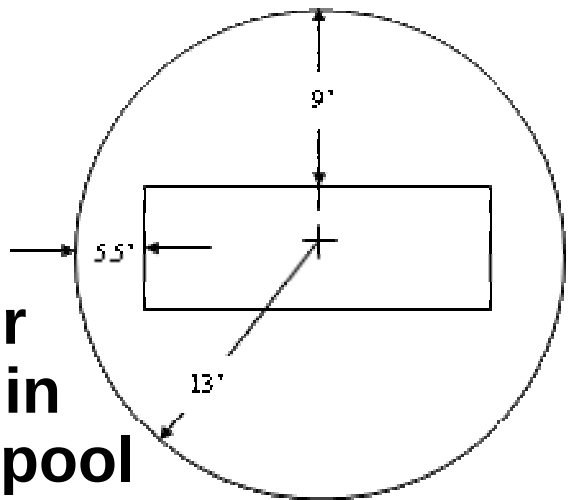




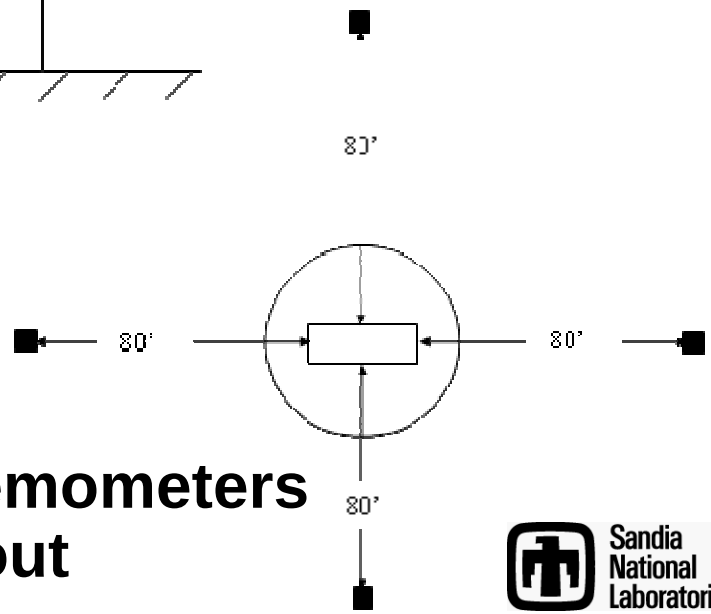
Test Layout



Calorimeter and heat flux gages setup



Calorimeter placement in round fuel pool



Anemometers layout

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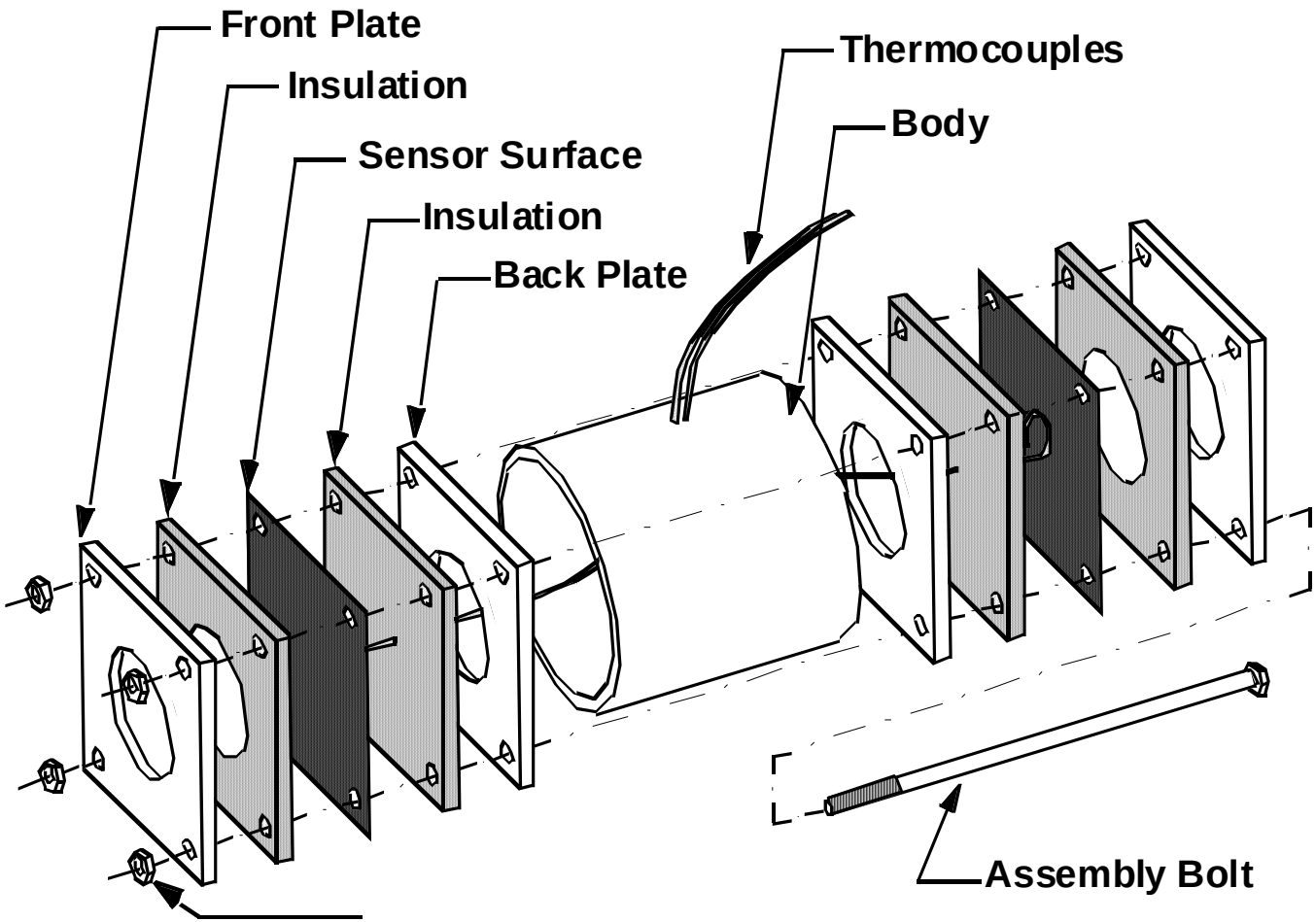
The Sandia Heat Flux Gage



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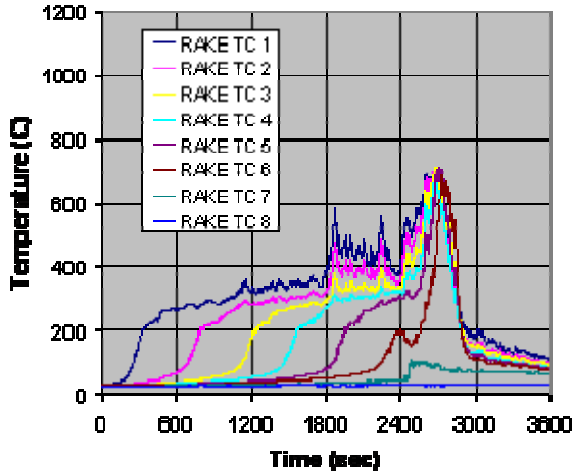
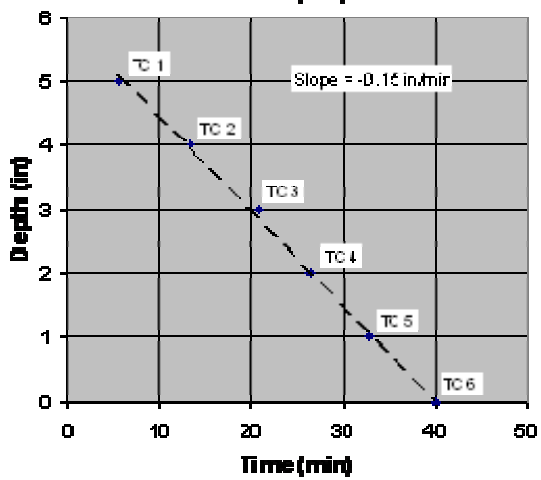
Thermocouple Rake

- TC rakes help estimate a time-varying fuel regression (evaporation) rate during a fire test





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Directional Flow Probes

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Ultrasonic Anemometers

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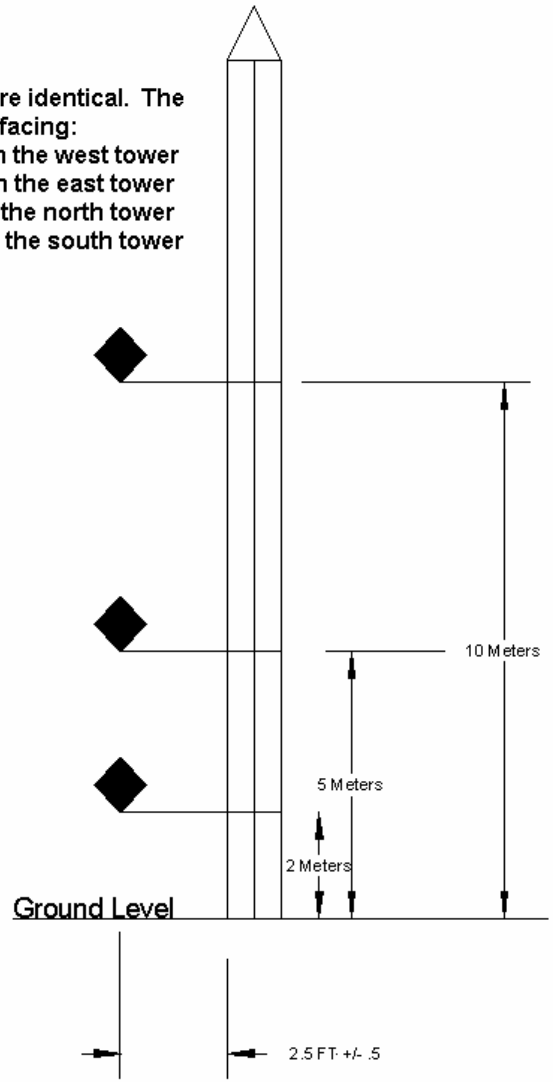
Location of Anemometers on Towers

Towers were identical. The arms were facing:
(a) north on the west tower
(b) north on the east tower
(b) east on the north tower
(c) west on the south tower



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Data Acquisition

Mobile Instrumentation Trailer

Underground Connection Panel

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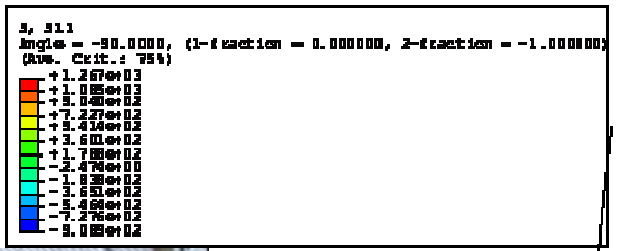
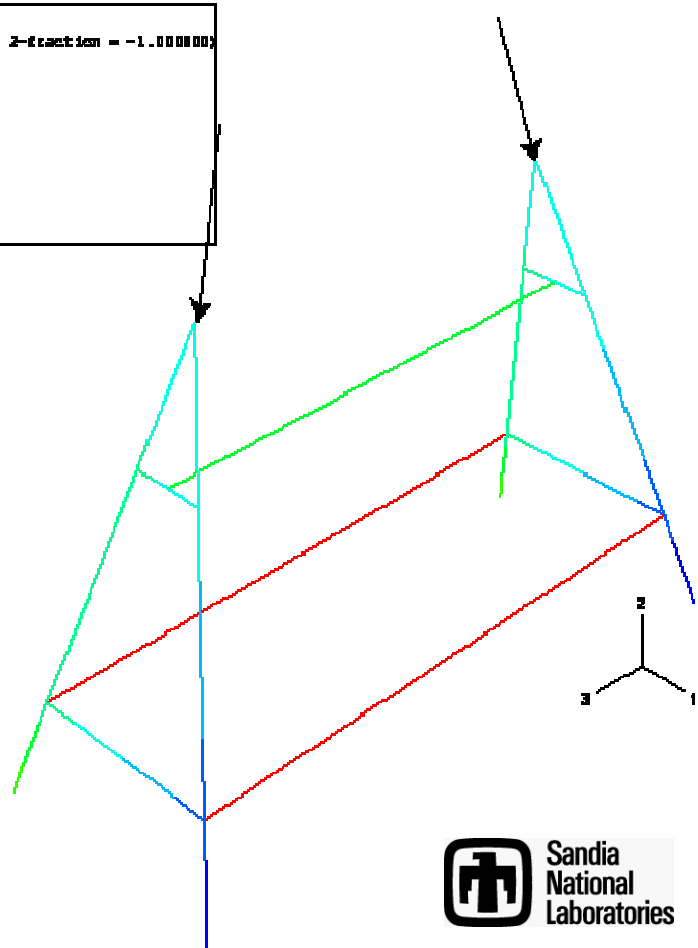
Structural Analysis of Stands

- **Available stands were analyzed to verify their structural integrity while exposed to the fire**





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Setting Up…

Calorimeter Ready to be Cooked!

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Early Morning Tests - Why So Early?

THE Test!

Test Video

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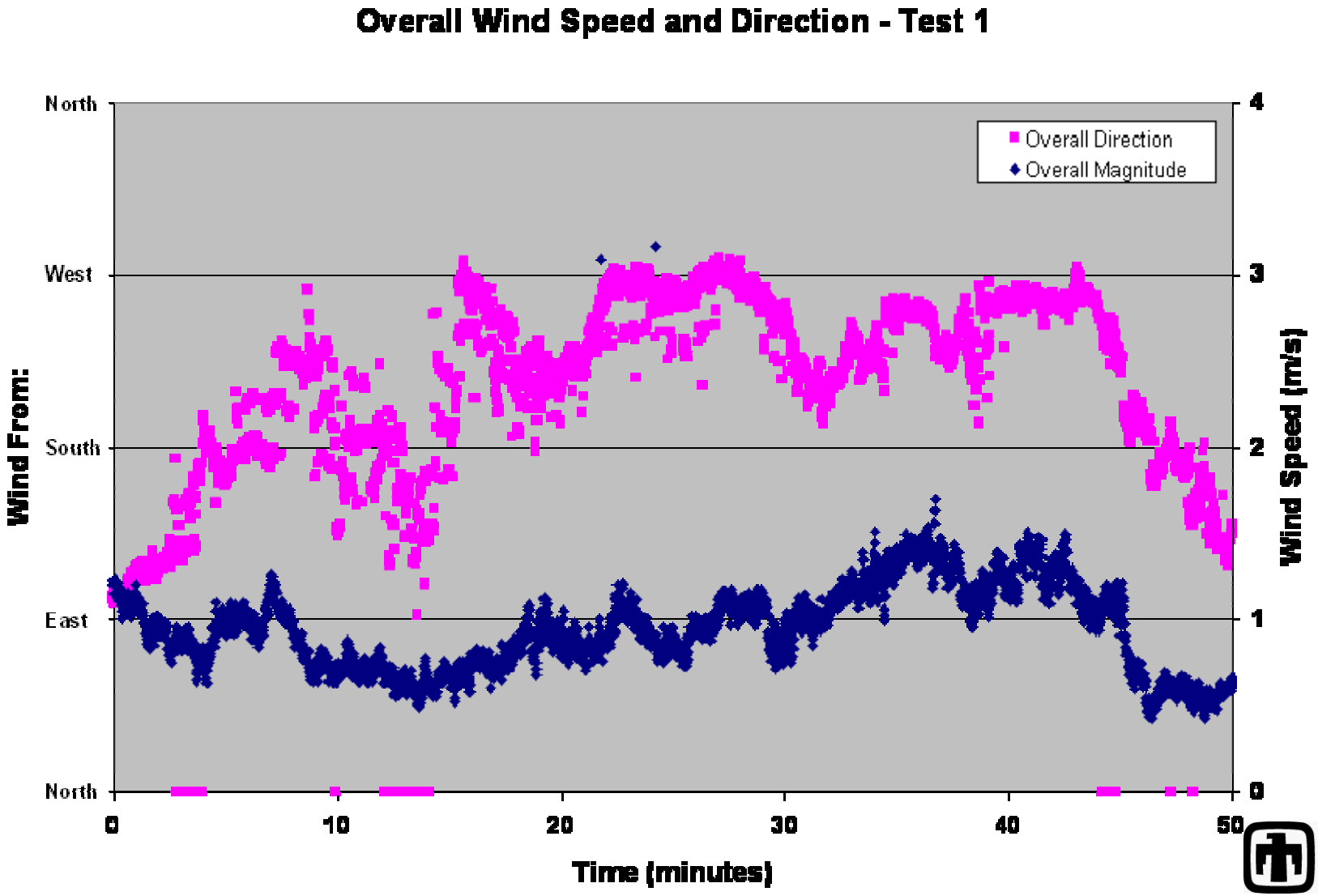
An Intense Fire

Hot Bands

Wind Measurements



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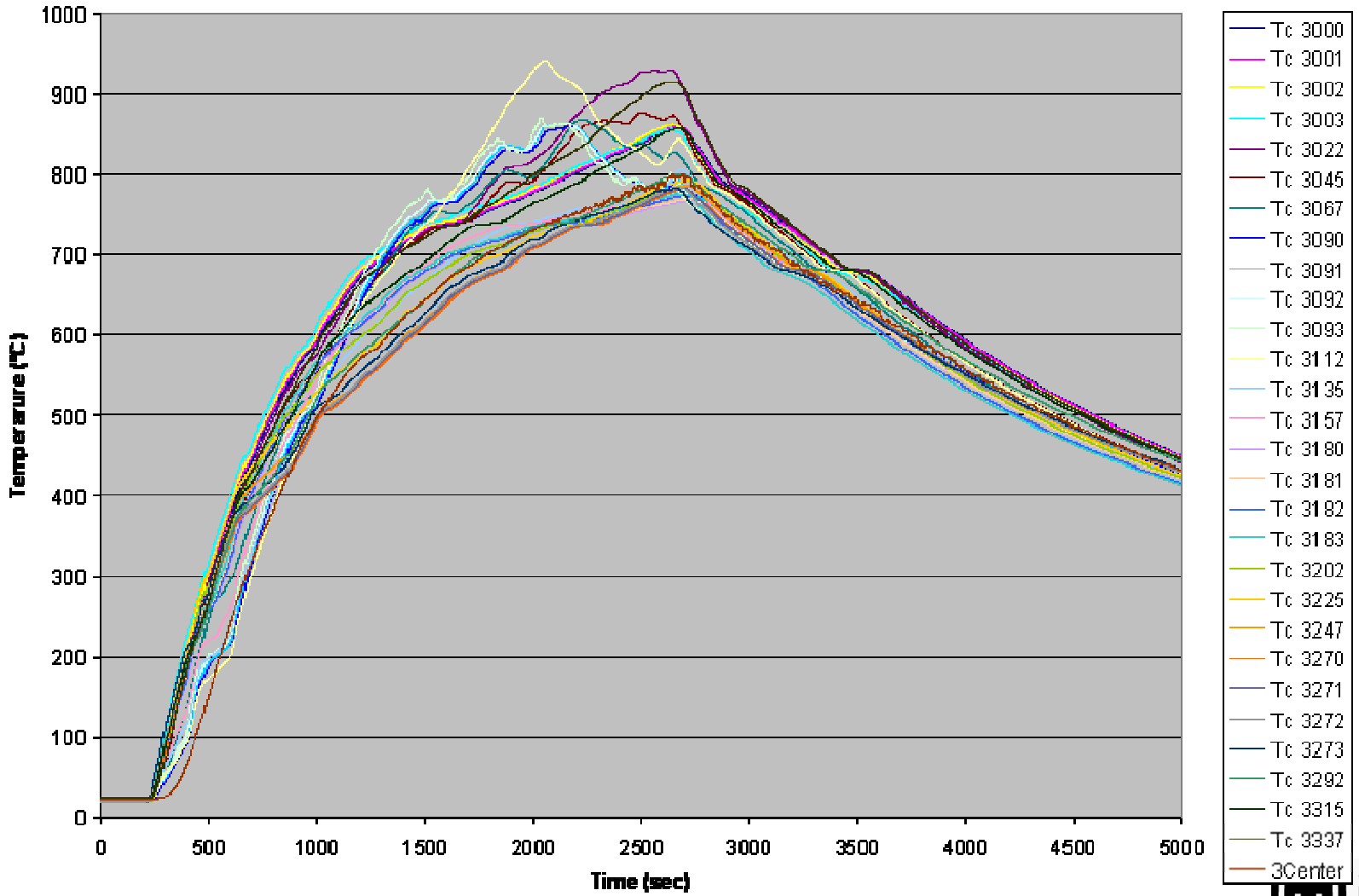
Calorimeter Thermal Response @ Center



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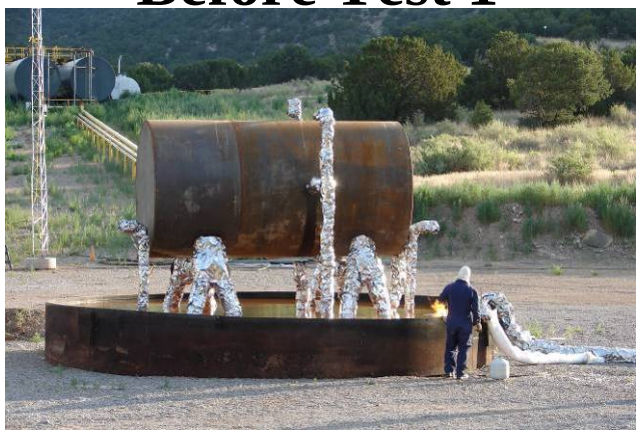
Soot on Calorimeter Before and After Each Fire

Before Test 1



After Test 2

After Test 1 (Before Test 2)

After Test 3

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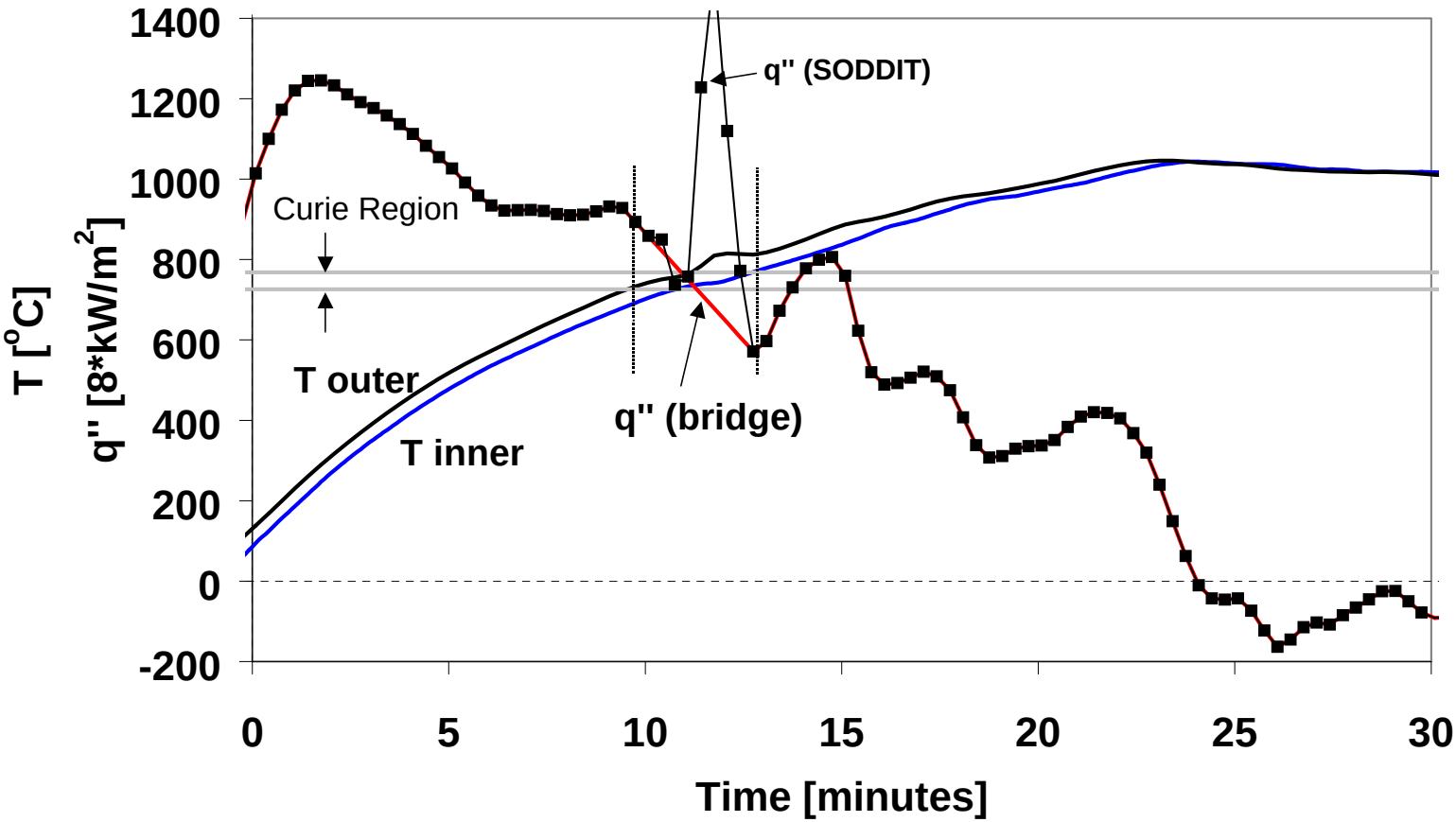
Inverse Heat Conduction – Heat Flux Estimation



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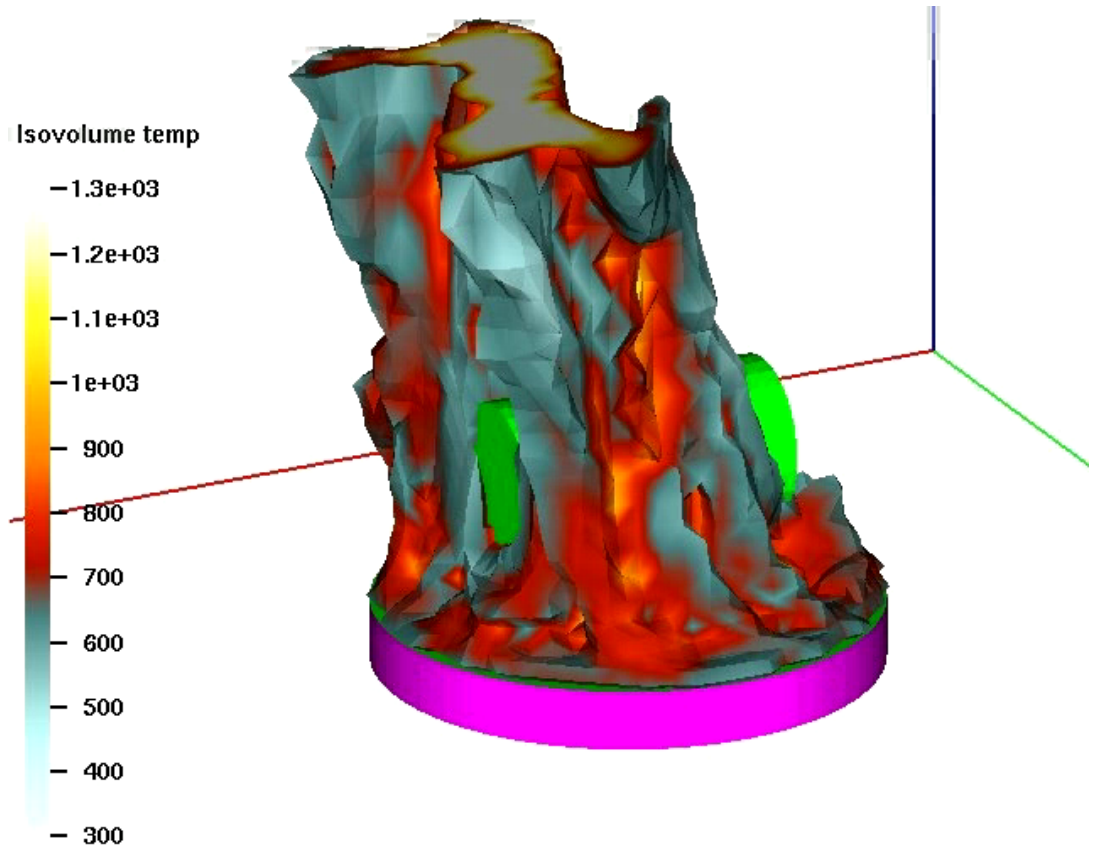
CAFE Fire Simulation – Code Benchmarking



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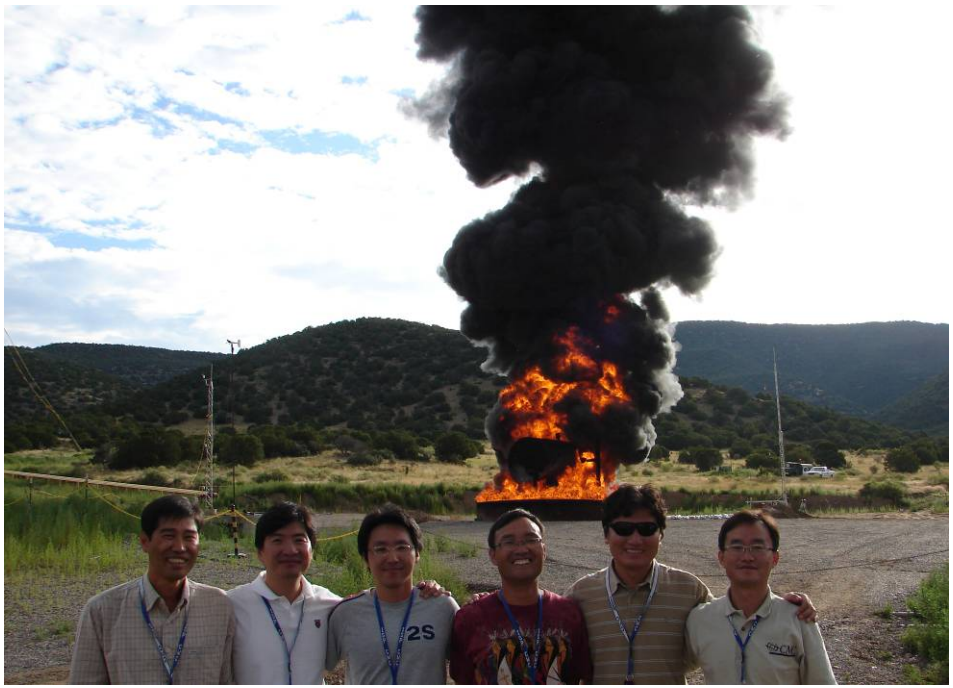
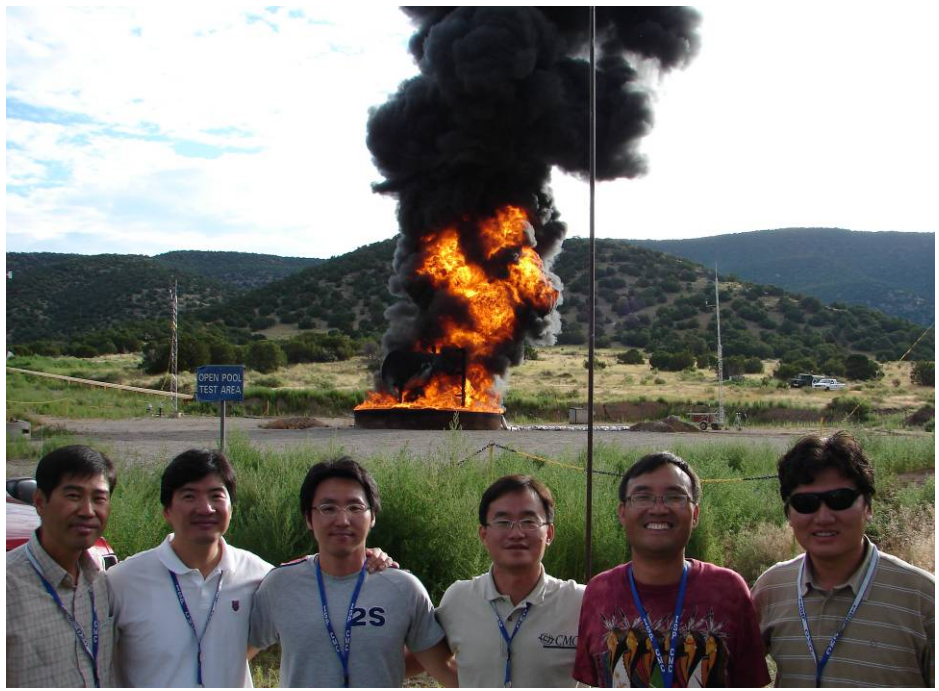
KHNP Trainees Witness Fire Test at SNL





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Questions?

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