IM Characteristics of Large Diameter Extruded Double Base Rocket Motors with Composite Cases

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Traditional Extruded Double Base IM Response

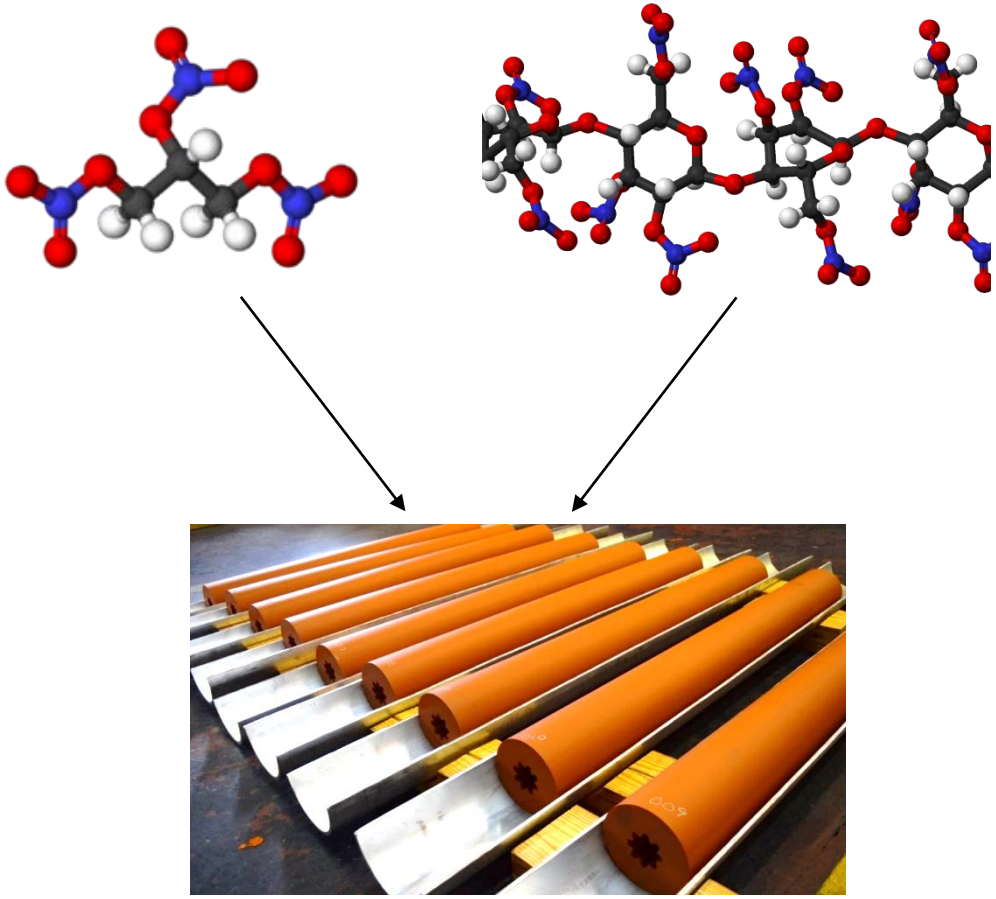
- Typical IM response of extruded double base motors well characterized
  - Violent reactions for metal combustion chambers
    - Bullet Impact*
    - Frag Impact
    - Slow Cookoff
    - Fast Cookoff*
- Larger diameters are typically less favorable
  - Critical diameter can be a factor
  - Long L/D may present additional challenges

USS Forrestal Fire

*Not all EDB motors exhibit a violent response to this stimulus

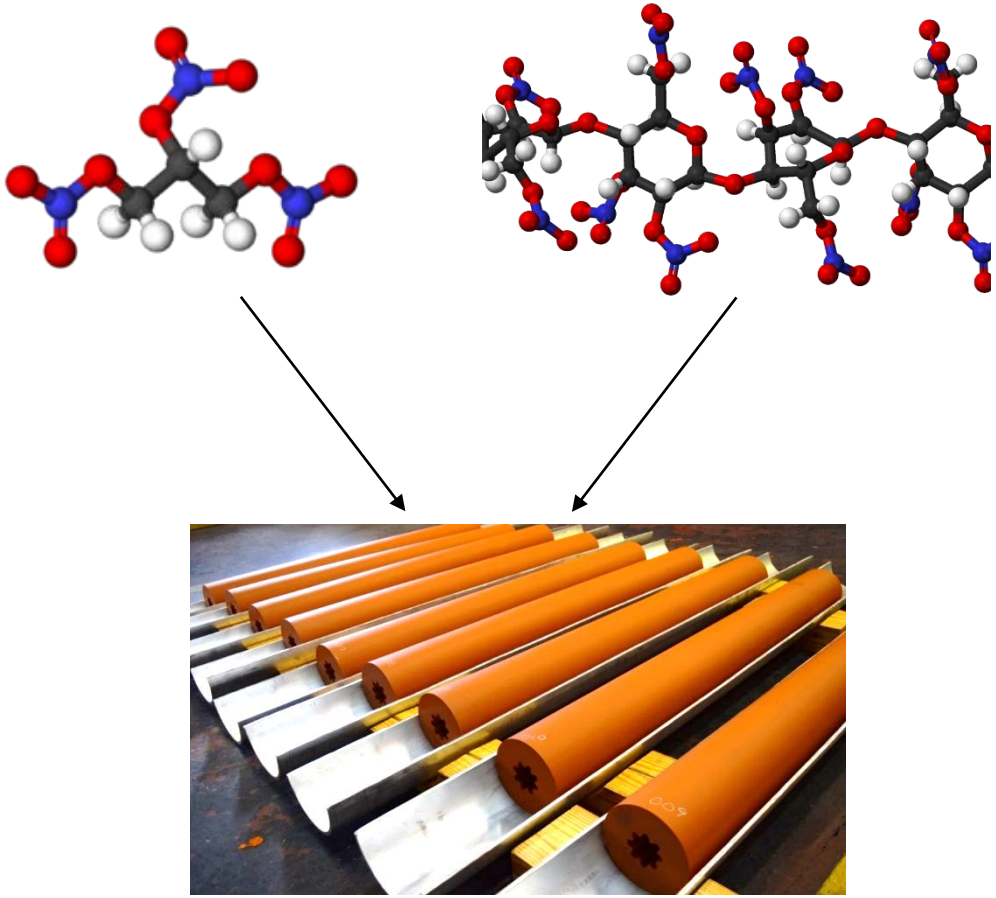
The Root of the Problem

- Inherent properties of EDB propellants
  - Both NG and NC are sensitive as individual components
  - The combination **REDUCES** the sensitivity of the materials
  - EDB propellants are the lowest card gap (least shock sensitive) in the Army production inventory
- Confinement
  - Confinement of double base is a known hazard
  - Metal cases provide minimal release in the event of a bullet or frag impact
  - Without bulkhead release mechanisms, cookoff results in the same issue



The Root of the Problem

- Lethal Fragments
  - Even less violent energetic reactions are a problem in the presence of lethal fragmenting materials
- Diameter
  - Even small diameters (less than 2”) result in violent reactions



Previous Work on Composite Cases

- Hydra Missile (2.75” Diameter)
  - Previous work on the Mk. 66 motor shows improved IM response with composite cases
  - Simulated release mechanisms improved responses to cookoff environments
  - Tests may improve by performing system level test (including payload on the forward interface)
- Conclusions and Questions
  - Violent IM response not inherent to the energetic in the Mk. 66 configuration
  - Composite cases are a viable mitigation for EDB propellants
  - Is there a diametric limitation?

IM Test w/MK-66	Aluminum Case	Composite Case
Frag Impact (Army)	III – IV	IV**
Bullet Impact (.50 cal)	V	V
Fast Cook-Off	IV	V
Slow Cook-Off	III	IV**

*All information from IMEM 2006, Paper 7A, Farabaugh et. Al.

Extension to Large Diameter

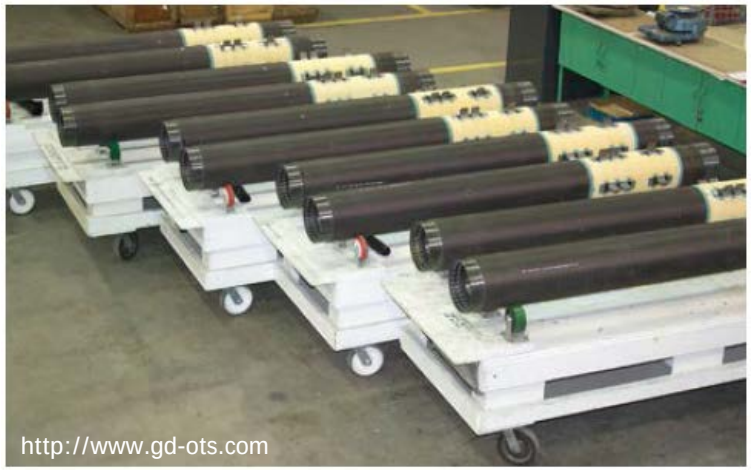
- Large Diameter Tactical Motors
  - Development of large diameter tactical motors using EDB propellants ongoing
  - Benefits in cost, volume, complexity, manufacturability
  - Can IM properties be retained?

Recent Large Diameter Tactical Work

- Design and Manufacturing Development
  - Composite case EDB motors up to 6” in diameter have recently been developed for tactical application
  - More than double the web of the Mk. 66 rocket motor
  - Grain extrusion, machining, inhibition as well as motor performance in static testing have all been successfully demonstrated

Demonstrated IM Properties of Large Diameter EDB Motors

- Technologies incorporated for IM
  - Low shock sensitivity EDB propellant
  - Filament-wound graphite epoxy motor case
  - Shape memory alloy retention rings for forward and aft bulkheads



Demonstrated IM Properties of Large Diameter EDB Motors

- Tests
  - Fragment Impact
  - Slow Cookoff
  - Fast Cookoff
- Results
  - Even at the larger diameter and length, the composite case motors retain the IM properties demonstrated in the 2.75” size

Future Large OD Motor Work

- Larger Diameters
  - Demonstration of manufacturing and diameters larger than 6”
  - Evaluate IM response at thicker webs
- Additional IM mitigation
  - Evaluate IM response at a system level (payload, packaging)
  - Investigate IM response as a function of grain design (perf, L/D etc.)
  - Additional reduction in propellant shock sensitivity
  - Maintenance of shock sensitivity at higher energies