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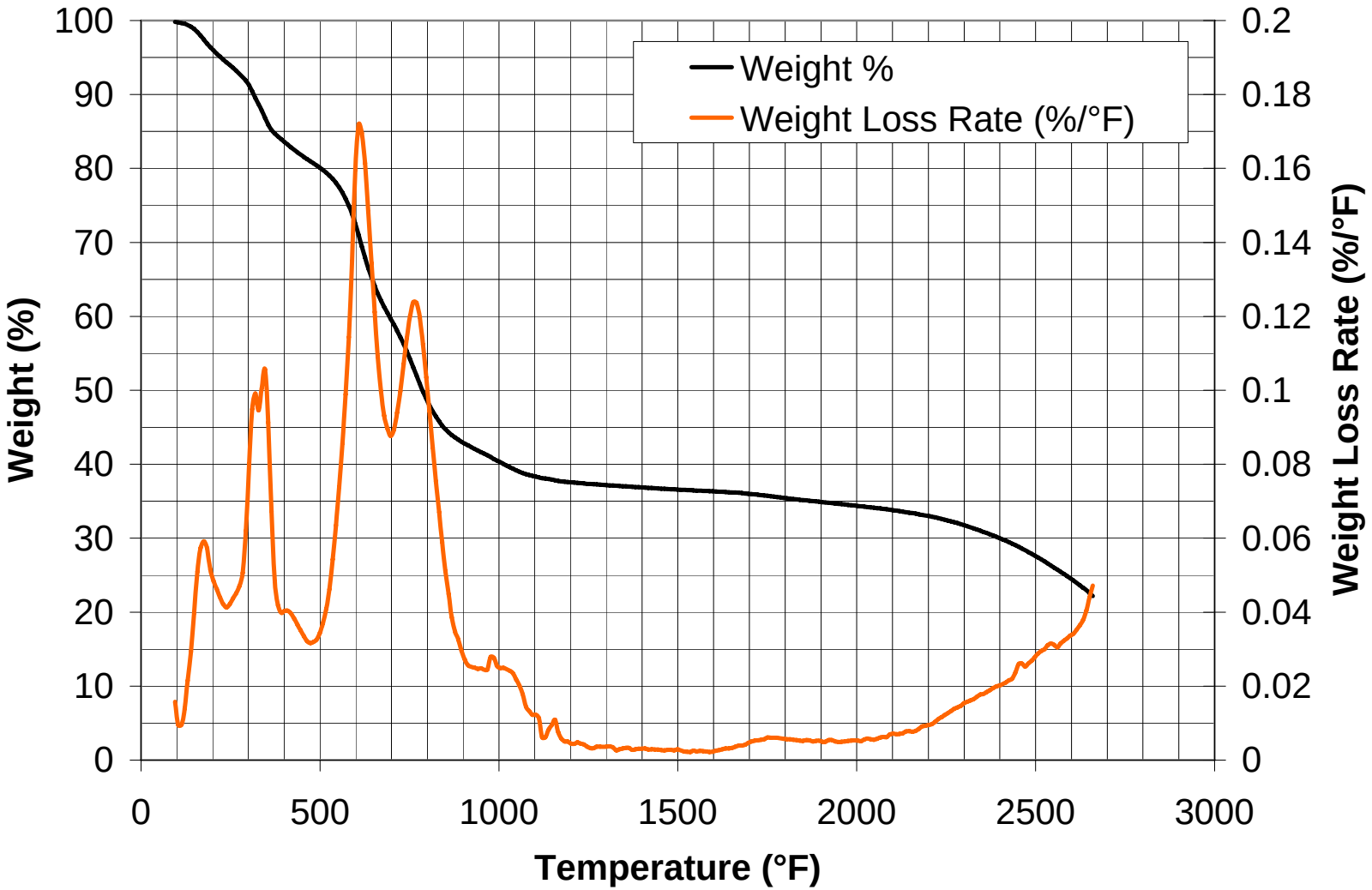
U.S. Army Research, Development, and Engineering Command (RDECOM)
Aviation and Missile Research, Development, and Engineering Center (AMRDEC)

Advanced Hypersonic Material Technology Program (AHMT)

RX2390 Thermal Analysis and Design

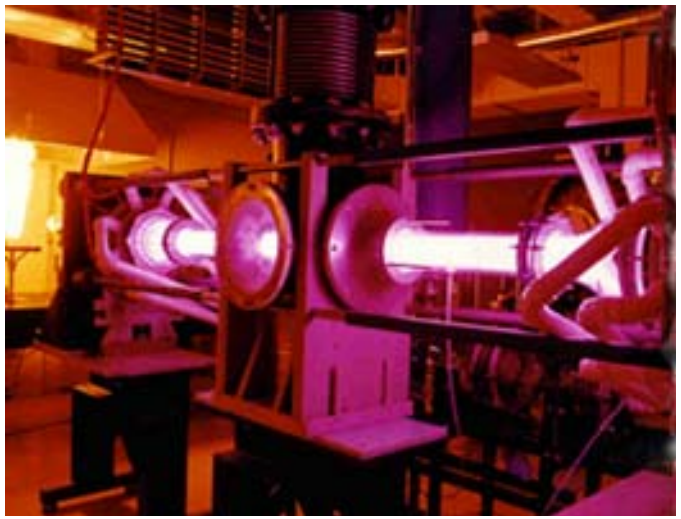
POC: Dr. Gerald Russell
(256) 876-1712

Thermogravimetric Analysis FIREX™ RX2390

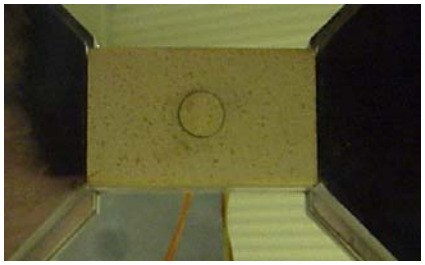


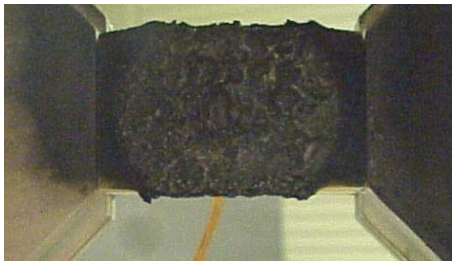
Reference: **Russell, G.W., Analytic Modeling and Experimental Validation of Intumescent Behavior of Charring Heatshield Materials, PhD Dissertation, University of Alabama in Huntsville, Huntsville, Alabama May, 2002.**

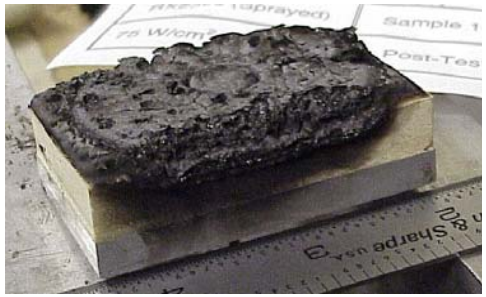
Army Aviation and Missile Hypersonic Heatshield Research

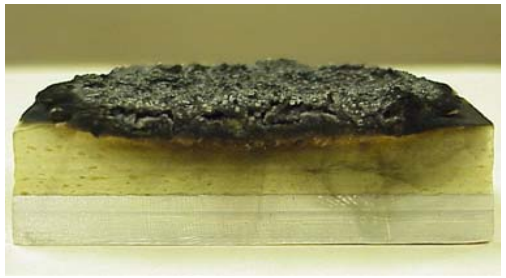


Wright-Patterson AFB
Laser Hardened Materials Evaluation Laboratory (LHMEL)



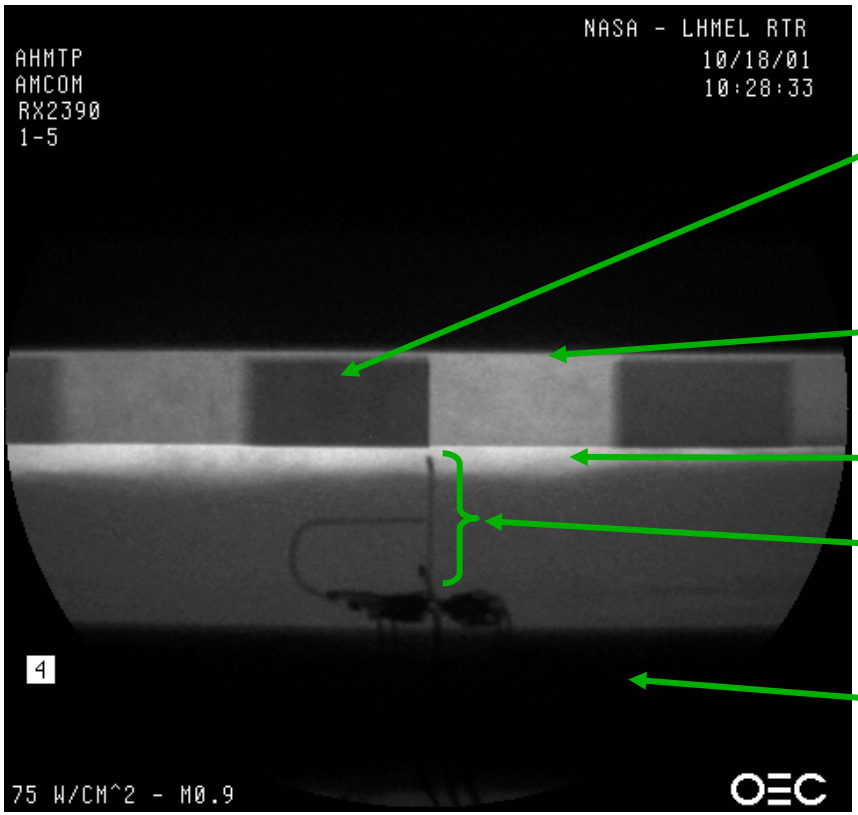






Reference: **Russell, G.W., Analytic Modeling and Experimental Validation of Intumescent Behavior of Charring Heatshield Materials, PhD Dissertation, University of Alabama in Huntsville, Huntsville, Alabama May, 2002.**

LHMEL Real Time Radiography & Embedded Thermocouples



Density Reference

Final Surface Position

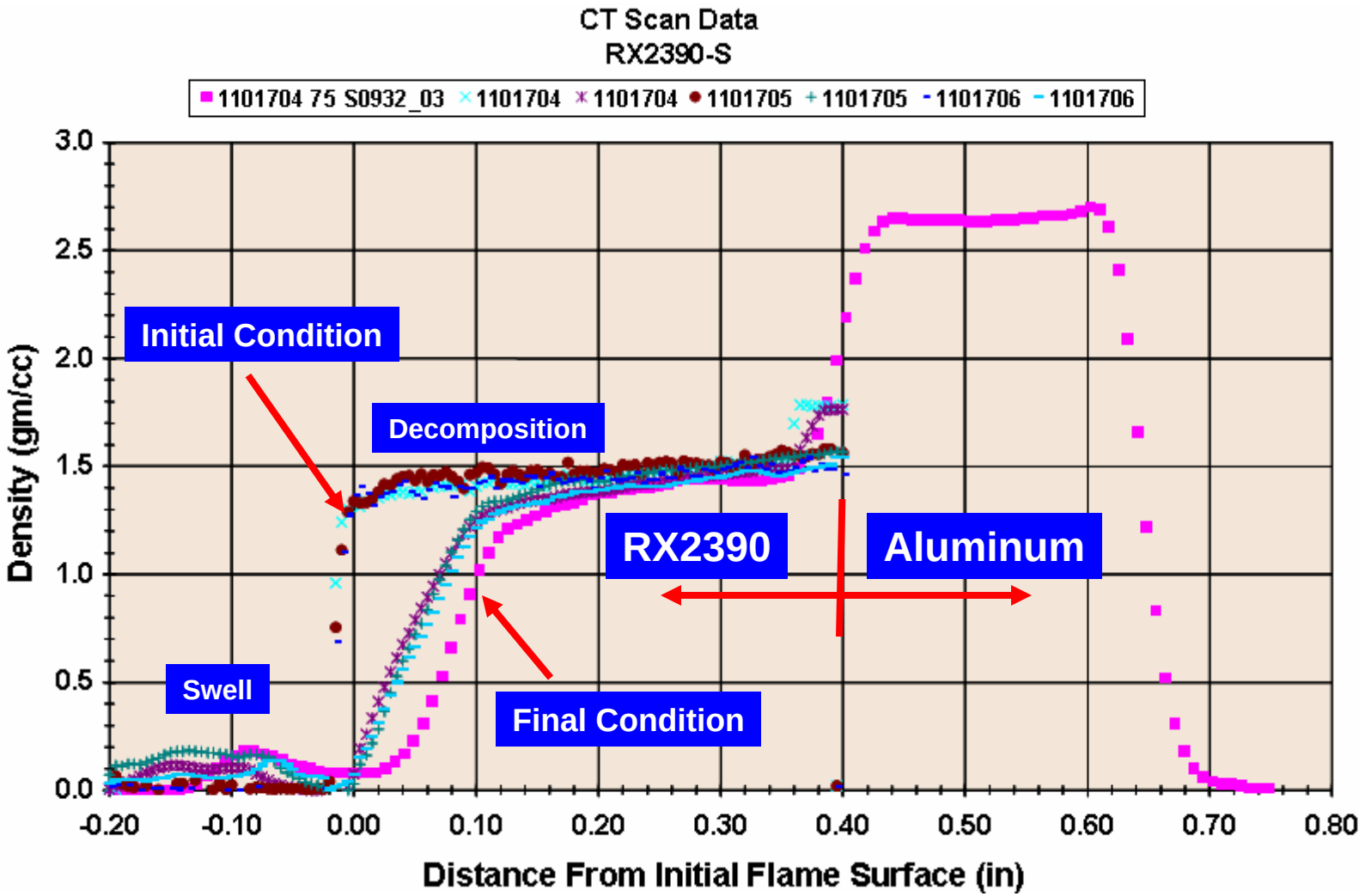
Initial Position

Thermocouples

Aluminum Substrate

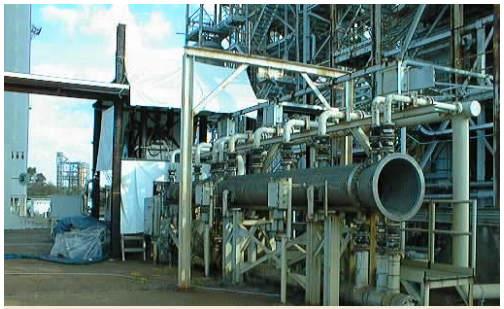
Reference: **Russell, G.W., Analytic Modeling and Experimental Validation of Intumescent Behavior of Charring Heatshield Materials, PhD Dissertation, University of Alabama in Huntsville, Huntsville, Alabama May, 2002.**

FIREX™ RX2390 Density Gradients for Pre and Post Test Conditions

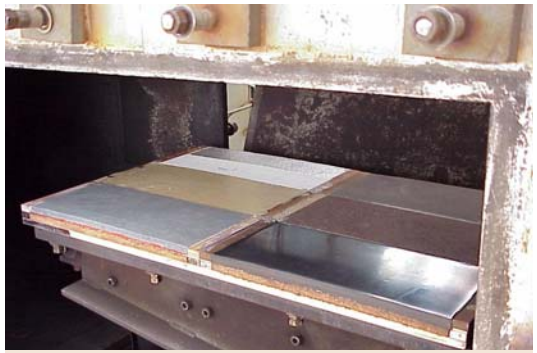


Reference: **Russell, G.W., Analytic Modeling and Experimental Validation of Intumescent Behavior of Charring Heatshield Materials, PhD Dissertation, University of Alabama in Huntsville, Huntsville, Alabama May, 2002.**

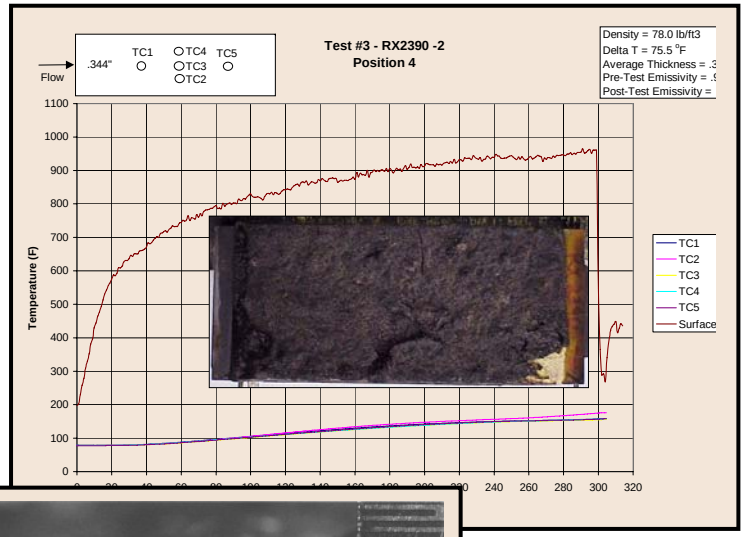
Hypersonic Convective Test

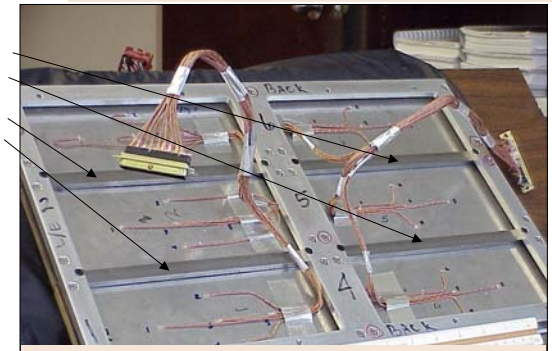


NASA Hypersonic
Hot Gas Test Facility

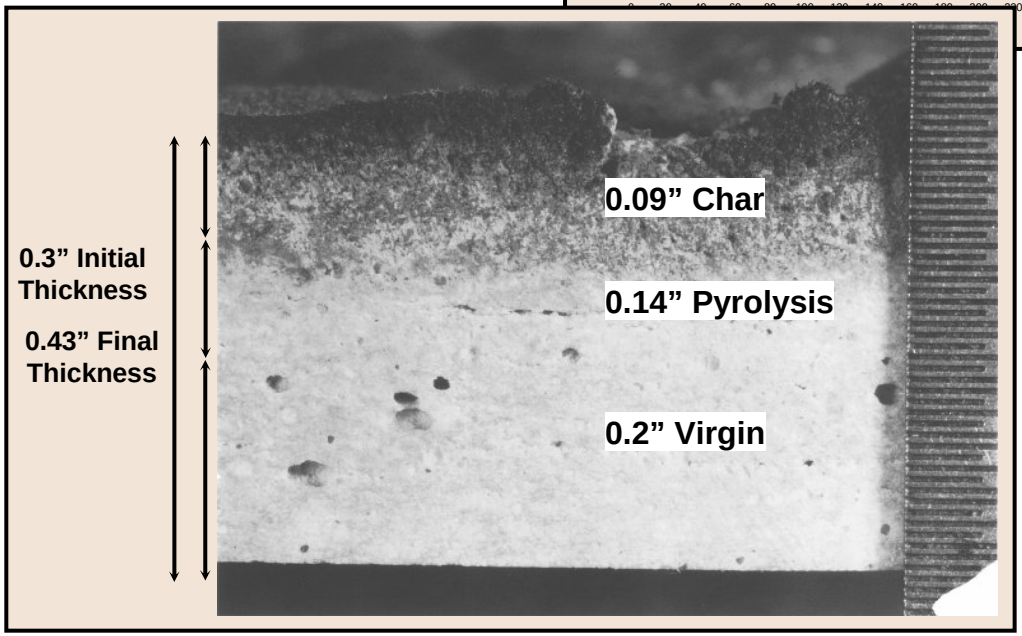


Test Panel Configuration in Test Cell





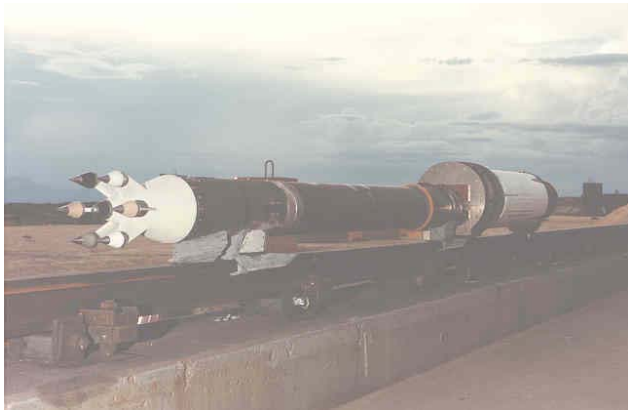
Test Panel Thermocouple
Instrumentation

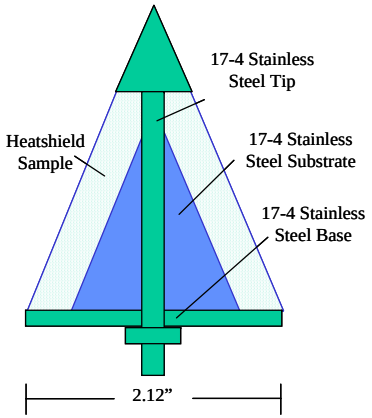


Reference: **Russell, G.W., Analytic Modeling and Experimental Validation of Intumescent Behavior of Charring Heatshield Materials, PhD Dissertation, University of Alabama in Huntsville, Huntsville, Alabama May, 2002.**

Air Force Holloman High Speed Test Track

- **Supersonic sled tests conducted for high shear thermal response**





15° Conical Sample

Reference:Reynolds, R.A., Russell, G.W, and Nourse, R.N., **Ablation Performance Characterization of Thermal Protection Materials for High Speed Tactical Missiles Using a Mach 4.4 Sled Test,** AIAA 92-3055, *28th Annual AIAA Joint Propulsion Conference and Exhibit*, July 1992

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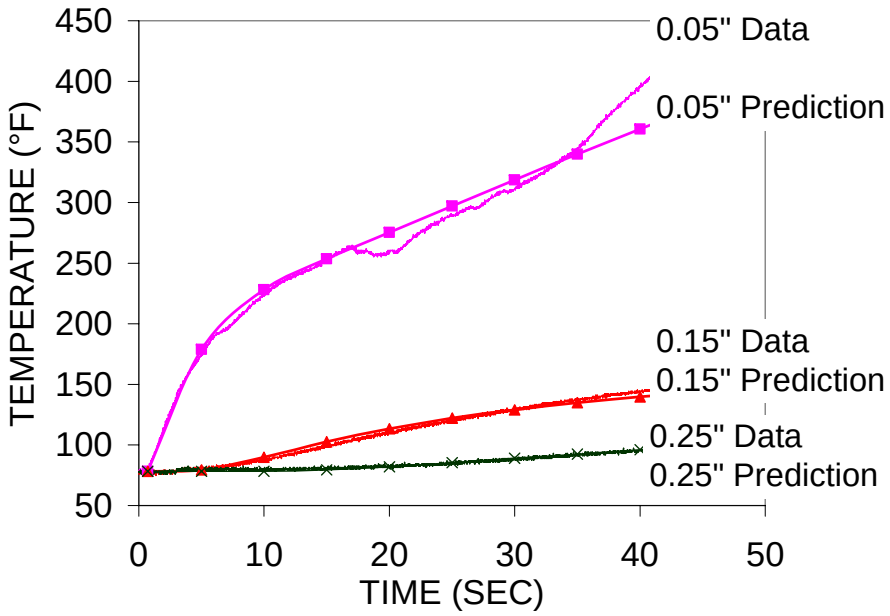
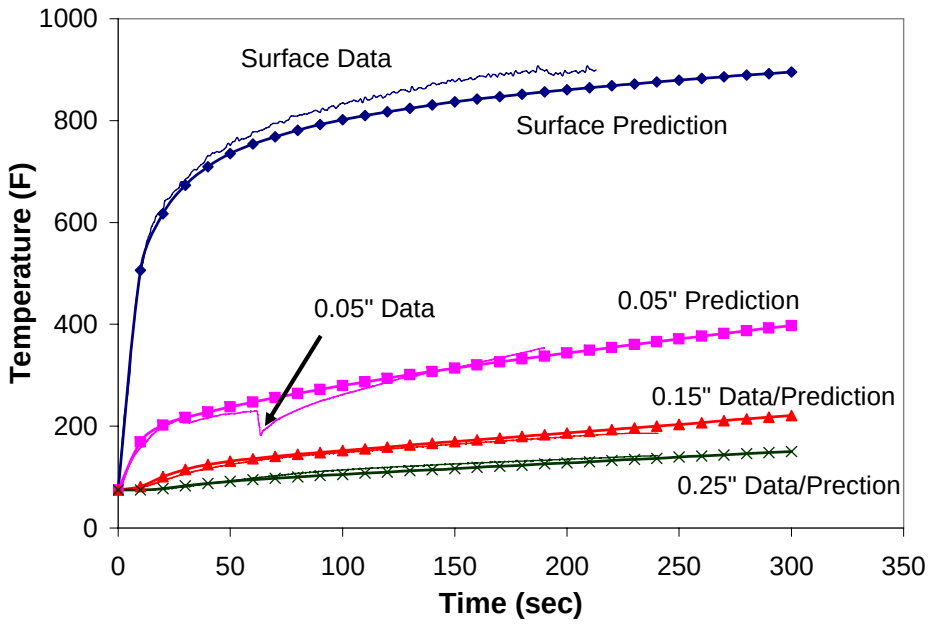
FIREX™ RX2390 Thermal Analysis and Design Models

- **Aerotherm Charring Material Thermal Response and Ablation Computer Program (CMA92FLO) with Intumescence and Mechanical Erosion**
- **Material properties for thermal response and intumescence developed**
- **Analytic predictions validated for both thermal response and intumescence**

LHMEL Test Data/Analysis Match



Hypersonic Test Data/Analysis Match



Reference: **Russell, G.W., Analytic Modeling and Experimental Validation of Intumescent Behavior of Charring Heatshield Materials, PhD Dissertation, University of Alabama in Huntsville, Huntsville, Alabama May, 2002.**

Applications Investigated

- Army
- Navy
- Missile Defense
- Air Force Holloman High Speed Test Track
- Fire Protection Research and Development

Summary

The Army AMRDEC/ ITT Industries Advanced Engineering Services (ITT AES) have developed and maintain:

- a complex design model based on test data for
  - FIREX™ RX2390
  - FIREX™ RX2376
  - FIREX™ RX2373
- These design models are available for analysis and support of *MIN*TEQ customer material applications
- AMRDEC, the Space and Missile Defense Command (SMDC), and ITT AES conduct material characterization efforts through the Army Composite and Advanced Material Program (CAM) for developing design and analysis models of high performance insulative and ablative material technologies