.50 Cal Advanced Propellants

Presented at the NDIA on May 25, 2011

By

St. Marks Powder (SMP), GD-OTS
.50 Cal Advanced Propellant Presentation

- .50 Cal Propellant Development Approach
- .50 Cal Ammunition Applications and their propulsion needs
  - Increased Performance (High velocity, KE, increased range)
  - Limited Range Training Ammunition (LRTA)
  - Green .50 Cal (Environmentally friendly)
  - Plastic Case (Light Weight)
  - Armor Piercing (SLAP)
- St. Marks’s Propellant Solutions and Results
Propellants are designed using interior ballistic models.

- Gun Parameters: Cham. Vol., caliber, projectile mass & design
- Burn Speed is controlled with particle size, chemistry, web
- Optimal performance requires maximum loading energy, controlled burn to Pmax, and 100% Propellant Burnout

Propellant samples are fabricated in the pilot plant.
Propellant samples are tested in ballistic EPVAT systems.
The modeling, fabrication, and testing process is repeated and refined.

### .50 Cal Interior Ballistic Modelling Simulations

- **Prop-I**, **Prop-II**, **Prop-III**
.50 Cal Propellant Development

- Other performance characteristic are considered
  - Barrel wear life (Propellant Flame Temperature)
  - Muzzle Flash (Low Flame Temperature, Flash reducing additives)
  - Temperature Sensitivity
  - Decoppering Agent to prevent barrel coppering
  - Propellant metering to control charge weight
.50 Cal High Performance

- How much additional performance is possible in .50 Cal M33?
  - The standard .50 Cal M33 performance is based on 50 year old requirements
  - Higher energy propellant technology has since been developed
  - Standard .50 Cal M33 has excess case capacity
- SMP’s Propellant Solution
  - Take advantage of excess case capacity to maximize propellant charge weight
  - Use a High Energy BALL POWDER® Propellant design (WC869) and optimize the burn speed to maximize ballistics
  - This gives substantial increase in Kinetic Energy without sacrificing barrel wear
## .50 Cal High Performance

### WC869 vs WC860 (Standard)

**.50 Cal M33 (650 grain) @ 55,000 psi (380 Mpa)**

<table>
<thead>
<tr>
<th>Powder</th>
<th>Barrel</th>
<th>Charge</th>
<th>Velocity</th>
<th>K.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WC860</td>
<td>36&quot;</td>
<td>235 grains</td>
<td>2905 ft/s (885 m/s)</td>
<td>12,175 lbf-ft (16.5 KJ)</td>
</tr>
<tr>
<td>WC869</td>
<td>36&quot;</td>
<td>265 grains</td>
<td>3085 ft/s (940 m/s)</td>
<td>13,730 lbf-ft (18.6 KJ)</td>
</tr>
<tr>
<td>Delta</td>
<td></td>
<td></td>
<td>+180 ft/s (55 m/s)</td>
<td>1,555 lbf-ft (2.1 KJ)</td>
</tr>
<tr>
<td>WC860</td>
<td>45&quot;</td>
<td>235 grains</td>
<td>2980 ft/s (908 m/s)</td>
<td>12,811 lbf-ft (17.4 KJ)</td>
</tr>
<tr>
<td>WC869</td>
<td>45&quot;</td>
<td>265 grains</td>
<td>3175 ft/s (968 m/s)</td>
<td>14,543 lbf-ft (19.7 KJ)</td>
</tr>
<tr>
<td>Delta</td>
<td></td>
<td></td>
<td>+195 ft/s (59 m/s)</td>
<td>1,732 lbf-ft (2.3 KJ)</td>
</tr>
</tbody>
</table>

**Kinetic Energy ~13% Greater at muzzle**
## .50 Cal High Performance

### WC869 vs WC860 (Standard)

**.50 Cal M33 (650 grain, B.C. 0.707) 45" Barrel @55,000psi (380 Mpa)**

<table>
<thead>
<tr>
<th>Powder</th>
<th>@muzzle</th>
<th>@500m</th>
<th>@1000m</th>
<th>@1500m</th>
</tr>
</thead>
<tbody>
<tr>
<td>WC860</td>
<td>908 m/s (17.4 KJ)</td>
<td>730 m/s (13.6 KJ)</td>
<td>544 m/s (7.6 KJ)</td>
<td>358 m/s (3.3 KJ)</td>
</tr>
<tr>
<td>WC869</td>
<td>968 m/s (19.7 KJ)</td>
<td>795 m/s (16.1 KJ)</td>
<td>609 m/s (9.5 KJ)</td>
<td>423 m/s (4.6 KJ)</td>
</tr>
<tr>
<td>Delta KE</td>
<td>13%</td>
<td>18%</td>
<td>25%</td>
<td>39%</td>
</tr>
</tbody>
</table>
.50 Cal LRTA (Limited Range Training Ammunition)

- Trajectory matches standard .50 Cal M33 to 800 meters
- Projectile is designed to go unstable after 800 meters
- 50% shorter range for reduced safety template
- Reduced range maintenance

.50 Cal LRTA propulsion challenges
- The LRTA projectile sits further into the case reducing case capacity and propellant charge

SMP’s Propellant Solution
- Design the propellant with a higher bulk density to compensate for reduced case capacity and adjust the burn speed
## 50 Cal LRTA (Limited Range Training Ammunition)

**WC860 @ 245 grains in 50 Cal LRTA**

Tested in .50 Cal Barrel (45”)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Velocity (m/s)</th>
<th>Velocity (ft/s)</th>
<th>Pressure (MPa)</th>
<th>Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+70°F</td>
<td>895</td>
<td>2936</td>
<td>350</td>
<td>50,750</td>
</tr>
<tr>
<td>+125°F</td>
<td>923</td>
<td>3028</td>
<td>380</td>
<td>55,100</td>
</tr>
<tr>
<td>-40°F</td>
<td>840</td>
<td>2755</td>
<td>322</td>
<td>46,690</td>
</tr>
</tbody>
</table>

Note: Ballistics meet MOPI requirements
GD-Canada’s .50 Cal Ball C162
  - The C162 cartridge meets NATO’s STANAG .50 Cal (12.7mm) requirements
  - The C162 projectile contains a soft steel core with a gilding metal Jacket
  - The C162 projectile contains no heavy metals

.50 Cal Green propulsion challenges
  - The C162 challenge is that the absence of lead from the projectile base removes the lead decoppering properties
  - The C162 projectile is heavier than the M33 (700 vs. 650 grains)

SMP’s Propellant Solution
  - A propellant decoppering agent is required to properly decopper the barrel and compensate for the lead free projectile
.50 Cal Lead Free Projectile

Pb in primer  Pb exposed at projectile base

Pb+Cu → Decoppering

Pb Free primer  Pb Free projectile

Copper Build up

Pb Free primer  Pb Free projectile

Decoppering Agent in Propellant  Decoppering Agent + Cu → Decoppering

Press  # SHOTS

Press  # SHOTS

Press  # SHOTS
## .50 Cal Lead Free Projectile

**WC862 @ 245 grains in 50 Cal C162**
Tested in .50 Cal Barrel (45"

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Velocity (m/s)</th>
<th>Velocity (ft/s)</th>
<th>Pressure (MPa)</th>
<th>Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+70°F</td>
<td>895</td>
<td>2936</td>
<td>340</td>
<td>49,300</td>
</tr>
<tr>
<td>+125°F</td>
<td>931</td>
<td>3054</td>
<td>380</td>
<td>55,100</td>
</tr>
<tr>
<td>-65°F</td>
<td>844</td>
<td>2769</td>
<td>310</td>
<td>44,950</td>
</tr>
</tbody>
</table>

*Note: Ballistics meet MOPI requirements*
.50 Cal Plastic Case

- **.50 Cal Plastic Case**
  - Offers ~20% weight reduction per rounds w/M33 projectile
- **.50 Cal Plastic Case Propulsion Challenges**
  - Has a ~15% reduced Chamber volume due to the plastic case
  - Must meet standard .50 Cal M33 Performance
- **SMP’s Propellant Solution**
  - Tailor a High Energy BALL POWDER® Propellant (WC869) design to meet standard .50 Cal/M33 performance at a lower propellant charge weight
  - Design the High Energy BALL POWDER® Propellant to have maximum bulk density to maximize charge weight
  - Flat velocities across temperature range
## .50 Cal Plastic Case

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Velocity (ft/s)</th>
<th>Velocity (m/s)</th>
<th>Pressure (psi)</th>
<th>Pressure (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+70°F</td>
<td>2903</td>
<td>885</td>
<td>56,533</td>
<td>390</td>
</tr>
<tr>
<td>+125°F</td>
<td>2860</td>
<td>871</td>
<td>51,916</td>
<td>358</td>
</tr>
<tr>
<td>-40°F</td>
<td>2883</td>
<td>879</td>
<td>57,756</td>
<td>398</td>
</tr>
</tbody>
</table>

Note: Standard .50 Cal M33 Performance in Match Barrel: 2905 ft/s (885 m/s) 56,000 psi (385 Mpa)
.50 Cal SLAP (Sabot Light Armor Penetrator)

- **.50 Cal Slap**
  - Defeats lightly armored vehicles from greater ranges than standard .50 Cal AP ammunition
  - Sabot round reaches velocities of 4,000 ft/s
  - Penetrates 3/4” Armor Plate at 1500 meters

- **.50 Cal Slap Propulsion Challenges/Opportunities**
  - High velocity performance required
  - The .50 Sabot round intrudes into the case less, ~18% increased case capacity compared to M33

- **SMP’s Propulsion Solution**
  - Requires a tailored BALL POWDER® Propellant which fills the case yet meets pressure requirements and burns out completely.
.50 Cal SLAP (Sabot Light Armor Penetrator)

WC856 @ 245 grains in .50 Cal C162
Tested in .50 Cal Barrel (45"

<table>
<thead>
<tr>
<th>Ammo</th>
<th>Powder</th>
<th>Charge</th>
<th>Velocity</th>
<th>Mouth Press</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slap</td>
<td>WC856</td>
<td>@~285 grains</td>
<td>4000 ft/s</td>
<td>51,000 CUP</td>
</tr>
</tbody>
</table>

Note: .50 Cal M33 propellant charge ~240 grains
.50 Cal Advanced Propellants Summary

Summary

- St. Marks Powder has the ability to develop BALL POWDER® Propellant solutions for various .50 Cal applications.
- This presentation covers a cross section of our technology. It has been applied to many other .50 Cal applications around the world, such as the Mk263 round.
- The St. Marks Technology allows for enhanced velocities, at flat temperature profiles, with low flame temperature for reduced barrel and low muzzle signature.
- These propellants are designed to meter well for consistent loading.