Temperature Insensitive Propulsion for KE Tank Ammunition

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KE Performance Limitations

- \( KE = \frac{1}{2} mv^2 \)
- Improved performance is achieved via increased velocity at target
- Therefore, the main goal is increased muzzle velocity
- Higher velocity is typically obtained through increased operating pressures
- But – Cannon pressure limits are established to ensure safety
- Problem – current systems already operate at the maximum safe limit of the cannon (rules out increased velocity via higher operating pressure)
Typical Pressure Curve for KE

- Total energy imparted to the projectile is equivalent to the integrated area under the pressure time curve
How to Increase Performance

• Many ideas to increase the area without increasing P-max have been limited in successes
  – Programmed Splitting Slotted Stick
  – Multi-layered Propellants
  – Deterred Propellants

• Some successful tests have been performed but not yet fielded due to various issues of safety, producibility, and aging
Typical Propellant Temperature Profile

Normalized Muzzle Velocity, %

Temperature, °C

AKE Slugs 8.8 kg Stick Propellant
Increase Performance by Altering Temperature Profile

• Every fielded round needs to be capable of firing across the operational temperature range, including extremes
• But – Majority of firing engagements are more normal “ambient” temperatures
• Temperature Insensitive Propulsion System (TIPS®) breaks the normal increased temperature – increased pressure correlation
• This allows for an increase in performance at those temperatures most commonly encountered
Typical Average Temperature

Average Temperature
Baghdad, Iraq

Monthly Average

Yearly Average

Degree, °C

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
Advanced Propulsion Work

- Ballistic testing was performed using a notional KE slug with a mass of 8.800 kg
- This work built on previous efforts
  - DM63 Development by Rheinmetall
  - SCDB Propellant Evaluation by PM-MAS
  - GD-OTS IRAD
- This work involved every component of the propulsion system including:
  - Combustible Cartridge Case
  - Primer
  - Propellant
Slug Cartridge

- Stick Propellant
- Igniter
- Granular SCDB Propellant
Propulsion System Components

SCDB Granular Propellant

Stick Propellant

M123 Primer (used with stick propellant in M830/M831 rounds)

M35L70 Primer (used in this work)

LEADING THE WAY
Problems Encountered

• SCDB Propellant Coating Strength
  – Dependent on loading density
  – Dependent on strength of ignition

• Ignition Issues due to the long aft boom intrusion and short primer
  – High Negative Delta Pressure
  – Flareback at cold temperature

• Ignition Issues solved by:
  – Changing primer configuration
  – Method of affixing propellant sticks
  – Integration of cartridge components
Final CV Test – Velocity Data

Increase for SCDB due to:
- Temp Shift of Pmax
- Increased Charge Mass

AKE Slugs 8.8 kg
Propellant 7.86 kg
YPG

AKE Slugs 8.8 kg
Stick Propellant 7.84
Final CV Test – Pressure Data

- Slugs 8.8 kg
- Propellant 7.86 kg
- YPG

- Slugs 8.8 Kg
- Stick Propellant 7.84 kg
- IB Simulation

Temperature, C

Breech Pressure, MPa

Tube Pressure Limit
Summary

• This program successfully demonstrated a Thermally Insensitive Propulsion System (TIPS®) with a KE slug in 120mm TankGun application

• The outcome was demonstration of a propulsion system that only varied 65 m/s across temperature range from cold to hot

• Demonstrated a significant increase in velocity at all temperatures below 35°C

• All of this was achieved within the safety pressure limits of the current 120mm cannon