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Gun and Electric Weapon Systems (E)

Comparing Fire Response of Simulated Rocket Motors in Steel and Carbon Fiber Composite Missile Launching Canisters

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Purpose of Experiment

- Gather comparative data on steel and carbon fiber composite missile launching canisters
- Assess relative performance of steel, aluminum, and carbon fiber composite rocket motor chamber materials
- Obtain data for converging and validating finite element models
- Obtain data for later comparison with propane gas fuel fire cook-off fires

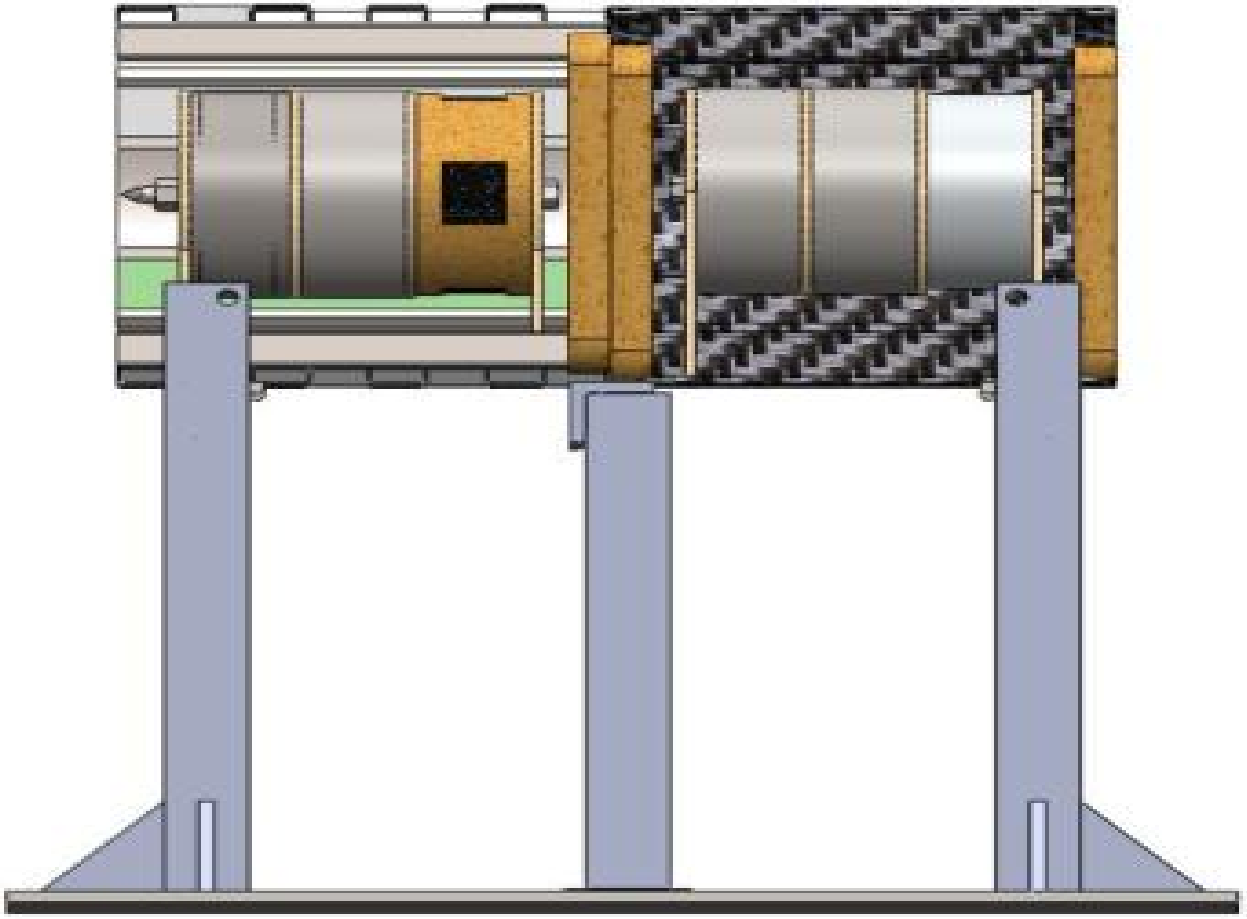
Simulated Steel and Carbon Fiber Composite Canisters in Dahlgren Fast Cook-off Pit

Two canister segments were insulated from each other and joined in the middle of the pit one meter above the fuel. Approximately 80 channels of thermocouple and displacement data were recorded during the test.

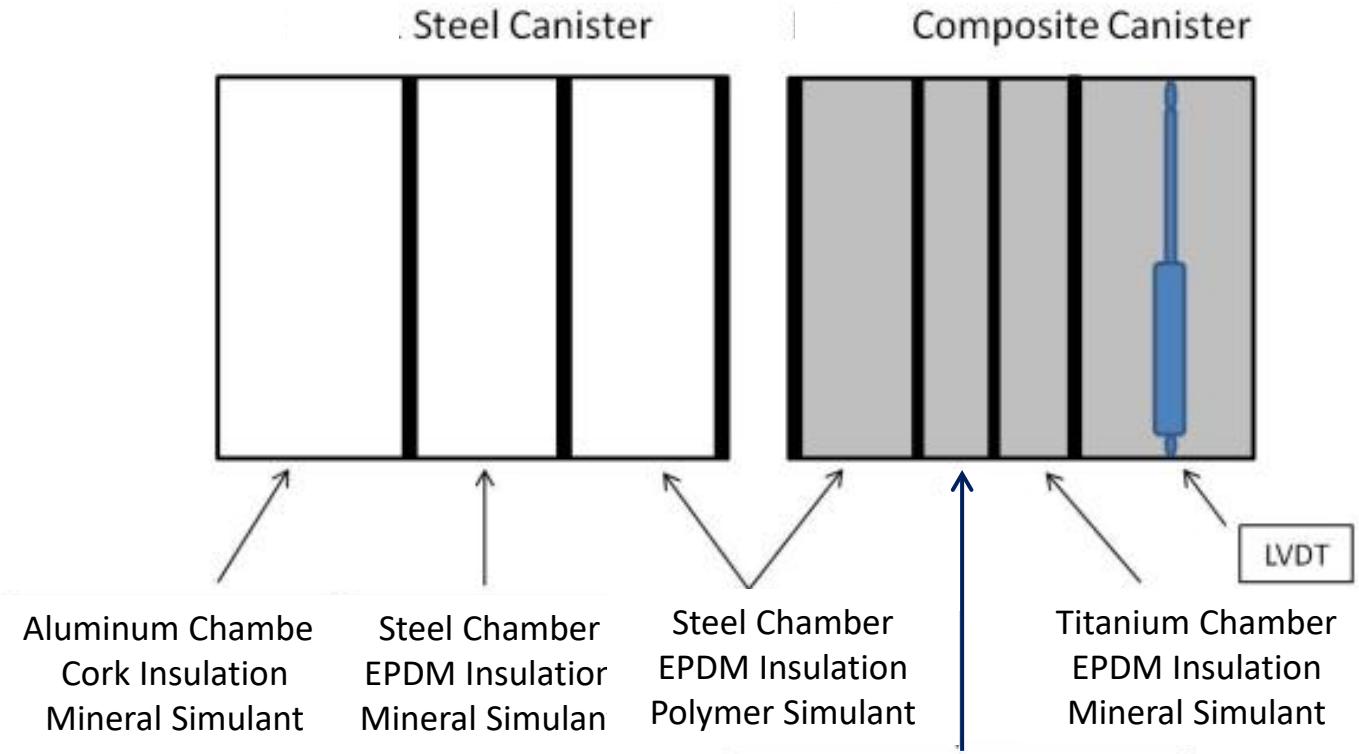
Canisters on Test Stand

Thermocouples were placed inside and outside each face of the simulated canisters to measure the temperature and calculate the heat flux.

Representative Rocket Motor Chambers

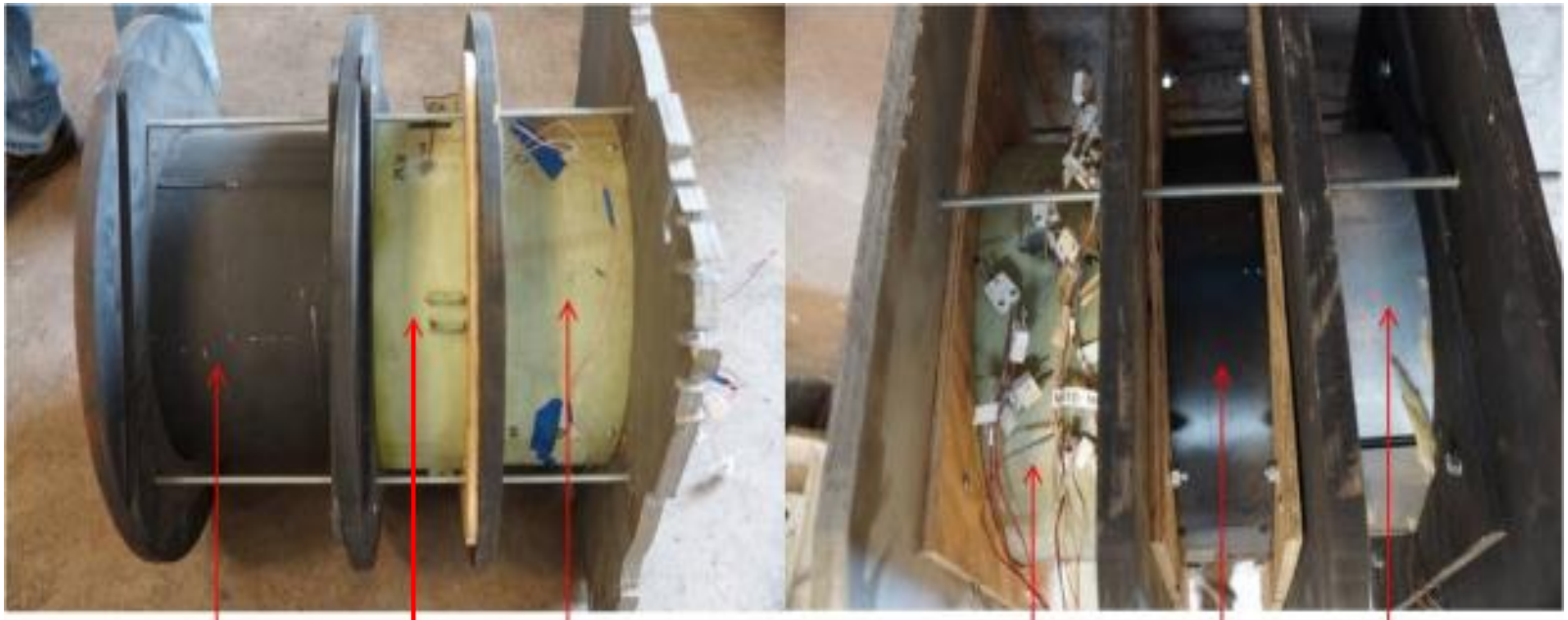


Simulated Motor Chamber Segments



The Linear Variable Distance Transformer (LVDT) measured the sagging deformation of the composite canister

Motor Segments with Instrumentation



Aluminum Chamber
Cork Insulation
Mineral Simulant

Steel Chamber
EPDM Insulation
Polymer Simulantt

Steel Chamber
EPDM Insulation
Mineral Simulant

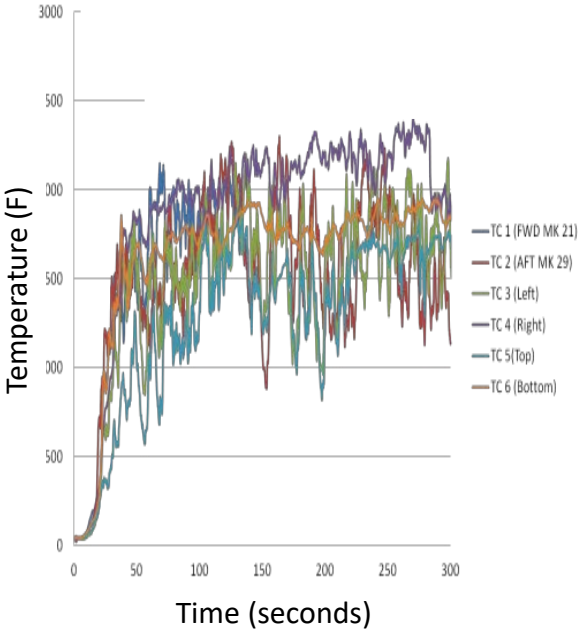
Steel Chamber
EPDM Insulation
Polymer Simulant

Simulated Composite Chamber
EPDM Insulation
Mineral Simulant

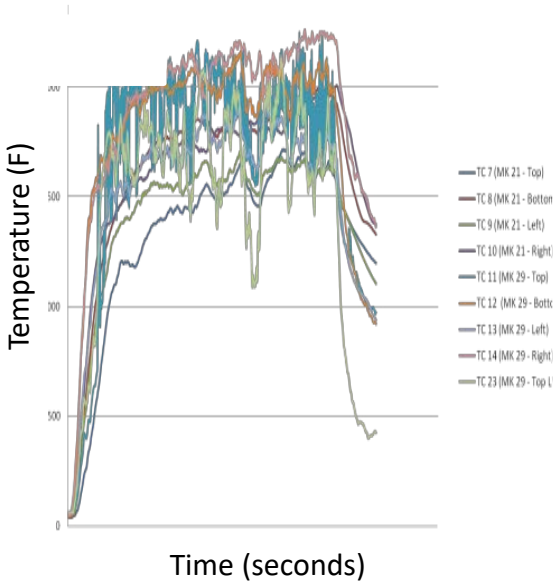
Titanium Chamber
EPDM Insulation
Mineral Simulant

Heat Flow from Fire Through the Canister Walls

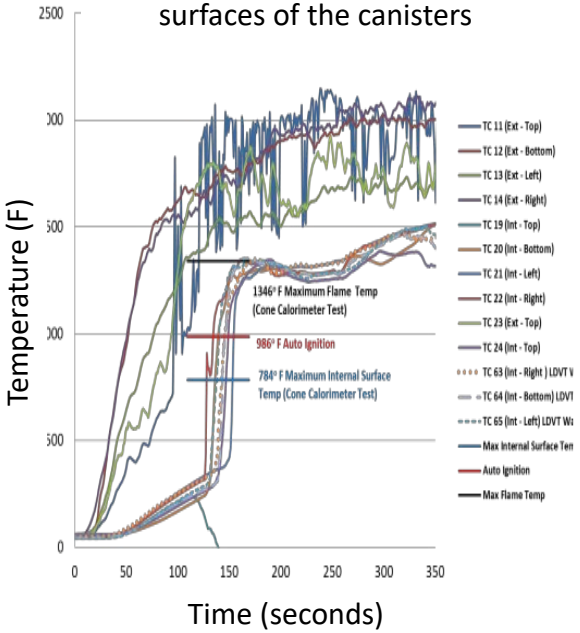
Temperature vs. time of flame



Temperature vs. time of external surfaces of the canisters



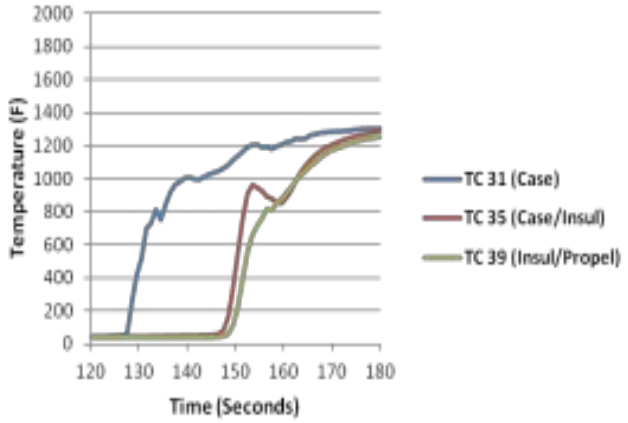
Temperature vs. time of internal surfaces of the canisters



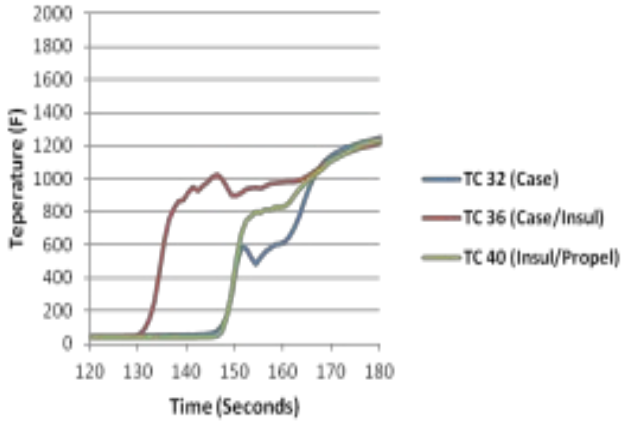
The flow of heat from the fire through the four faces of each canister was measured. A thermal event occurred in the carbon fiber composite canister.

Heat Flows Through Steel Chamber, Insulation, and into Propellant

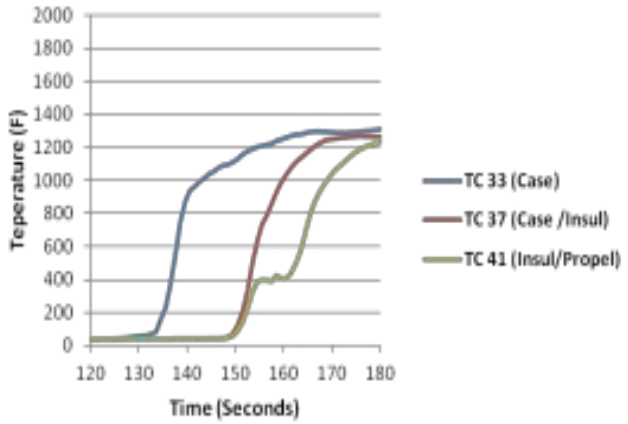
Temperature vs. Time Top of Steel Canister



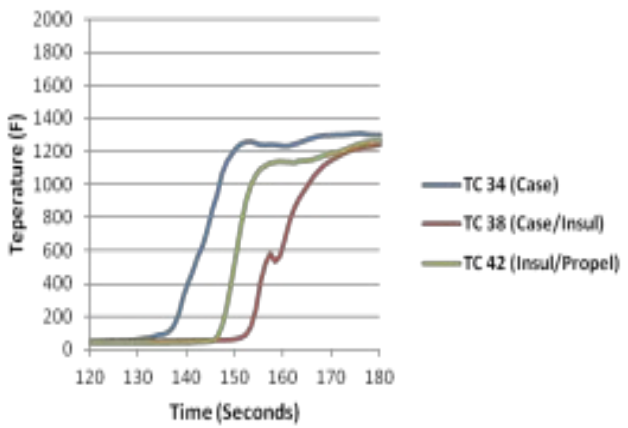
Temperature vs. Time, Right Side of Steel Chamber in Steel Canister



Temperature vs. Time, Right Side of Steel Chamber in Steel Canister

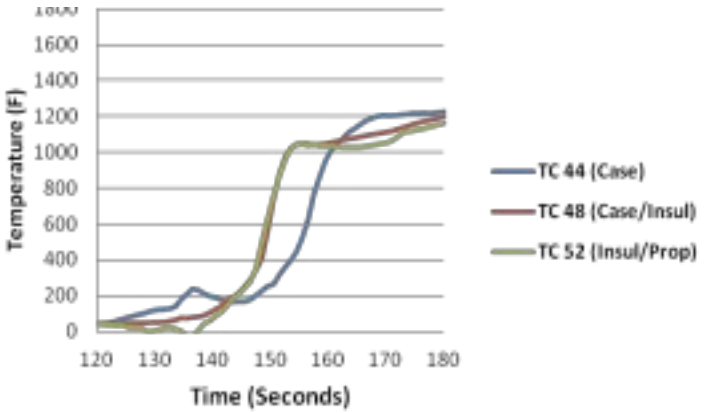


Temperature vs. Time, Left Side of Steel Chamber in Steel Canister

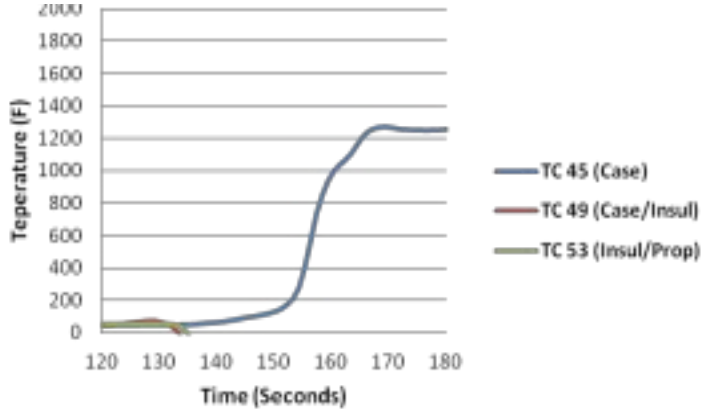


Heat Flow Through Composite Chamber, Insulation, and into Propellant

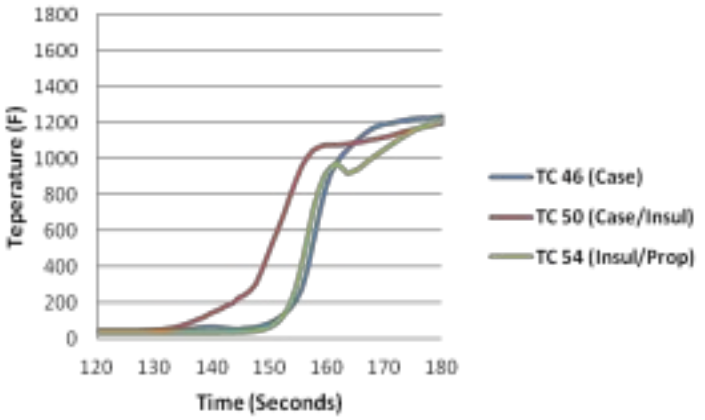
Temperature vs. Time, Top of Steel Chamber in Composite



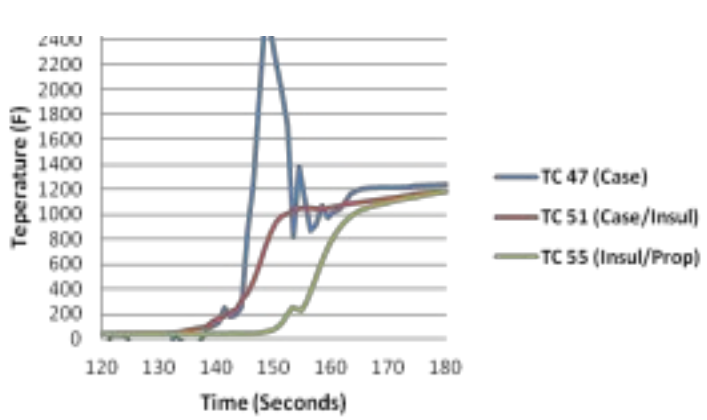
Temperature vs. Time, Right Side of Steel Chamber in Composite



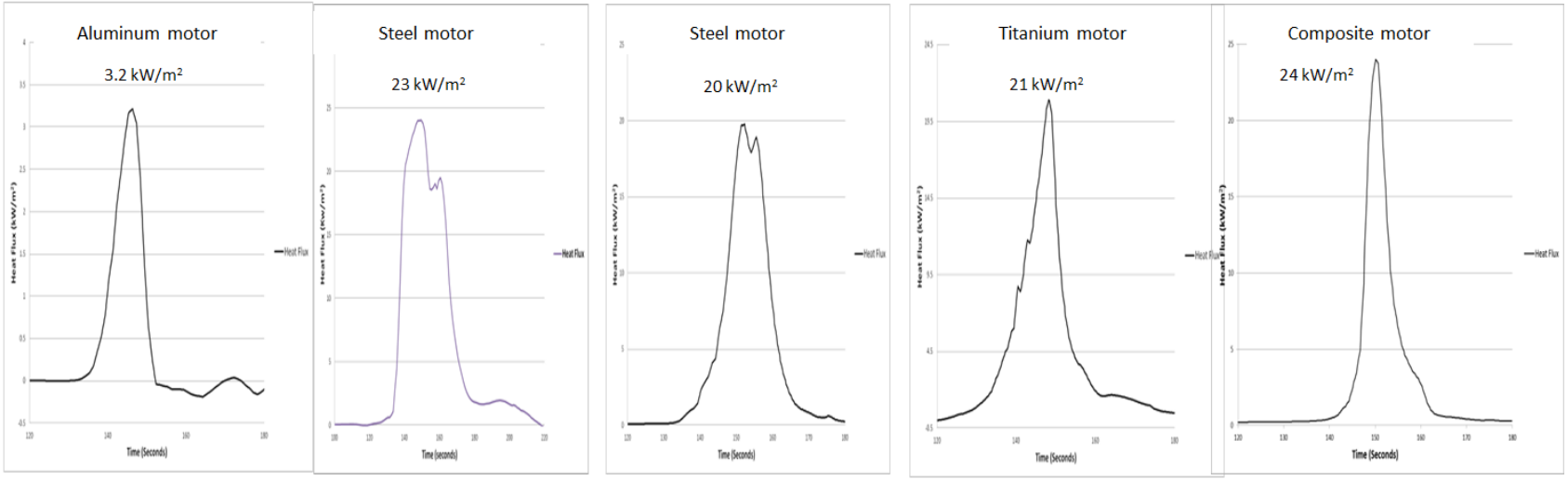
Temperature vs. Time, Bottom of Steel Chamber in Composite



Temperature vs. Time, Left Side of Steel Chamber in Composite



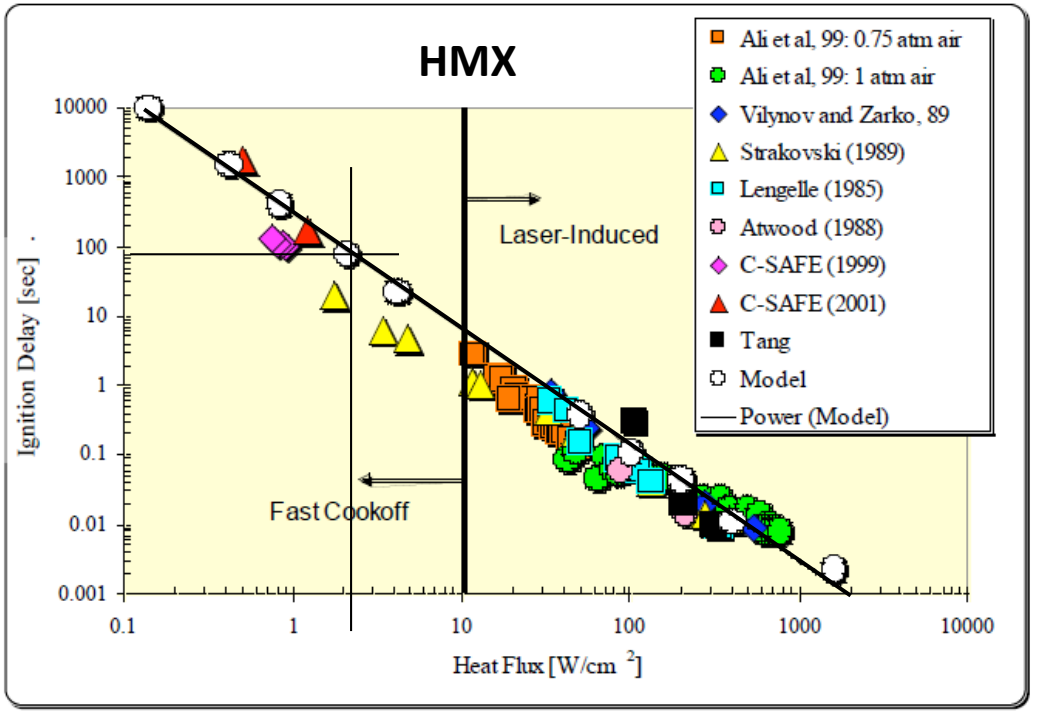
Heat Fluxes into Propellant



Except for the aluminum motor with cork insulation, the heat fluxes were all in the range of 20–24 kW/m^2.

Estimated Time to Cook-Off

The heat fluxes were all around 20–24 kW/m^2 (2-2.4W/cm^2). This would cause cook off at approximately a 90 seconds after this heat flux is attained in either canister for a propellant like HMX. Data for heat flux versus time to reaction data is needed for other energetic materials. The very tight clustering of the data along a straight line, spanning five orders of magnitude, suggests this may be a very fundamental property of explosives.



Ignition delay versus heat flux

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Post-Test Remains

The canisters retained their shapes throughout the fire.

Summary and Conclusions

- Experimental data for six simulated rocket motors was obtained using a steel missile launching canister and a carbon fiber composite canister
- The data showed similar rocket motor thermal responses in either canister type and all motor types with EPDM insulation
- The peak heat fluxes into the motors were in the range of 20 to 24 kW/m^2
- There was little deformation of the carbon fiber composite canister
- Data are now available to validate computer models of fast cook-off with a variety chamber materials and steel and carbon fiber canisters
- The experiment should be repeated in a propane fire