Instrumentation of Liquid Fuel Fires

K.P. Ford, A.I. Atwood, J.M. Grey, J.E. Wilson, M.T. Gennrich, A.L. Daniels, E. Woods, and C.J. Wheeler
Naval Air Warfare Center Weapons Division
China Lake, California

J.J Yagla, D. Griffiths, and J.F. Busic
Naval Surface Warfare Center
Dahlgren, Virginia

Objectives

- Improve test methodologies and instrumentation to allow for comparisons among test sites and test methods
  - Identify heat fluxes found in fuel fire and ranges that the ordnance item sees
    - JP-8
    - Kerosene
    - Wood
- Explore feasibility of alternative fuel (e.g., propane)

Liquid Fuel Fire

- Required
  - Hazard Classification
    - External Fire/Bonfire Test
      - 1.1, 1.2.X, 1.3, 1.4, 1.6
  - Insensitive Munitions
    - Fast Cook-off

STANAG 4240

- Temperature Requirements
  - 550°C in 30 seconds
  - Average Flame Temperature 800°C
- Wind velocity ≤ 10 km/hr
- Burn – 150% Reaction Time
- Instrumentation
  - Temperature (Forward, Aft, Starboard, Port)
  - Blast or Pressure Gages
  - Thermal Flux for HD 1.3 and 1.4
  - Video

Background

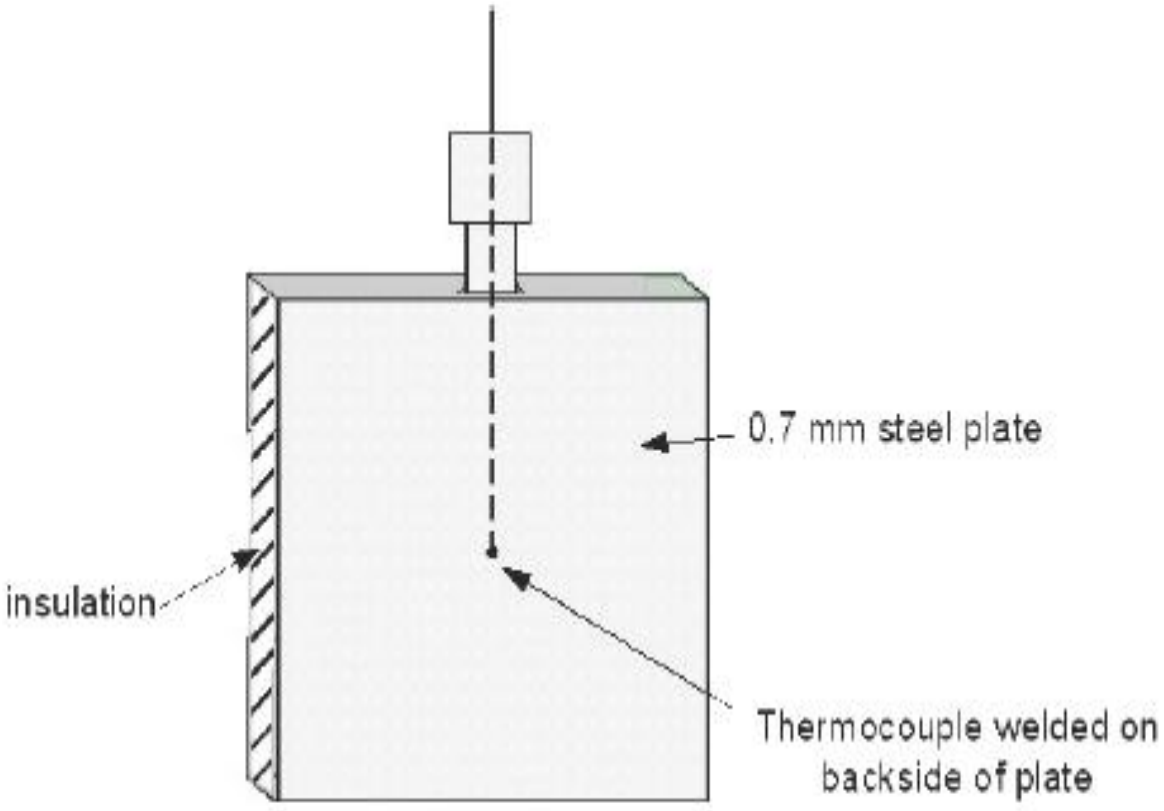
- Increased Environmental Regulation has limited the use of Liquid Fuel Fires due to soil, ground water contamination, air quality
  - Canada
  - Sweden
  - Germany
- Development of Alternates
  - Propane
- Meppen, Germany – Feb 2010
  - AOP-39 has only a temperature requirement
    - Temperature should not be the only metric
    - Lack of Heat Flux data for Liquid Fuel Fires

Approach

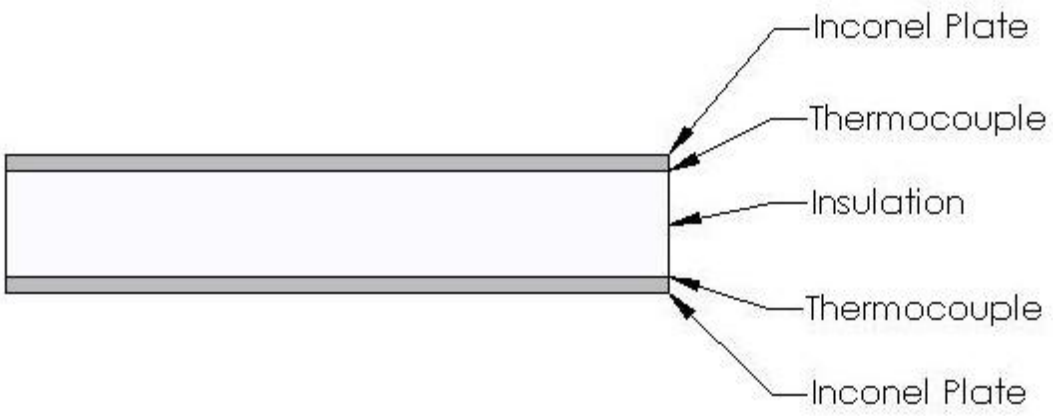
- Measure heat fluxes in different fuel fires (JP-8, Kerosene, and Wood) using different sensors
  - Plate Thermometer (PT)
    - High Temperature Oven Tests
  - Directional Flame Thermometer (DFT)
    - Sandia's Liquid Fuel Fire Testing
  - Virginia Tech's High Temperature Heat Flux Gage (HTHFG)
- Develop standard instrumentation suite to characterize fires
- Measured heat fluxes in propane fires for comparison
  - Meppen → March 26-30, 2012

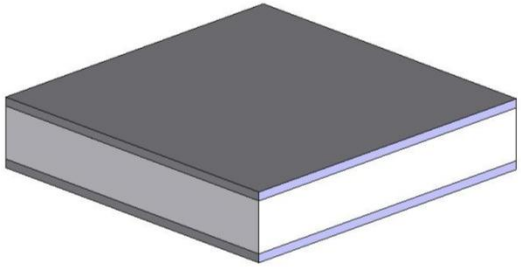
Instrumentation

Plate Thermometer

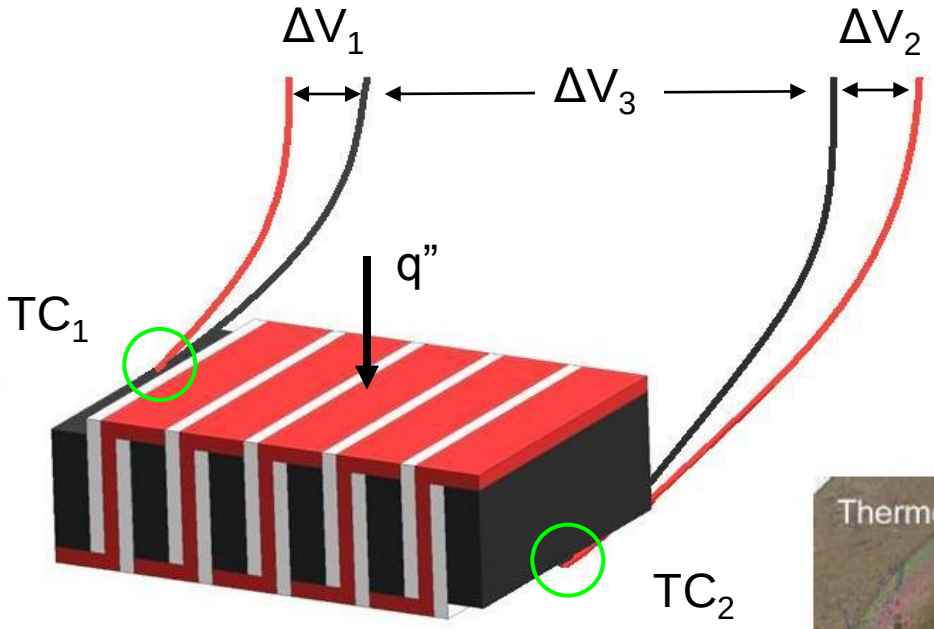


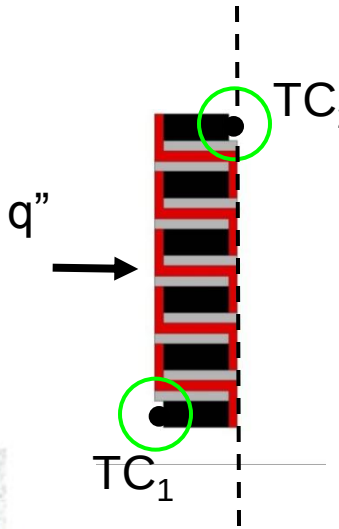
Directional Flame Thermometer





HTHFG – VT Gage

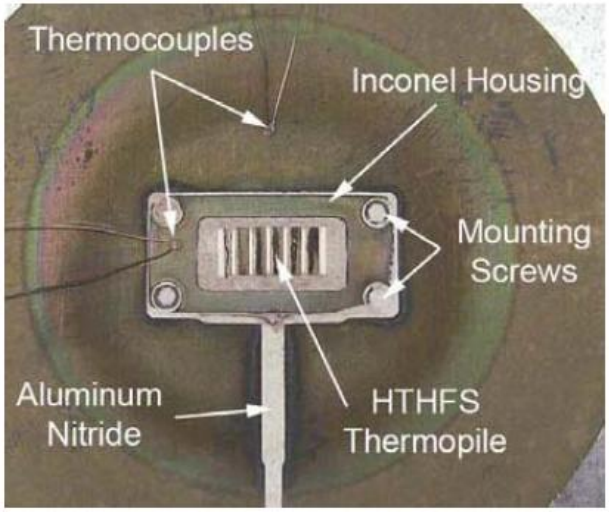




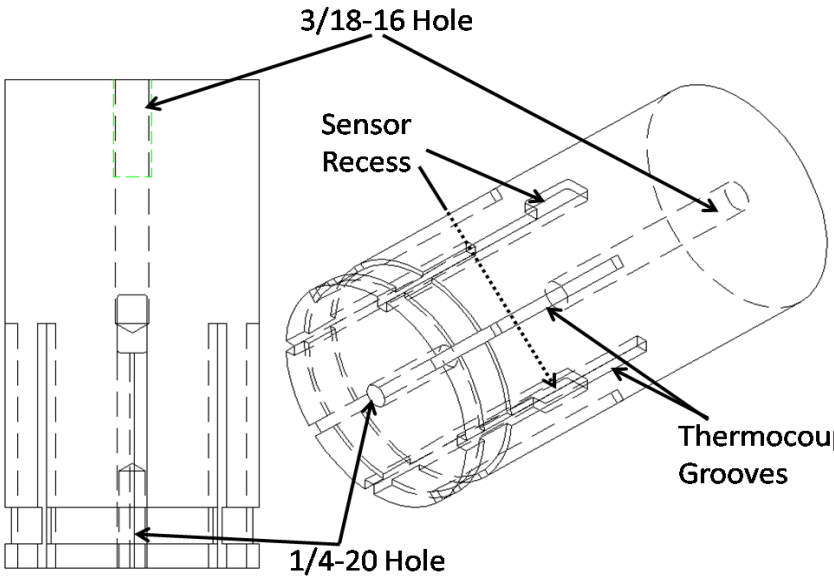
Alumel ®

Chromel ®

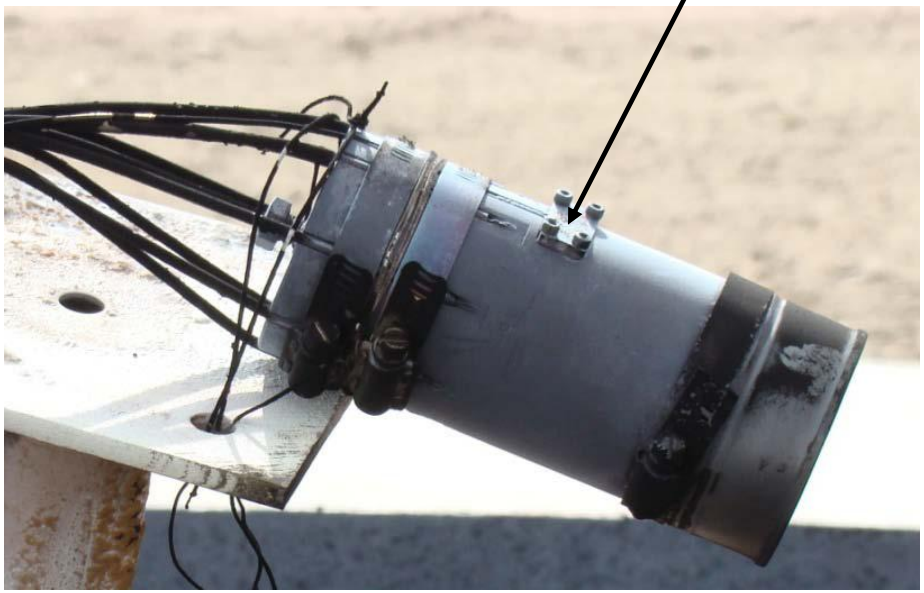
Insulation



VT Test Article



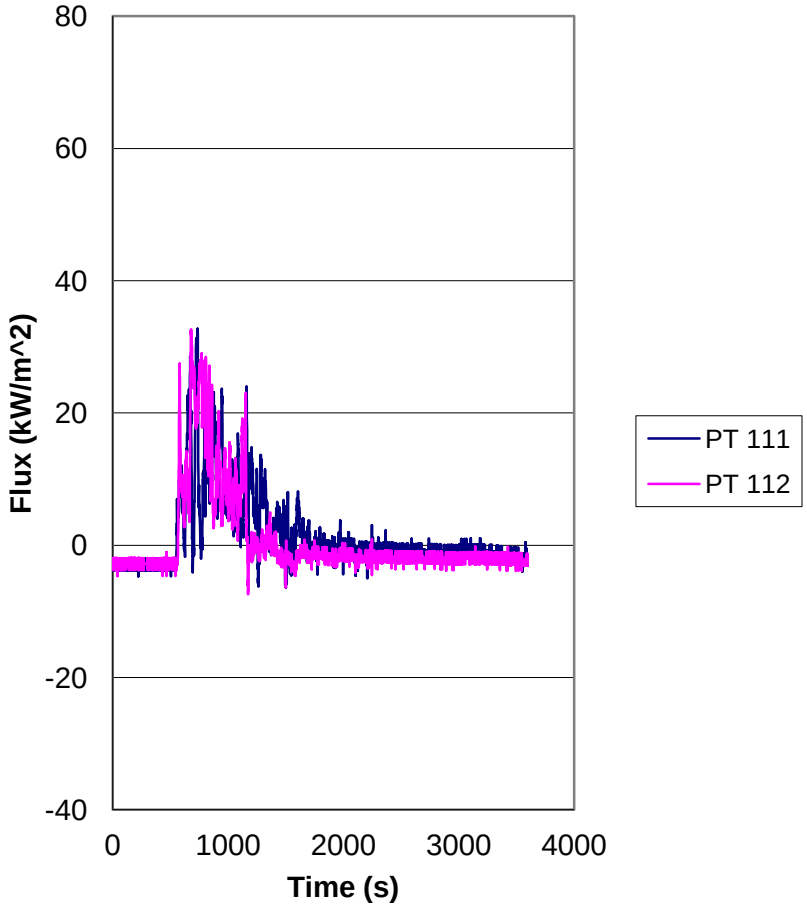
HTHFG - VT

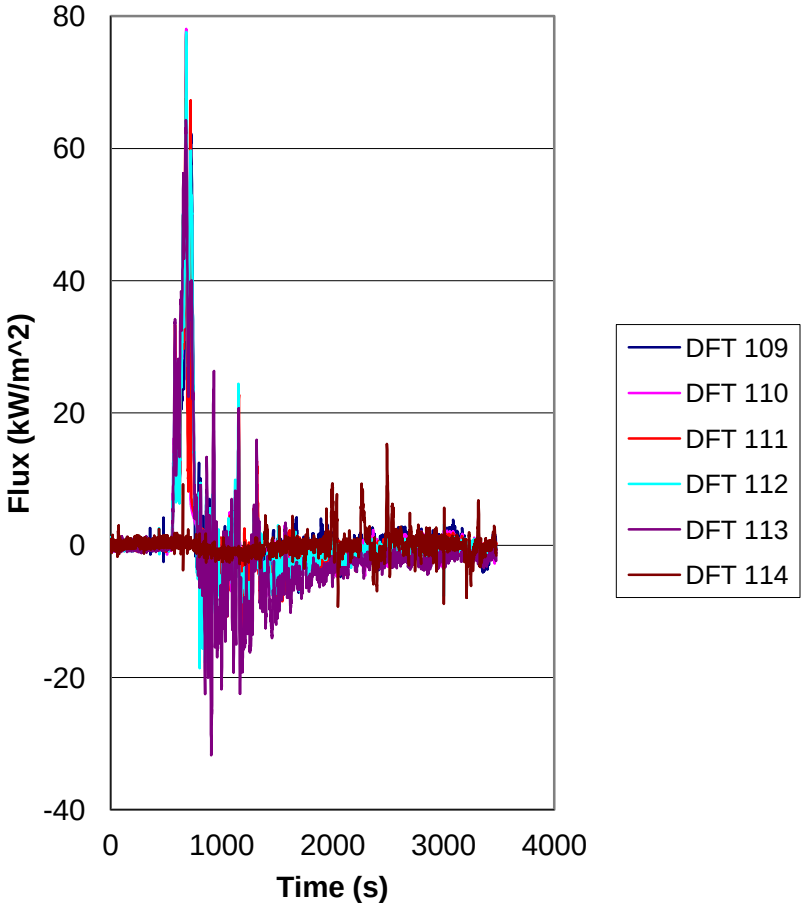


Tests

Wood Fire

PT vs. DFT

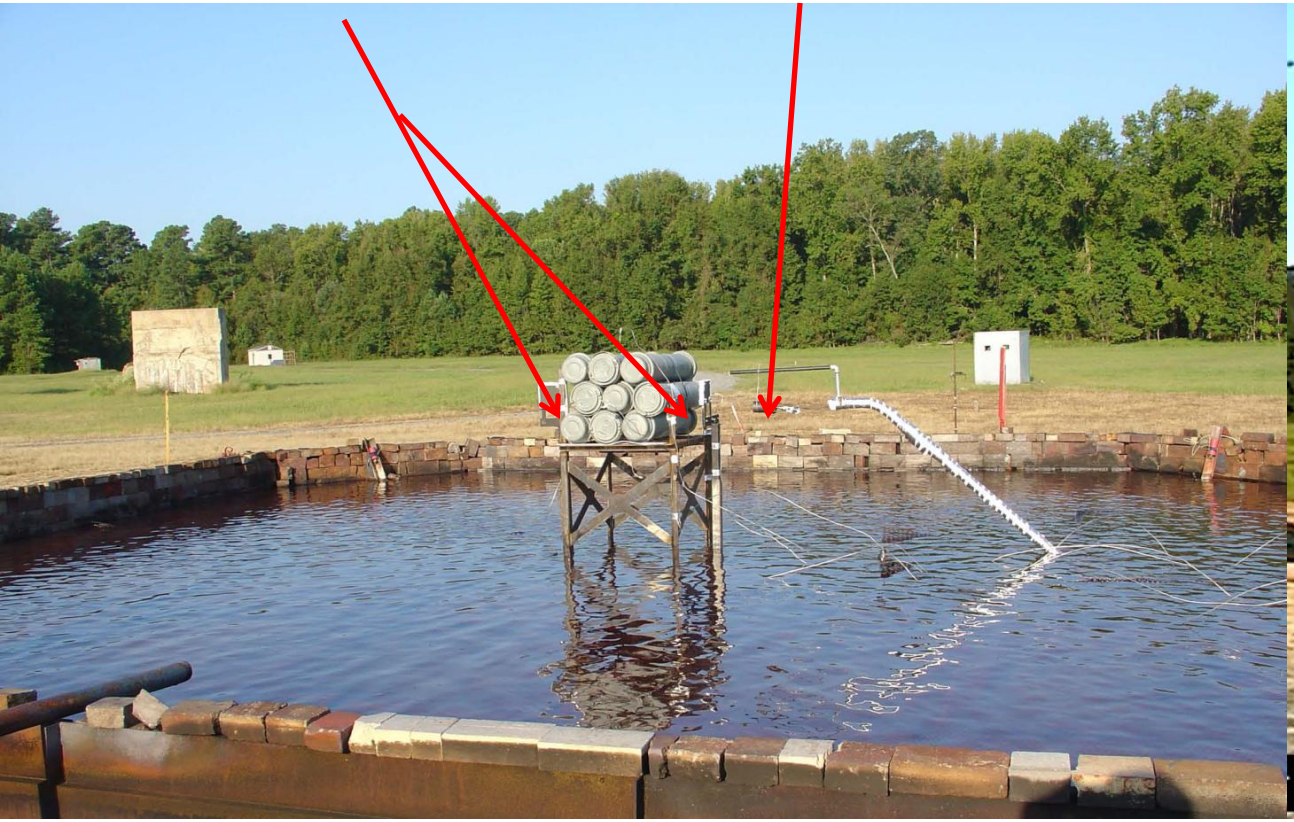




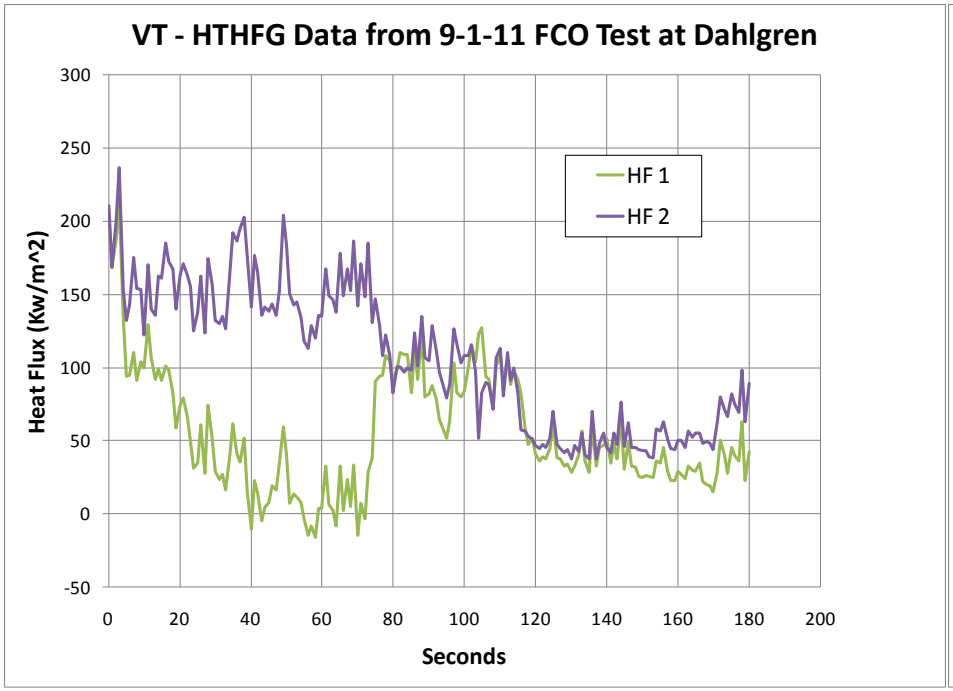
Wood Fire Measured Heat Flux Range: 10-77 kW/m^2

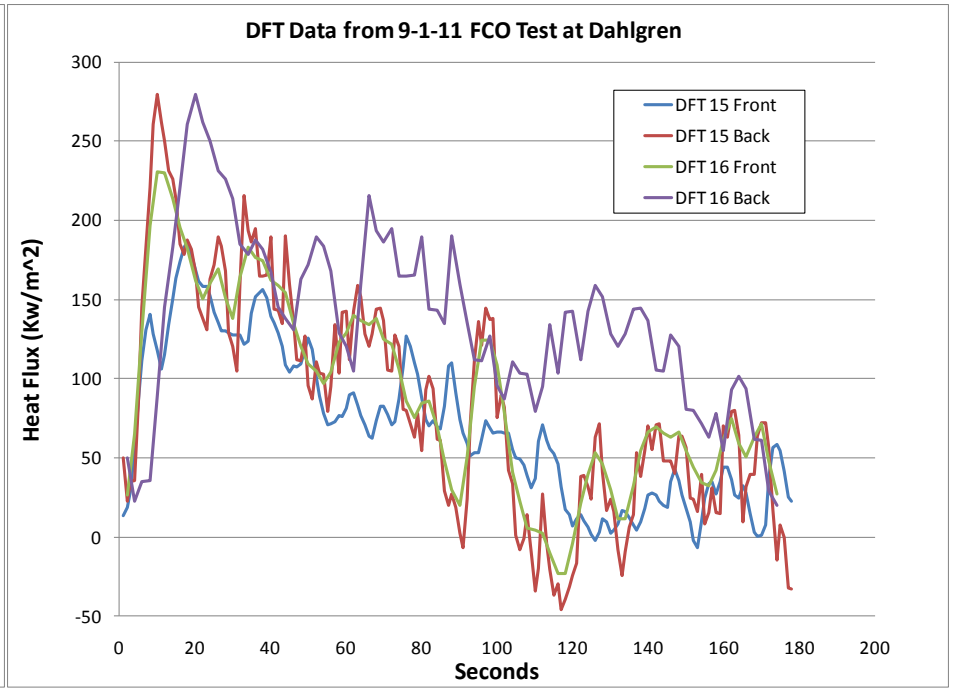
Kerosene Fire

DFT VT



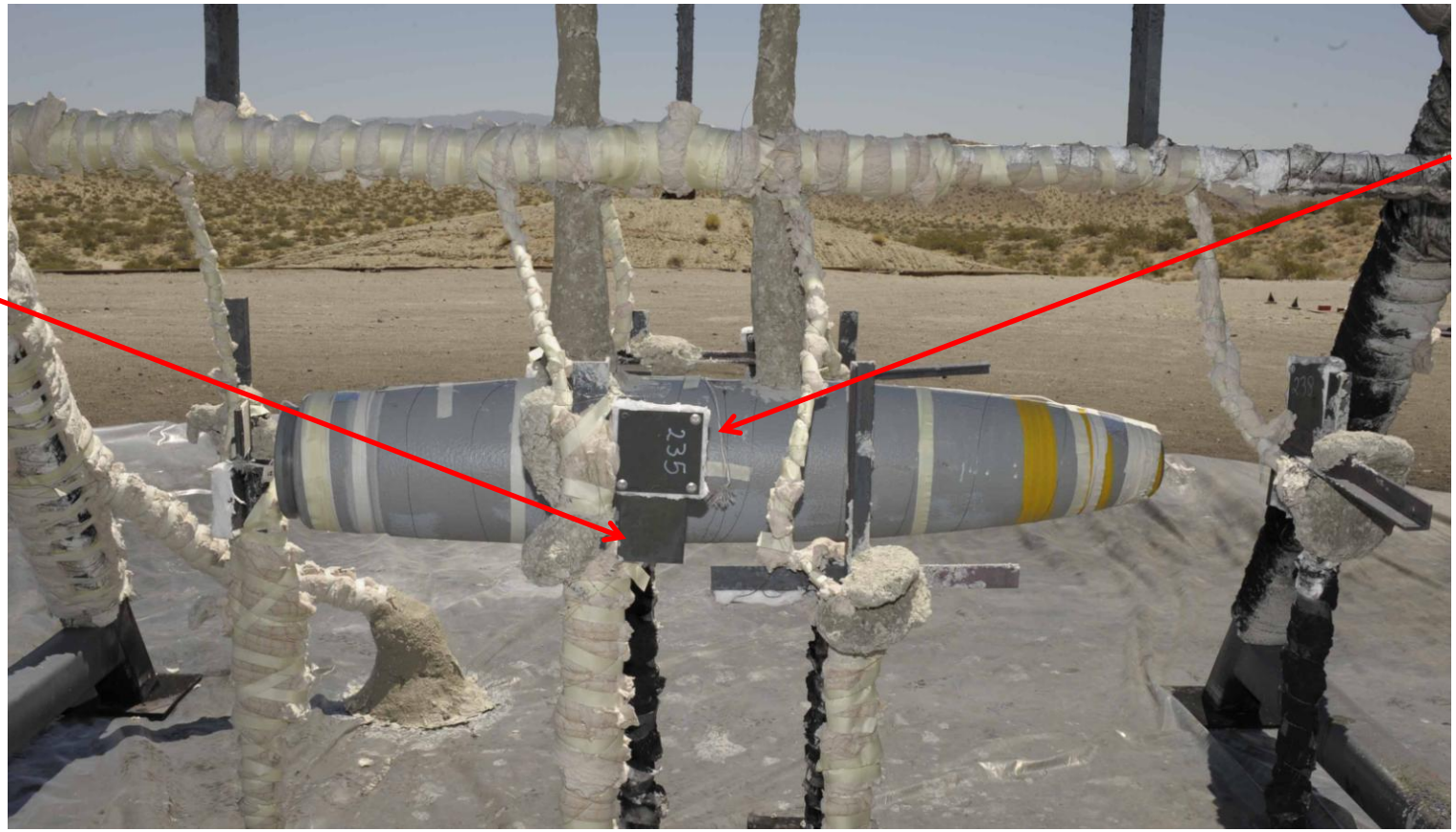
Kerosene Heat Flux Data



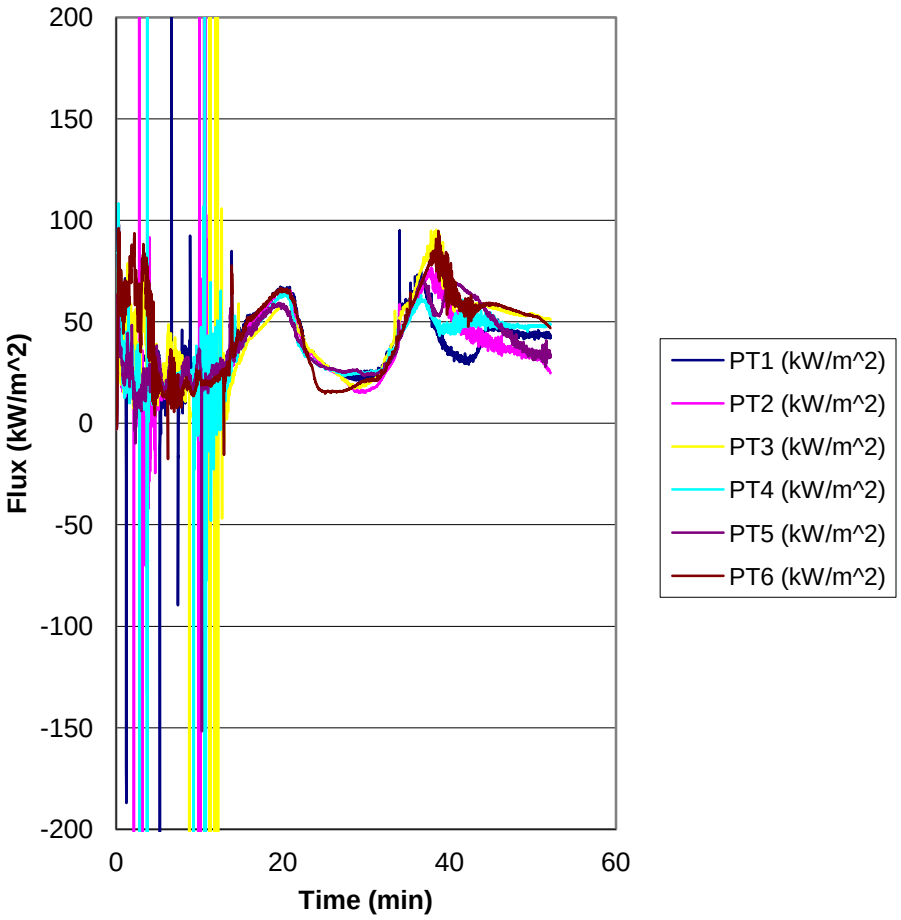


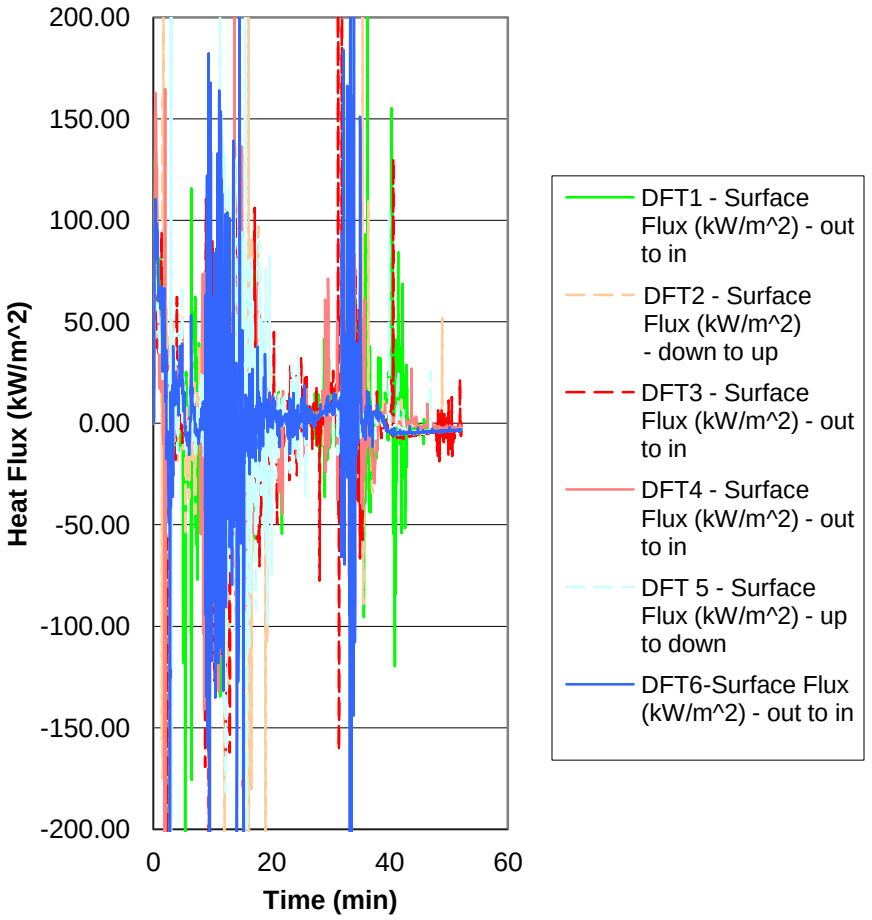
Kerosene Fire Measured Heat Flux Range: 10-324 kW/m^2

JP-8 Fire



JP-8 Heat Flux Data





JP-8 Fire Measured Heat Flux Range: 25-400 kW/m^2

Propane – Next presentation

Meppen Propane Measured Heat Flux Range: 20-134 kW/m^2

Summary

- Increased Environmental Scrutiny need to utilize different fuel for Liquid Fuel Fire Test
  - Heat Flux should be used to evaluate
- Heat Flux Ranges
  - Dependent on wind, location, and orientation
  - 1 Wood Fire
    - 10-77 kW/m^2
  - 4 Kerosene Fuel Fires
    - 10-324 kW/m^2
  - 4 JP-8 Fire
    - 25-400 kW/m^2
  - 8 Propane
    - 20-134 kW/m^2

Future Work

- Continue building heat flux database with JP-8, Kerosene, and wood fuels
- Continue evaluating propane based fuel fires
  - Swedish Device
  - Controlled Heat Flux Device
  - Alternative devices