Caseless Ammunition and Advances in the Characterization of High Ignition Temperature Propellant (HITP)

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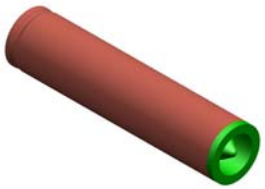
Outline

- Objective
- Background
- Overall Program Requirements
- Advantages
- Technical Approach
- Status
- Summary
- Future Plans

Caseless Program Objectives

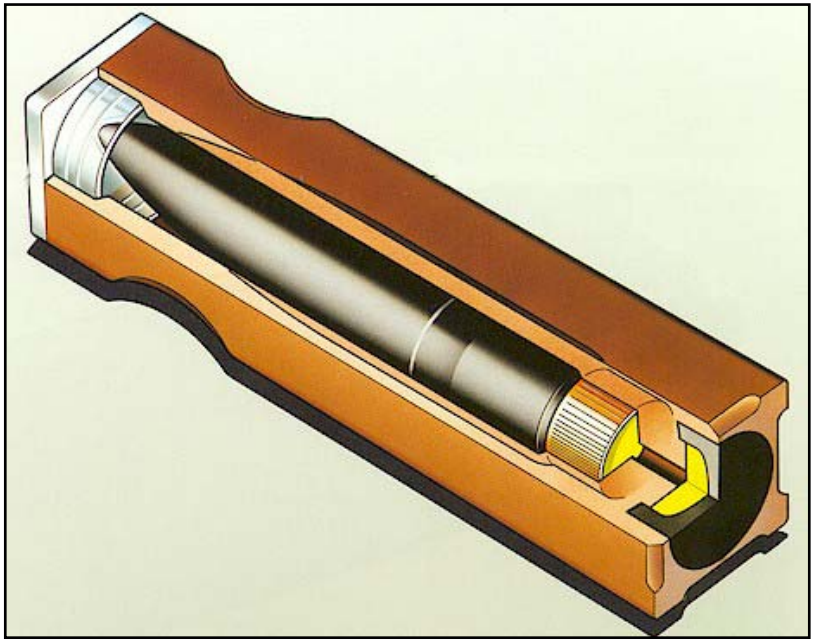
- Characterize the HITP
- Demonstrate a function and production capability
- Identify & address technical challenges/potential risk areas
- Deliver prototype Caseless ammunition for ballistic demonstration in support of the Lightweight Small Arms Technologies (LSAT) Defense Technology Objective
  - 5.56mm cartridge configuration
- Transfer technology to industry

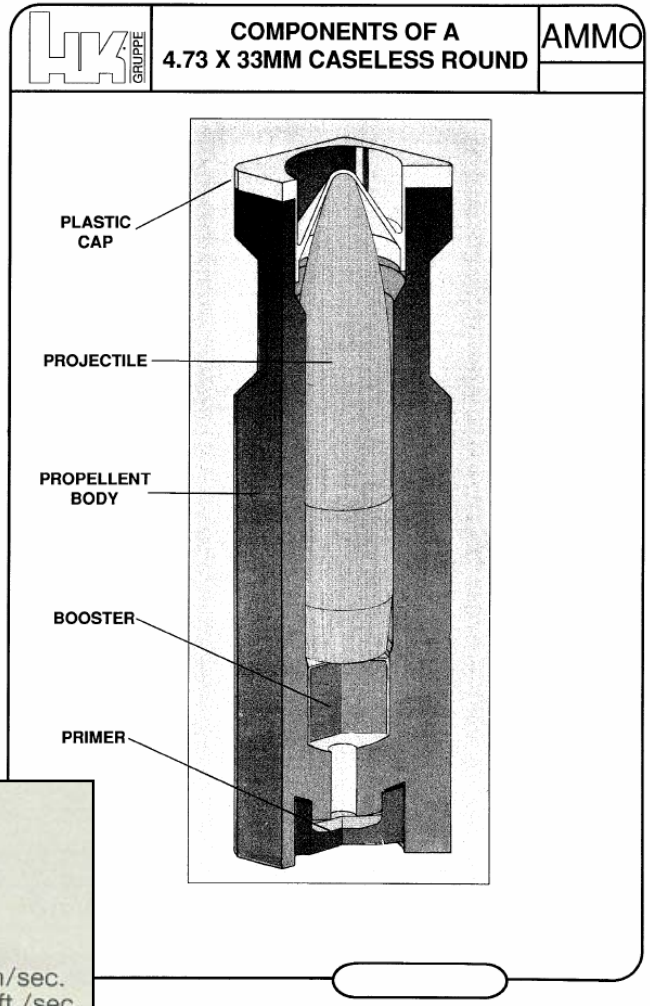


Background

- Original work performed under the Advanced Combat Rifle (ACR) Program
- Technology Development funded by US (ARDEC) and Germany to Heckler & Koch(H&K)/Dynamit Nobel(DNAG)
- Successful Demonstration of a Caseless Ammunition Rifle System
- Technology Licensed & Transferred to the US at ARDEC

G-11 Open Source Data





Caseless ammunition

Length	33 mm/1.29 in.	Ignition	mechanical
Cross-section	8 × 8 mm/0.32 in.	Mean gas pressure	3850 bar
Total weight	5.20 g/0.18 oz.	Muzzle velocity V_o	approx. 930 m/sec. 3051 ft./sec.
Projectile weight	3.25 g/0.12 oz.		

Overall Program Requirements

Threshold requirements

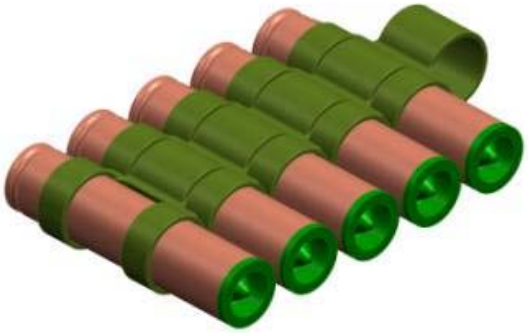
- 25% Decrease in ammunition weight
- Same lethality as the 5.56mm M855 cartridge
- Environmentally friendly alternatives for processing
- Low life-cycle costs

Desired requirements

- Additional decrease in ammunition weight
- Increased lethality over the 5.56mm M855 cartridge
- Same cost/round as current 5.56mm M855 ammunition

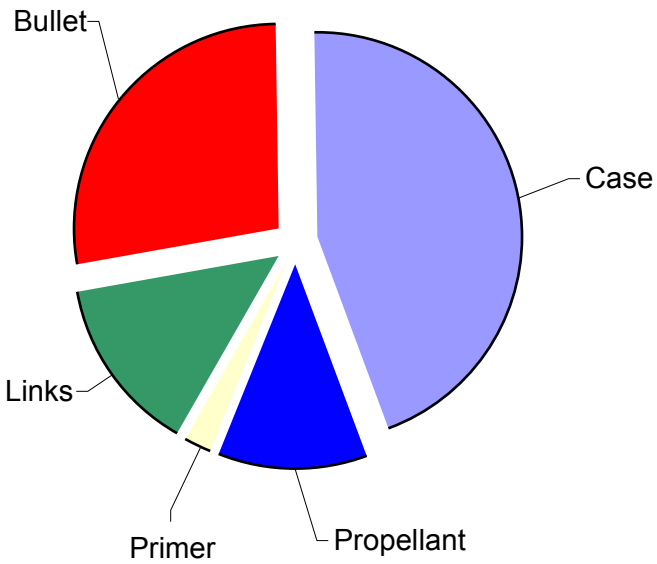
Why Caseless Ammunition?

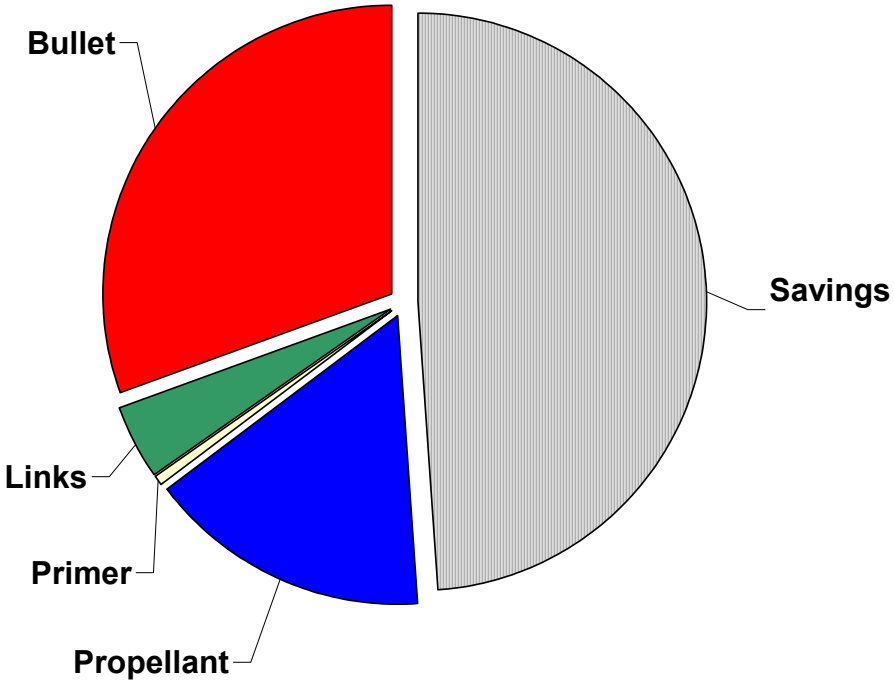
- Lightweight
  - Force Multiplier
  - Decreased Logistics Burden
- High Ignition Temperature Propellant (HITP) Provides Improved Propellant Characteristics & Energetic Behavior
- Technology with other potential applications



Weight Reduction Potential

- The brass cases account for 50 % of total ammunition weight!
- Current Ammo Weight (600 rds): 20.8 lbs
- Target Ammo Weight (600 rds): 10.2 lbs ≈ 50% Weight Reduction





Why Use an HITP?

- Advantages of Brass Casing
  - Barrel & chamber temperature:
    - Brass is a heat sink that is discharged with each round fired
  - Brass has a long history in small caliber ammunition
  - Brass provides structural strength to ammunition
  - Brass provides gas seal in weapon
- **<u>Advantages of HITP</u>**
  - Weight savings with elimination of the brass case
    - Potential for high firing rates with the elimination of the case ejection cycle
  - High thermal stability over typical ball powder
  - Structural integrity over a wide temperature range

Initial Caseless Development

ARDEC

Caseless Program Status

- **Overall ARDEC In-house Progress**
- HITP formulation verified by ARDEC/ATK
- Viable material sources identified
- Producibility demonstrated
  - Several hundred rounds have been produced from lab-scale propellant mixes
- Conducted three ballistic firings
- Continue manufacturing processes and prototyping

Caseless Program Status

- Conducted three ballistic firings in Mann Barrel at Armament Technology Facility at ARDEC

- **Test Firing I**
  - Five Shots
  - Chamber Pressure (8190-11314 psi)
  - Muzzle Velocity (589-1204 fps)

- **Test Firing II** (Addition of Booster Charge)
  - 12 Shots
  - Chamber Pressure (14372-62225 psi)
  - Muzzle Velocity (1489-2795 fps)

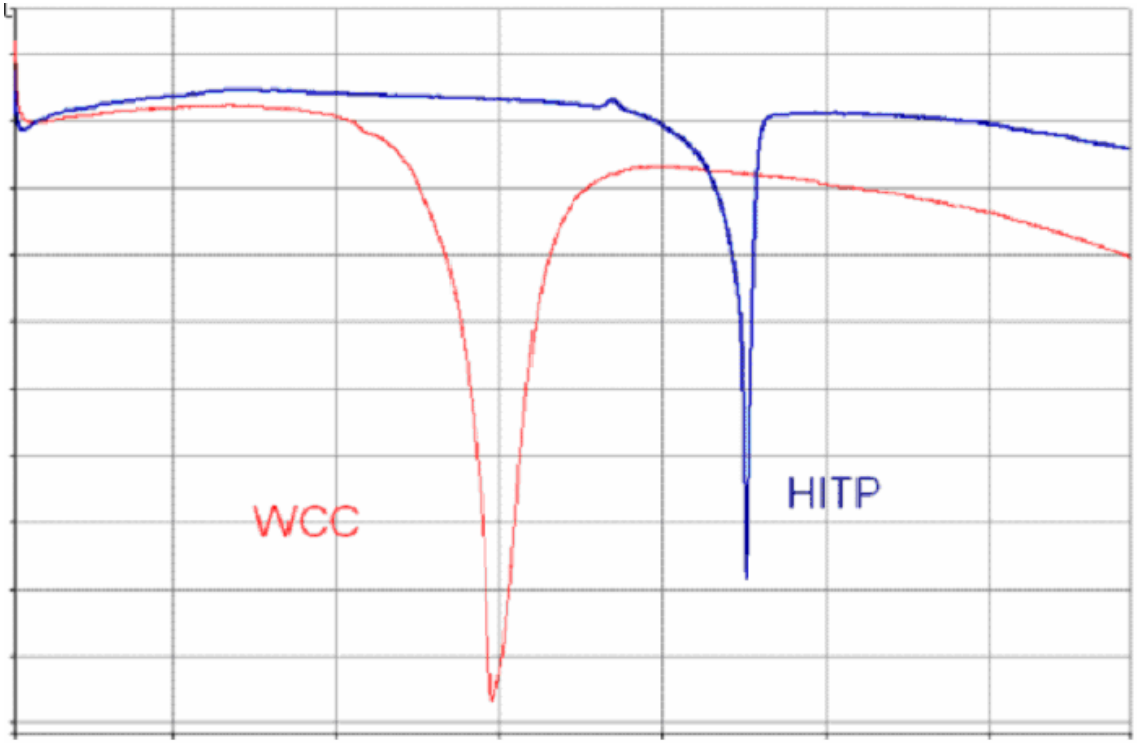
- **Test Firing III**
  - 14 Shots
  - Chamber Pressure (15992-24579 psi)
  - Muzzle Velocity (1000-1686 fps)

Caseless Program Status

- **<u>Material Characterization</u>**
- Cooperative effort between ARDEC & ATK
- Original & New HITP
  - Chemical Analysis
  - Density
  - Thermal Properties/Ignition Temperature
  - Heat of Explosion

Caseless Program Status

- **HITP Characterization**
  - Differential Scanning Calorimetry - Thermal Properties of HITP in comparison to Nitrocellulose based Propellant



Formulation & Process Development

ATK Thiokol

Caseless Program Status

- **<u>Overall Formulation & Process Development Progress</u>**
- HITP Characterization
  - Formulation verified
- Material sources identified - CONUS and OCONUS
- Raw materials procured or synthesized
- Compatibilities verified between ingredients
- Hazard Analysis
- HITP Mixing & Processing
  - Identifying manufacturing processes & limitations
- Closed Bomb Testing and Modeling

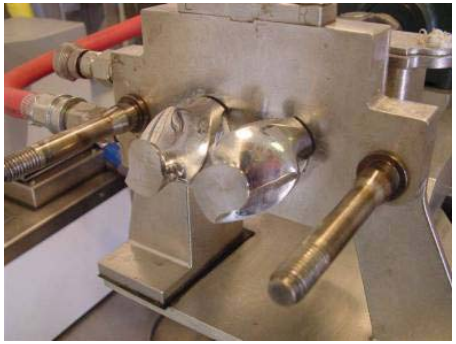
Caseless Program Status

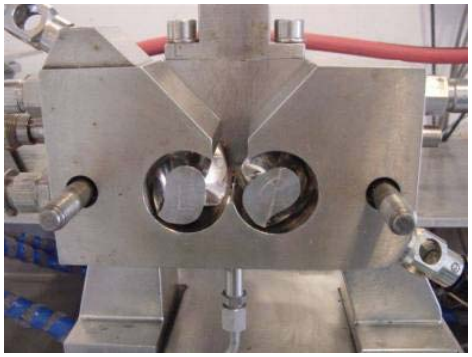
- **<u>Hazard Analysis</u>**
- Safety Data Determined
  - Propellant ingredients
  - HITP

ABL Impact (cm)	ABL Friction (lbs @ fps)	TC ESD (J)
>80	>800 @ 8	>8

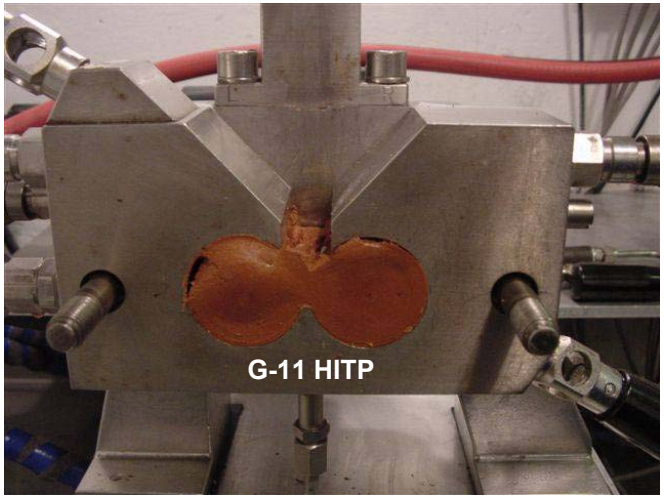
Caseless Program Status

- **<u>HITP Characterization- Mixing</u>**
- Four HITP hand mixes produced
  - Safety testing/Lab analysis
  - Original HITP re-processed for lessons-learned
  - Multiple sub-scale HITP mixes in progress-Design of Experiment (DOE)



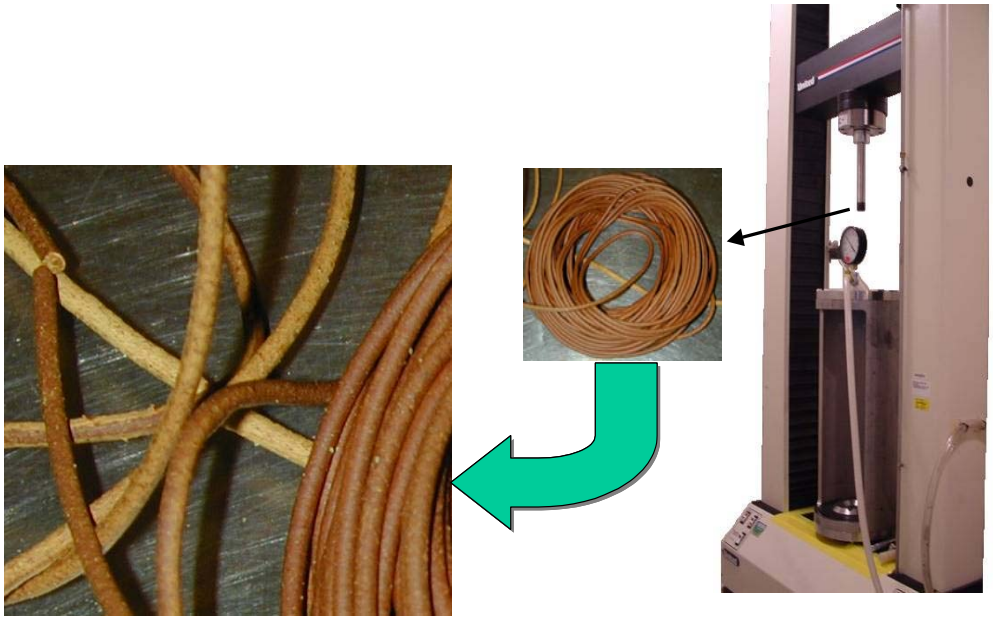


Rheochord Viscometer ideal for sub-scale (≈100-gr) mixing



Caseless Program Status

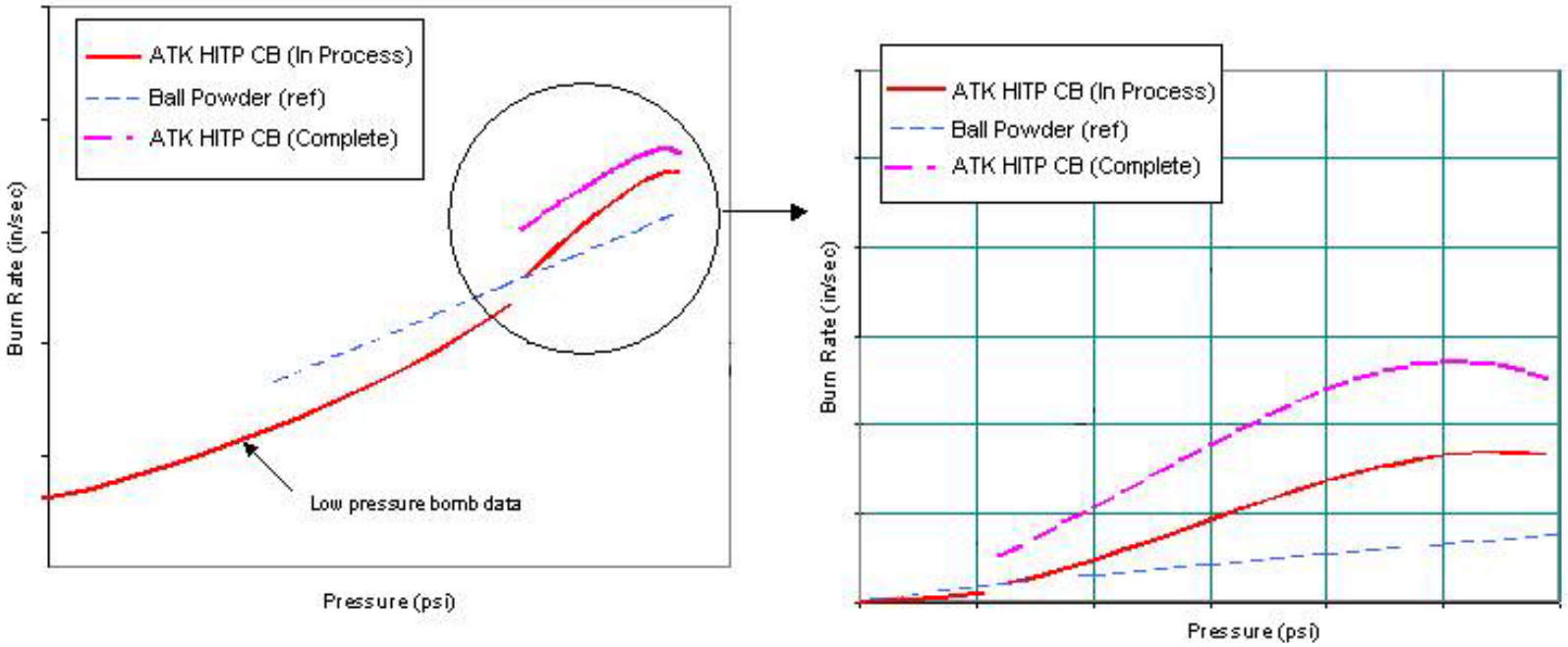
- **<u>HITP Processing</u>**
  - HITP Rheology and molding studies
    - Material characteristics and processability testing with Capillary Rheometer



Capillary Rheometer

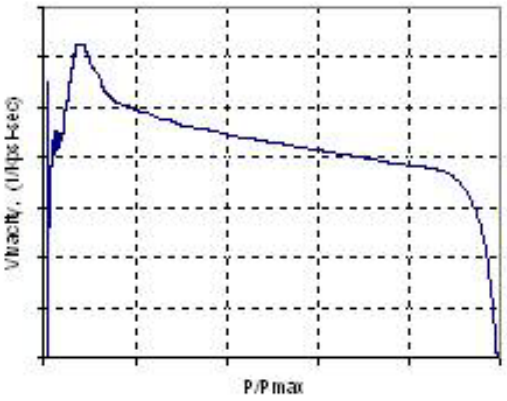
Caseless Program Status

- **HITP Testing**
  - Low & High Pressure Bomb analysis

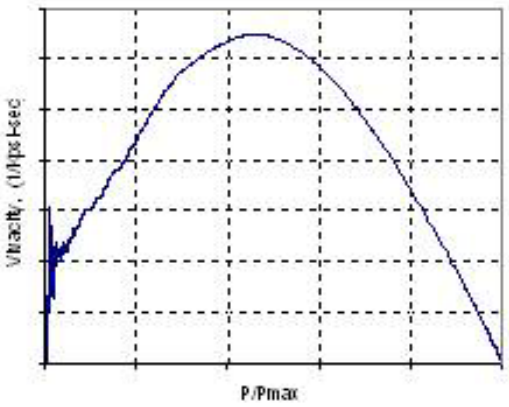


Caseless Program Status

- **HITP Modeling**
  - Initial closed bomb testing gave repeatable but unexpected results
    - The CB data from the HITP tests show the vivacity plots to be inconsistent with regressive burnback
    - Grains did not appear to burn with the expected type form function
    - Additional testing is planned to understand this issue



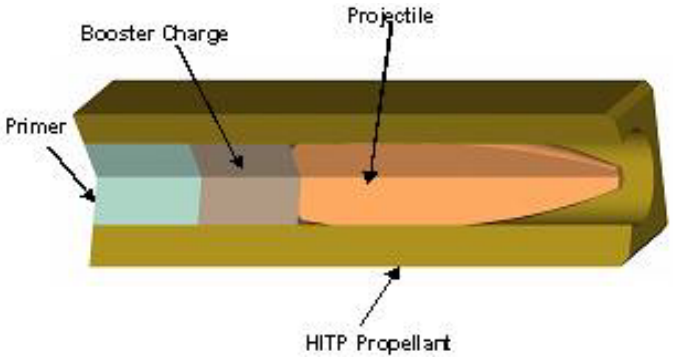
Typical Regressive Vivacity Plot



Obtained Progressive Vivacity Plot

Caseless Program Status

- **HITP Modeling** – cont
  - JHU/APL Status
    - ACR 1B sequence recreated
    - Modeled as single perf grain
    - HITP burn data



  - Reasonable results given limited data
    - Pressure & velocity close
    - Sensitivity analysis of several parameters generally consistent
  - Model will be updated as additional data becomes available

Caseless Program Status

- **Future Plans**
  - Complete HITP Development DOE
    - Identify critical formulation and process parameters
  - Produce first prototype Spring 2006
    - Begin Mann barrel testing to screen DOE mixes
  - 1st Delivery of test articles for validation testing by Summer of 2006
    - Primary goal is to deliver cartridges for proof-of-concept
  - Secure material sources for process scale-up work
    - Some materials require a 6-month lead time
  - Support follow-on process improvements

Caseless Program Summary

- **Technical**
  - Initial mixing and processing very promising
  - Fabrication solutions appear viable
  - Interior ballistic modeling is underway that is critical to cartridge design – can be accomplished with additional testing
- **Schedule**
  - Mix process DOE has been prepared and set for completion in Spring 2006
  - Smaller DOE will likely follow to finalize process/formulation parameters – Summer 2006
  - Cartridge fabrication for testing and demonstration – Summer 2006