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THE EFFECTS OF PROPELLANT POSITION ON SMALL CALIBER BALLISTIC PERFORMANCE

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INTRODUCTION

- Ullage: The amount by which a container falls short of being full.
  (http://www.dictionary.com)

- Historical studies have generally shown that when more ullage is present in the cartridge, the position of the propellant during firing has a greater effect on characteristics such as velocity and pressure.

- Purposes of Testing

  – To characterize the ullage of small caliber ball and tracer cartridges through the use of x-ray analysis

  – To analyze the effects of propellant position on the ballistics characteristics of small caliber ball and tracer cartridges

TEST SAMPLES

5.56mm

M855 Ball (left)

M856 Trace (right)

7.62mm

M80 Ball (left)

M62 Trace (right)

Caliber .50

M33 Ball (left)

M17 Trace (right)

TEST METHOD – OVERVIEW

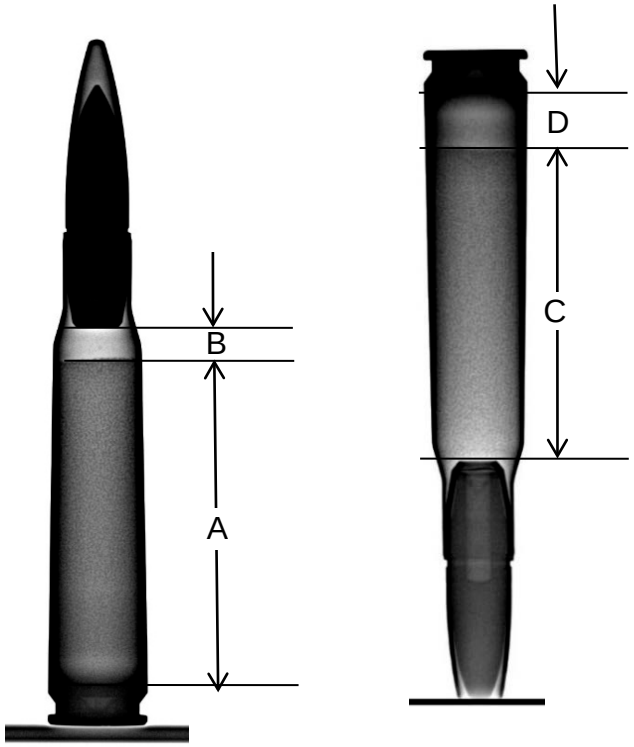
- X-ray analysis was used to estimate the ullage for a subset of each of six cartridge types
- Ballistics analysis consisted of Electronic Pressure, Velocity, Action Time Testing (EPVAT) testing resulting in the following data:
  - Velocity at 78 feet
  - Chamber Pressure
  - Action time
  - Pressure-Time Curves

- To orient the propellant prior to x-ray and ballistics analysis, each round was rotated slowly 360 degrees in a vertical plane, pausing at 180 degrees
- After one full rotation, the round was tapped lightly on a flat surface to further settle the propellant
- Care was taken during handling to minimize propellant shift during horizontal loading of the weapon

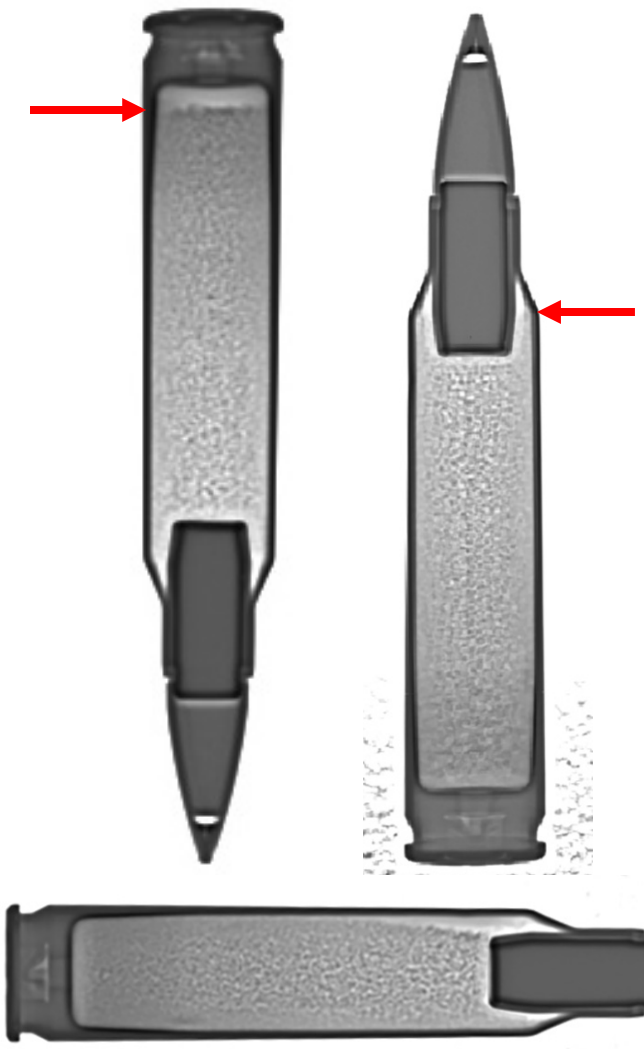
Nose Up:
Propellant positioned near primer

Nose Down:
Propellant positioned near projectile

- 10 unfired rounds from each cartridge type were x-rayed in 2 orientations: nose up & nose down
  - Propellant and ullage heights were approximated from each image
- One additional unfired round from each cartridge type was also x-rayed in the horizontal position



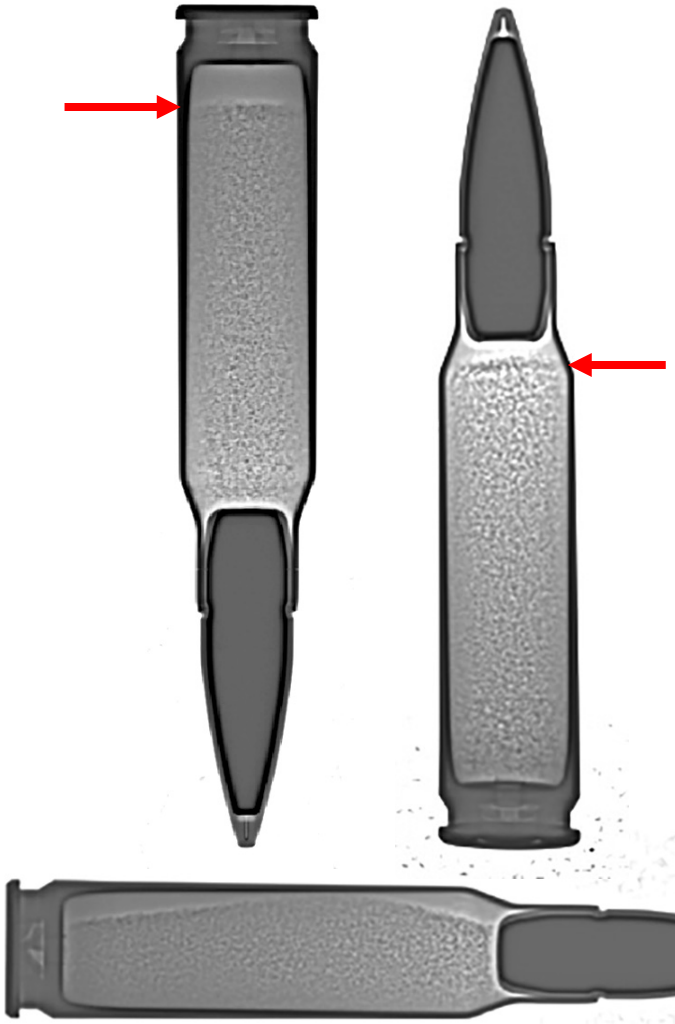
X-RAY IMAGES – 5.56MM



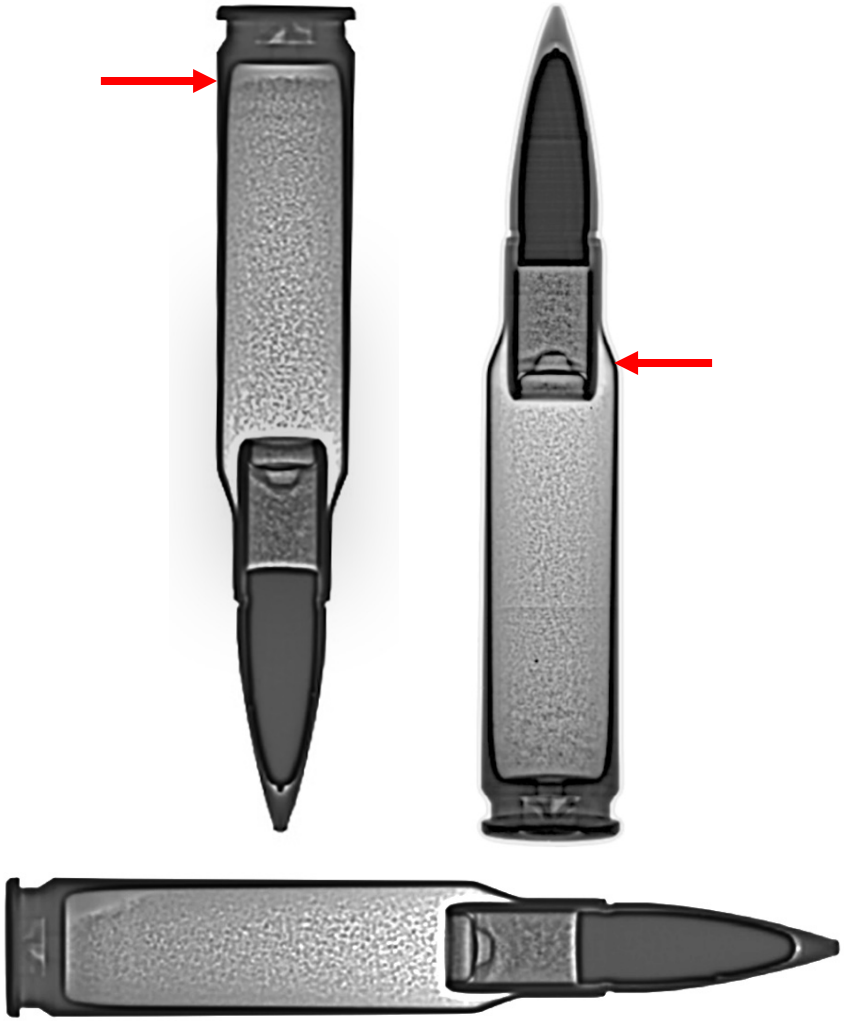
M855 Ball

M856 Trace

X-RAY IMAGES – 7.62MM

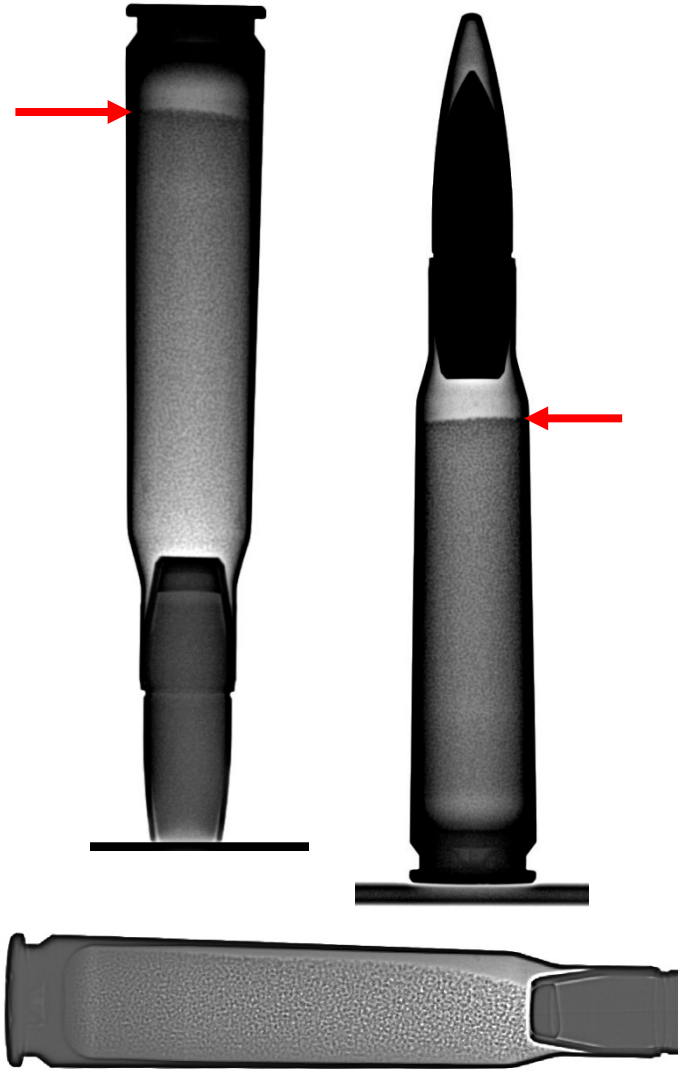


M80 Ball

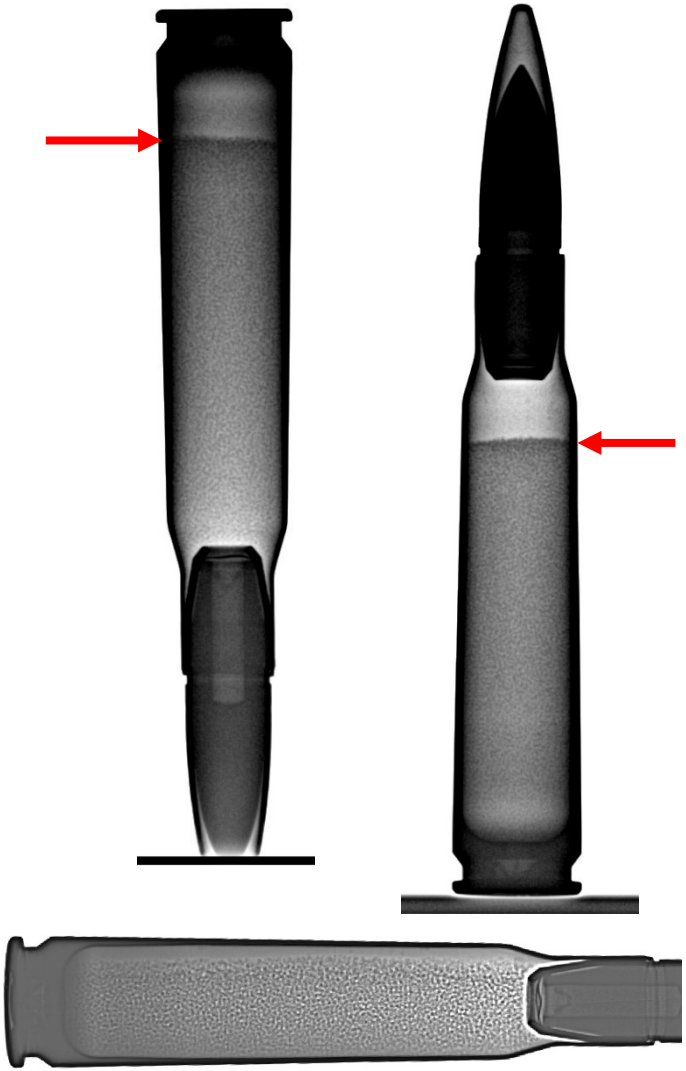


M62 Trace

X-RAY IMAGES – CALIBER .50



M33 Ball



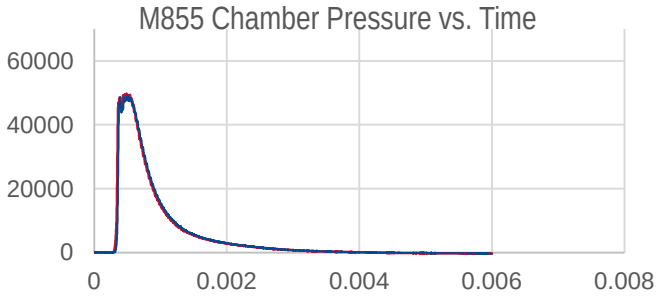
M17 Trace

Sample Number	Caliber	Cartridge Type	Total Sample Size Fired	Nose Up Sample Size	Nose Down Sample Size
1	5.56mm	M855 Ball	100	50	50
2	5.56mm	M856 Trace	100	50	50
3	7.62mm	M80 Ball	100	50	50
4	7.62mm	M62 Trace	100	50	50
5	Cal .50	M33 Ball	90	45	45
6	Cal .50	M17 Trace	90	45	45

Note: Of the10 x-rayed rounds from each cartridge type, 5 were fired with the propellant oriented near the primer and the other 5 were fired with the propellant oriented near the projectile.

5.56MM BALLISTICS

Cartridge Type	Orientation	Avg. Chamber Pressure *(psi)*	Avg. Velocity *(ft/s)*	Avg. Action Time *(ms)*
M855	Nose Up	48772.71	2939.33	0.785
	Nose Down	49330.81	2941.36	0.765
M856	Nose Up	50996.24	2973.94	0.770
	Nose Down	51158.69	2978.69	0.770

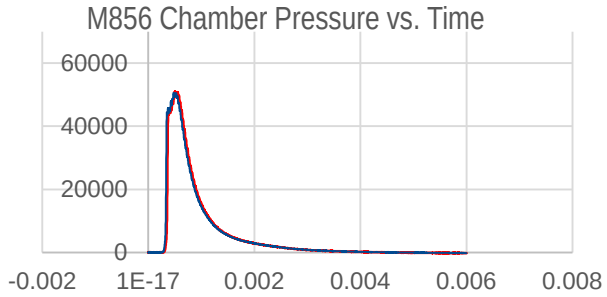


M855 Ball Findings:

Δ Chamber Pressure: 558.11 psi (nose down)

Δ Velocity: 2.03 ft/s (nose down)

Rise Time: Unaffected by propellant orientation – varies by <1%



M856 Tracer Findings:

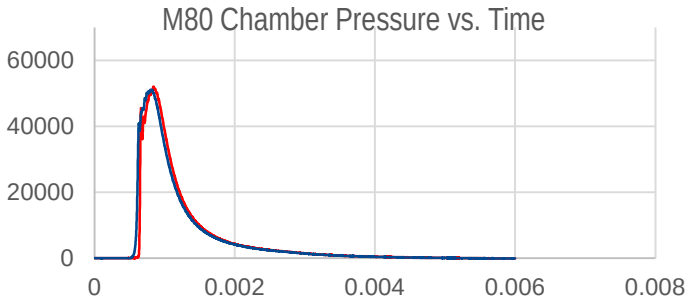
Δ Chamber Pressure: 162.45 psi (nose down)

Δ Velocity: 4.75 ft/s (nose down)

Rise Time: Unaffected by propellant orientation – varies by <1%

7.62MM BALLISTICS

Cartridge Type	Orientation	Avg. Chamber Pressure *(psi)*	Avg. Velocity *(ft/s)*	Avg. Action Time *(ms)*
M80	Nose Up	50363.04	2733.98	1.293
	Nose Down	51652.10	2772.21	1.240
M62	Nose Up	52981.93	2691.12	1.088
	Nose Down	52158.94	2685.54	1.058

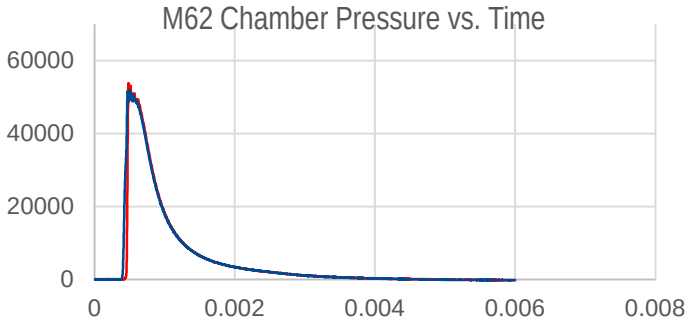


M80 Ball Findings:

Δ Chamber Pressure: 1289.06 psi (nose down)

Δ Velocity: 38.23 ft/s (nose down)

Rise Time: Unaffected by propellant orientation – varies by <1%



M62 Tracer Findings:

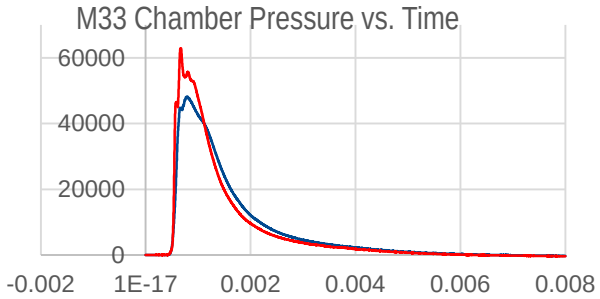
Δ Chamber Pressure: 823.00 psi (nose up)

Δ Velocity: 5.59 ft/s (nose up)

Rise Time: Unaffected by propellant orientation – varies by <1%

CALIBER .50 BALLISTICS

Cartridge Type	Orientation	Avg. Chamber Pressure *(psi)*	Avg. Velocity *(ft/s)*	Avg. Action Time *(ms)*
M33	Nose Up	59,675.56	2911.84	1.830
	Nose Down	48,033.31	2790.66	1.915
M17	Nose Up	49,080.13	2873.89	2.017
	Nose Down	50,908.47	2896.24	1.975

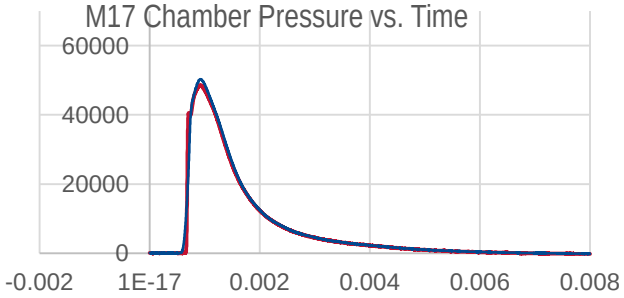


M33 Ball Findings:

Δ Chamber Pressure: 11,642.25 psi (nose up)

Δ Velocity: 121.18 ft/s (nose up)

Rise Time: Unaffected by propellant orientation – varies by <1%



M17 Tracer Findings:

Δ Chamber Pressure: 1828.34 psi (nose down)

Δ Velocity: 22.35 ft/s (nose down)

Rise Time: Unaffected by propellant orientation – varies by <1%

SUMMARY OF RESULTS

Cartridge Type	Approx. % Ullage	Δ Avg. Chamber Pressure *(psi)*	Δ Avg. Velocity ***(ft/s)***	Δ Avg. Action Time *(ms)*
M855	3.90%	-558.11	-2.03	0.0194
M856	1.04%	-162.45	-4.75	-0.001
M80	9.53%	-1289.06	-38.23	0.053
M62	4.19%	823.00	5.59	0.030
M33	12.05%	11,642.25	121.18	-0.084
M17	15.17%	-1828.34	-22.35	0.042

Note: Negative values indicate that the particular characteristic in nose down orientation is greater than in nose up orientation.

5.56MM CONCLUSIONS

- M855: The propellant orientation does not have a significant effect on the ballistic results due to very little ullage within the cartridge

- M856: The propellant orientation does not have a significant effect on the ballistic results due to very little ullage within the cartridge

M855 Ball

M856 Tracer

7.62MM CONCLUSIONS

- M80: The effects of ullage in nose-down orientation appear to be overcome by a flashover effect resulting from the exposure of more propellant surface area along the diagonal to the flash hole

- M62: The propellant orientation does not have a significant effect on the ballistic results due to very little ullage within the cartridge

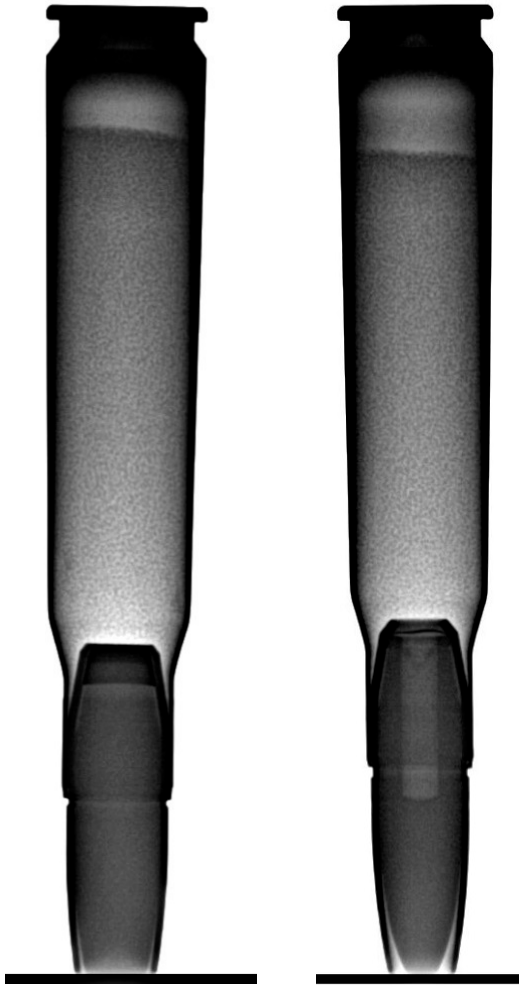
M80 Ball

M62 Tracer

CALIBER .50 CONCLUSIONS

- M33: The relatively large percentage of ullage manifests itself as drastic variations in chamber pressure and velocity due to dissipation of energy in the space between the primer and propellant in nose-down orientation.

- M17: In nose-down orientation, effects of the relatively large percentage of ullage appears to be overcome by back pressure originating from the igniter mix which initiates the tracer



M33 Ball M17 Tracer

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