GENERAL DYNAMICS
Strength on Your Side

.50 Cal Advanced Propellants

Presented at the NDIA on May 25, 2011

By

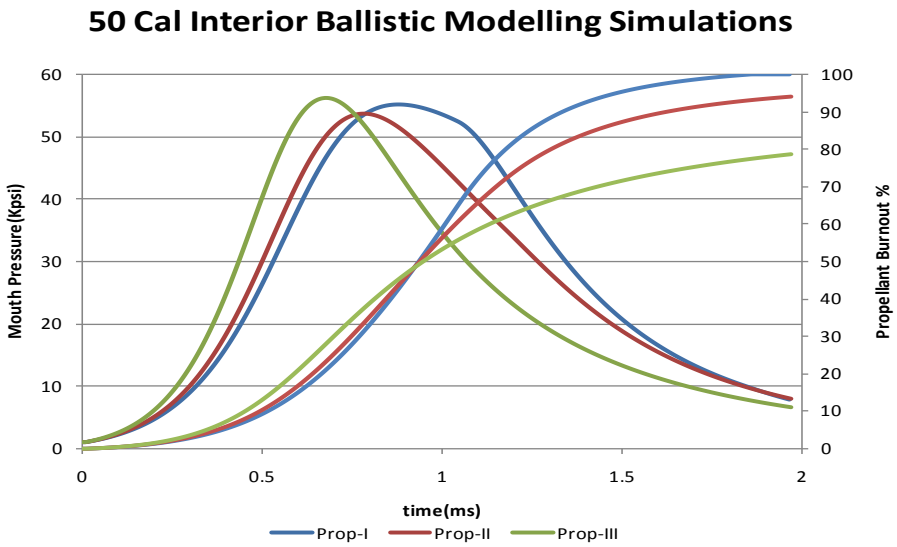
St. Marks Powder (SMP), GD-OTS

.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

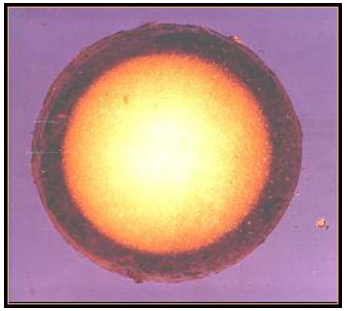
.50 Cal Propellant Development

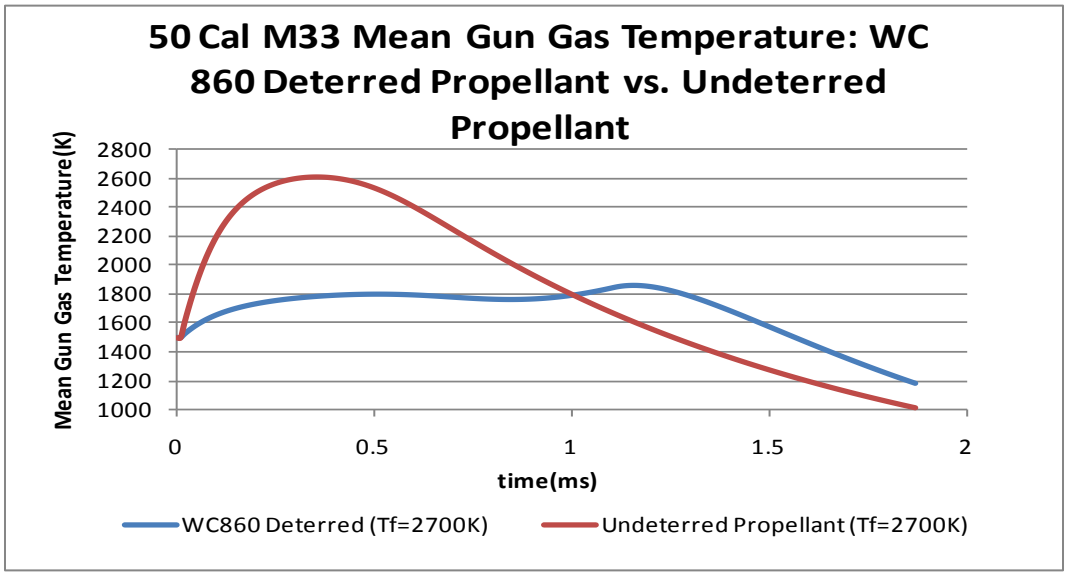
- Propellants are designed using interior ballistic models.
  - Gun Parameters: Cham. Vol., caliber, projectile mass & design
  - Burn Speed is controlled with particle size, chemistry, web
  - Optimal performance requires maximum loading energy, controlled burn to Pmax, and 100% Propellant Burnout
- 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 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) @55,000psi (380 Mpa)

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

Kinetic Energy ~13% Greater at muzzle

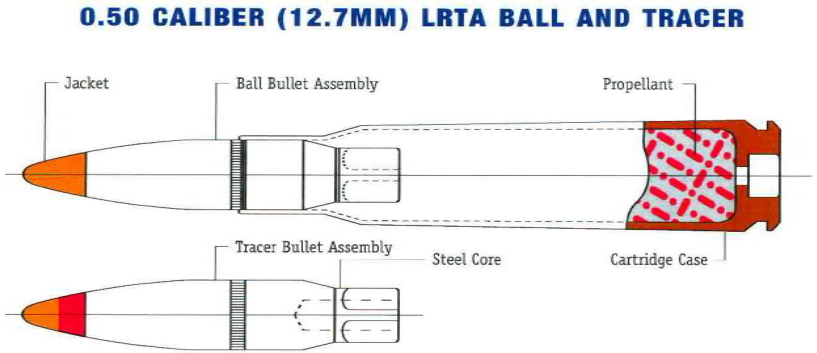
.50 Cal High Performance

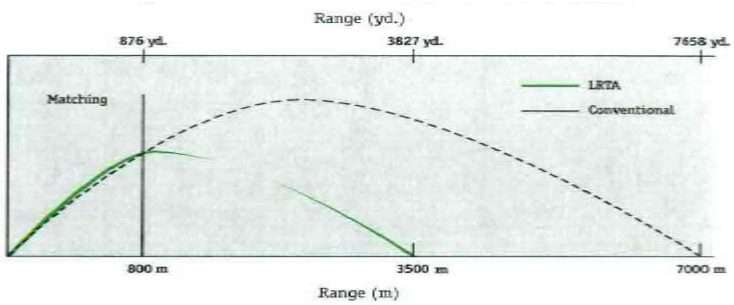
WC869 vs WC860(Standard)
.50 Cal M33(650 grain, B.C. 0.707) 45" Barrel @55,000psi (380 Mpa)

Powder	@muzzle	@500m	@1000m	@1500m
WC860	908 m/s (17.4 KJ)	730 m/s (13.6 KJ)	544 m/s (7.6 KJ)	358 m/s (3.3 KJ)
WC869	968 m/s (19.7 KJ)	795 m/s (16.1 Kj)	609 m/s (9.5 KJ)	423 m/s (4.6 KJ)
Delta KE	**13%**	**18%**	**25%**	**39%**

.50 Cal LRTA (Limited Range Training Ammunition)

- .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")

+70F	**895 m/s(2936 ft/s)**	**350 MPa(50,750 psi)**
+125F	**923 m/s (3028 ft/s)**	**380 MPa (55,100 psi)**
-40F	**840 m/s (2755 ft/s)**	**322 MPa (46,690 psi)**

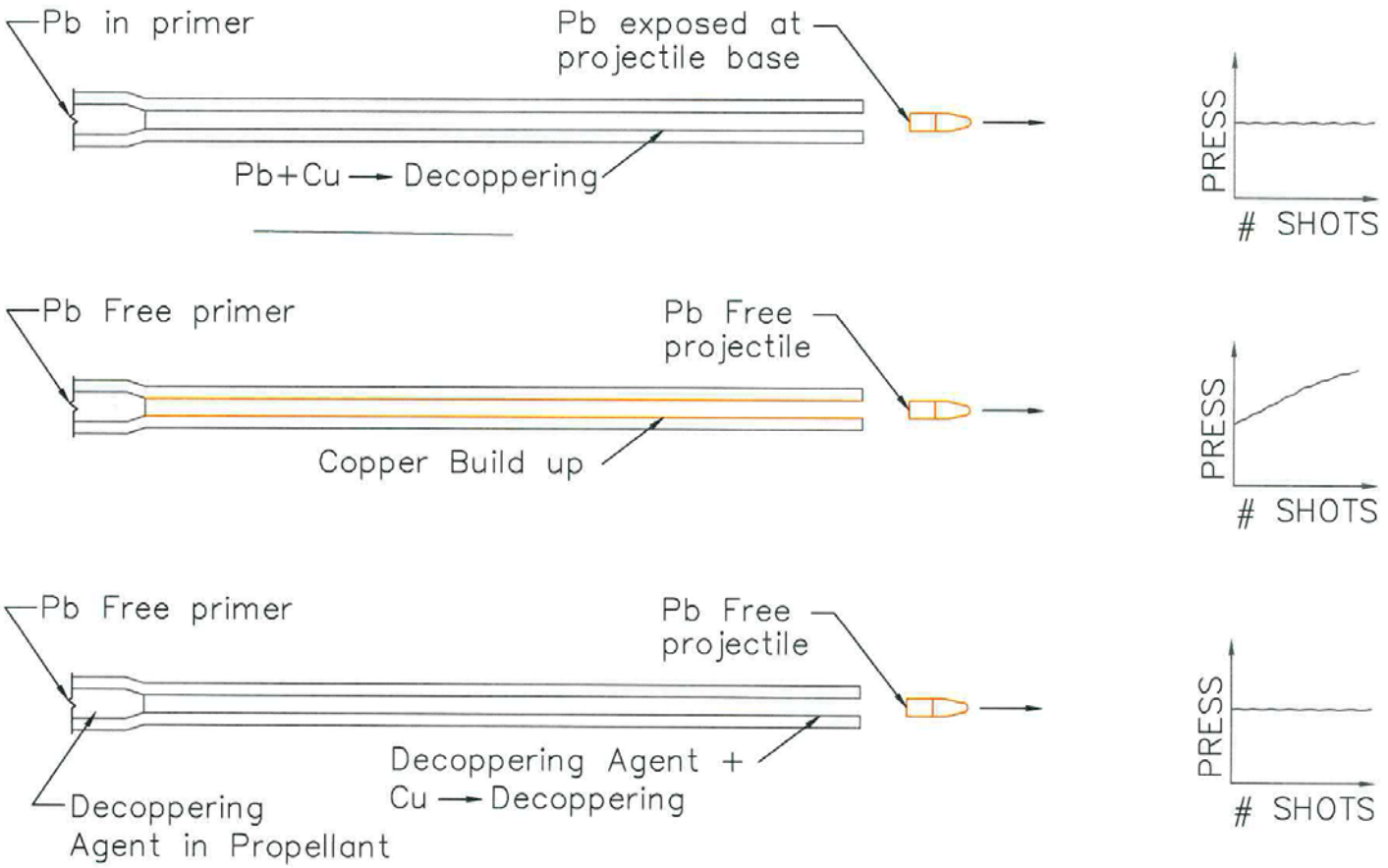
Note: Ballistics meet MOPI requirements

.50 Cal Lead Free Projectile

- 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



.50 Cal Lead Free Projectile

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

+70F	**895 m/s(2936 ft/s)**	**340 MPa(49, 300 psi)**
+125F	**931 m/s (3054 ft/s)**	**380 MPa (55,100 psi)**
-65F	**844 m/s (2769 ft/s)**	**310 MPa (44,950 psi)**

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

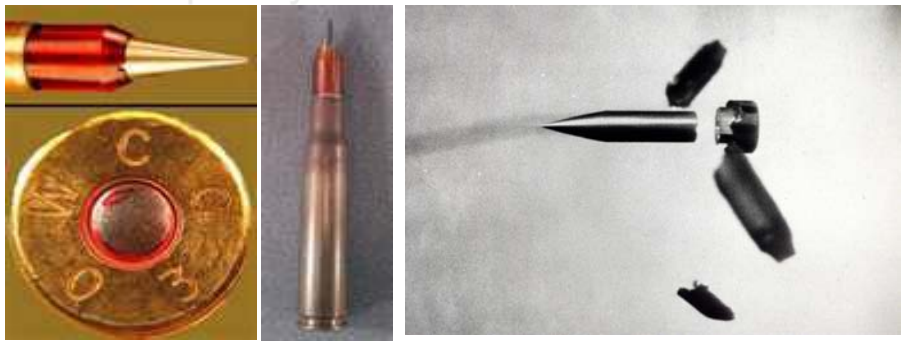
WC869 @ 220 grains in .50 Cal Plastic Cases and M33 Proj. Tested in .50 Cal Match Barrel (36")

+70F	**2903 ft/s (885 m/s)**	**56,533 psi (390 Mpa)**
+125F	**2860 ft/s (871 m/s)**	**51,916 psi (358 Mpa)**
-40F	**2883 ft/s (879 m/s)**	**57,756 psi (398 Mpa)**

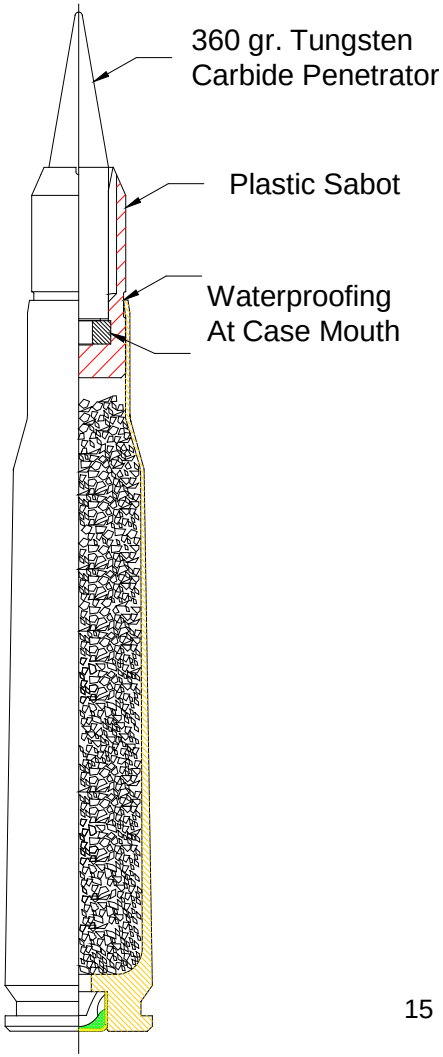
Note: Standard .50 Cal M33 Performance
in Match Barrel: 2905 ft/s (885 m/s) 56,000 psi (385 Mpa)

.50 Cal SLAP (Sabot Light Armor Penetrator)

- .50 Cal Slap
  - Defeats lightly armored vehicles from greater ranges then 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.



Caliber 50
SLAP (M903)



.50 Cal SLAP (Sabot Light Armor Penetrator)

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

Ammo	Powder	Charge	Velocity	Mouth Press
Slap	WC856	@~285 grains	4000 ft/s	51,000 CUP

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