TECHNOLOGY ★ TEAMWORK ★ TRADITION

2010 Insensitive Munitions & Energetic Materials Technology Symposium

Characterization of Decomposition Behavior of Highly-loaded Polymeric Materials

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Slow Heating of Unmitigated Large Tactical Motors

Typical Responses

Theories regarding the cause of this behavior have existed for decades!

Why Do High-Performance Propellants Behave Poorly in Cookoff?

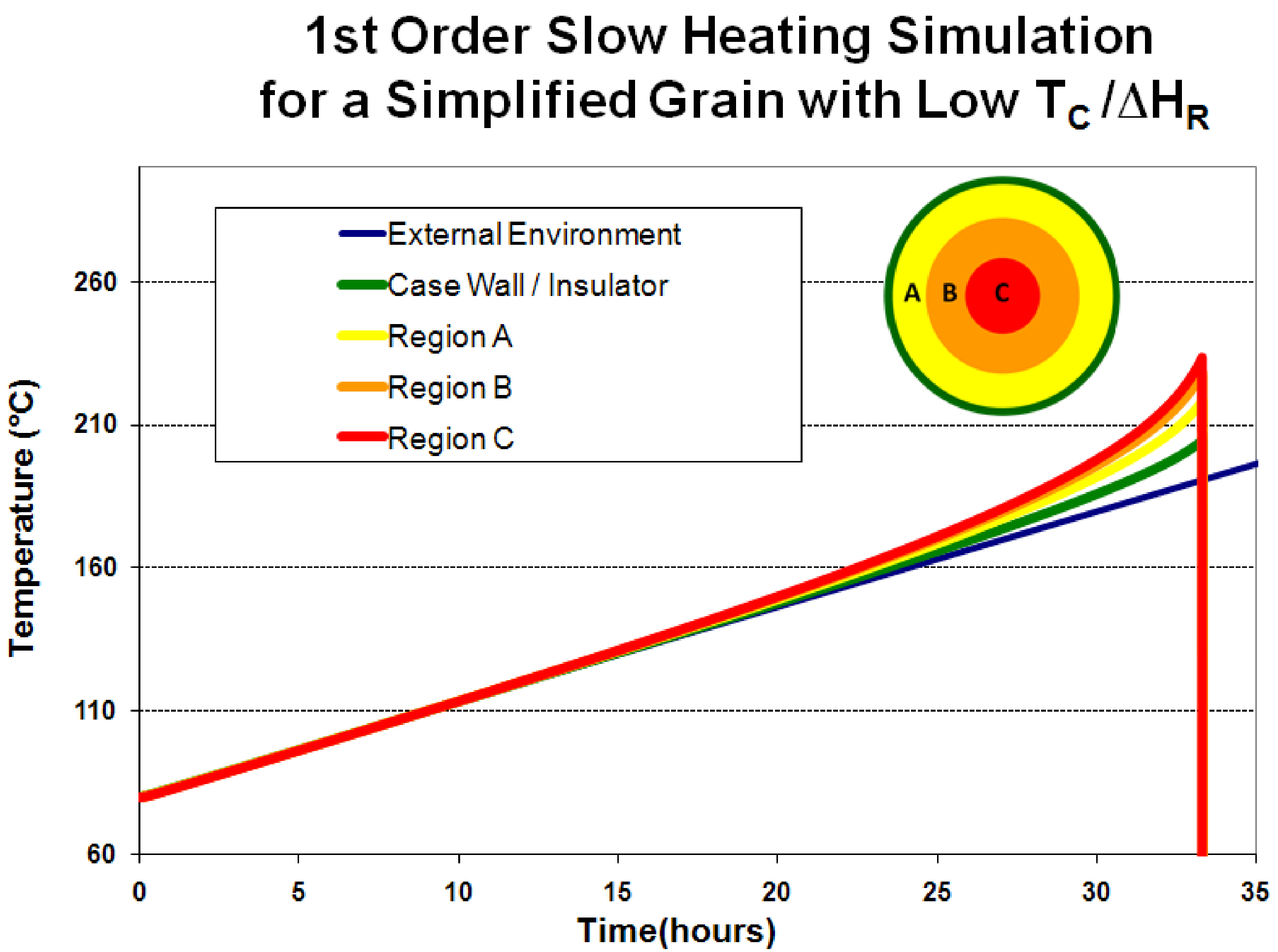
- **Internal heating[1] causes ignition in the middle of the propellant web.**
  - **Propellant provides it's own confinement, so venting the motor case is not sufficient.**
- **Propellant swell creates uncontrolled burning surface area.**
  - **Infinite burning surface creates infinite pressurization.**

[1]Butcher, A.G. *Propellant Response to Cookoff As Influenced by Binder Type.* AIAA Publication 90-2524. 1990

Why Does the Propellant Ignite in the Bulk?

- Propellant exothermic reaction is a function of time and temperature.
- In a slow heating environment, areas near the propellant wall transfer heat into the case and surrounding air.
  - The propellant is a good insulator, and the areas in the middle of the web retain more heat than areas near the case wall.
  - The increased heat in the middle of the web drives increased reaction rates, leading to runaway in the propellant bulk.
  - Runaway location is driven by thermal conductivity, heat of reaction, heating rate, and test article size.

Why Does the Propellant Ignite in the Bulk?



Ignition occurs in <u>Region C</u> and exhaust gases have nowhere to go! (Propellant provides confinement.)

Why Does Propellant Swell Contribute to Reaction Violence?

- At low reaction rates, product gases create small voids in the propellant web.
  - Voids nucleate and grow, but gaseous diffusion is limited by bulk propellant properties.
    - Some binder systems will trap the gas in smaller bubbles than others.
    - The same amount of propellant swell (void volume) can represent vastly different amounts of interfacial area.
- Interfacial area ultimately becomes burning surface area on ignition, driving pressurization rate!

Surface Area Increases Dramatically as Void Size Decreases

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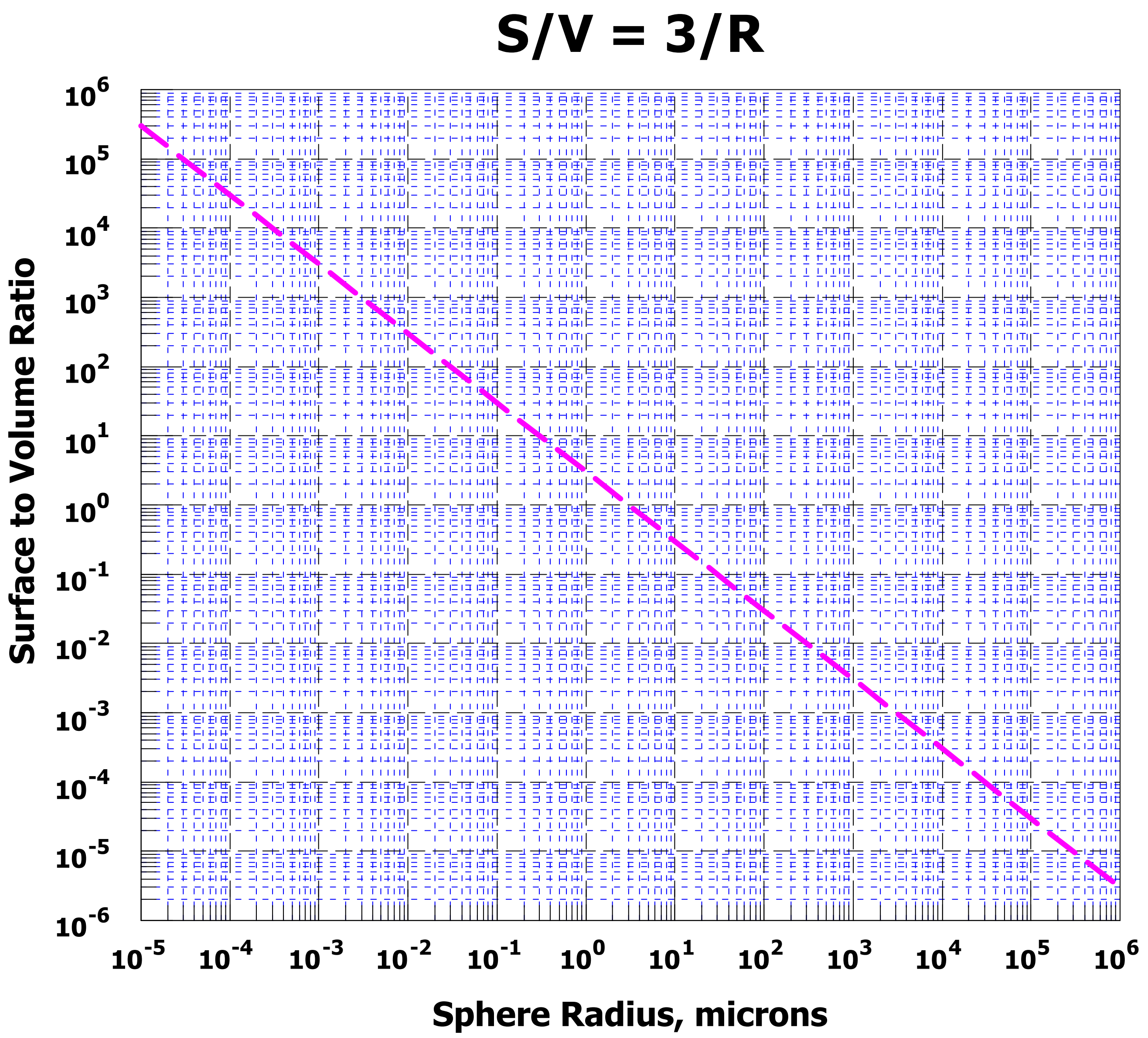

How Do We Look At Propellant Swell?

- **A Subscale Slow Cookoff Visualization (SCV) test was developed by the United States Navy in the late 1980s[2].**
  - **This test evolved from a simple toaster oven test to a highly instrumented test to monitor propellant behavior.**
- **Aerojet has adapted the SCV test to achieve the goals of the Navy SCV with reduced instrumentation, rapid turnaround, and reduced cost.**

[2]Victor, Andrew. *Insensitive Munitions Technology for Tactical Rocket Motors*. Tactical Missile Propulsion, Vol. 170, AIAA Astronautics and Aeronautics Series, ISBN 1-56347-118-3/96, 1996.

Aerojet Slow Cookoff Visualization

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Thermal Expansion of Various High-Performance Propellants

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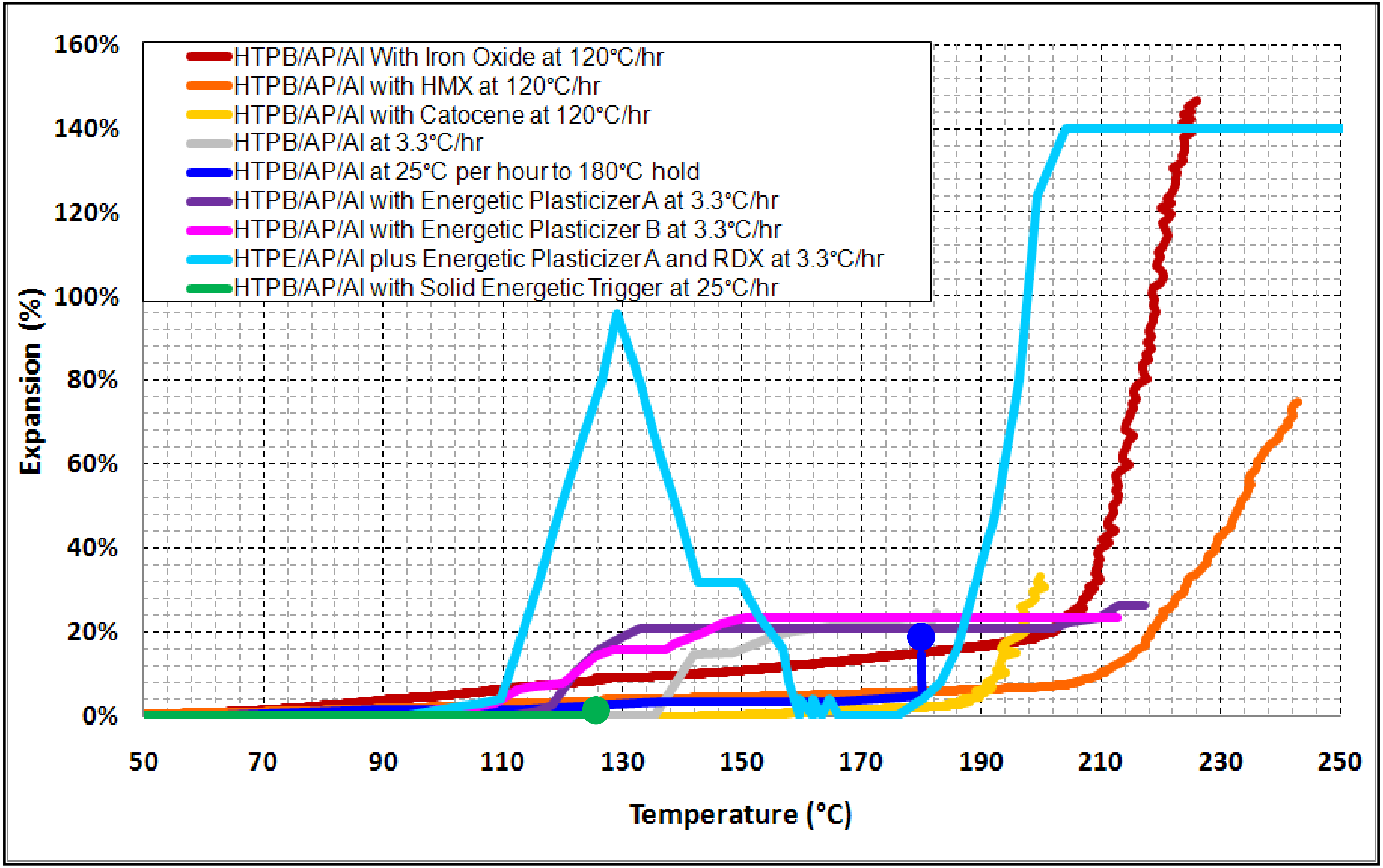

Violence is Highly Dependant on Swelling Behavior