HIGH PRECISION METAL FORMING

Mr. Jerry Dickson, US Army AMCOM
Mr. Bill Baschnagel, Creare, Inc.
Mr. Albert Tatka, US Army TACOM-ARDEC

Why?

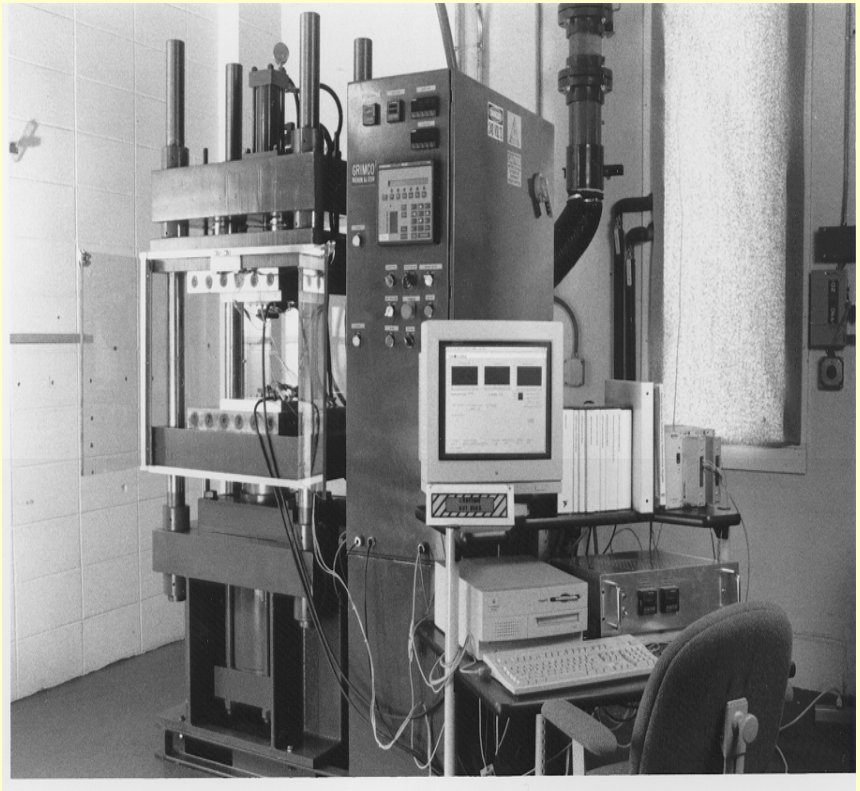
- Sabot is a critical component to launch a smaller diameter subprojectile
- M919 sabot is parasitic – not carried to target i.e. not a direct lethality contributor
- Sabot was 20% of M919 cost

Background

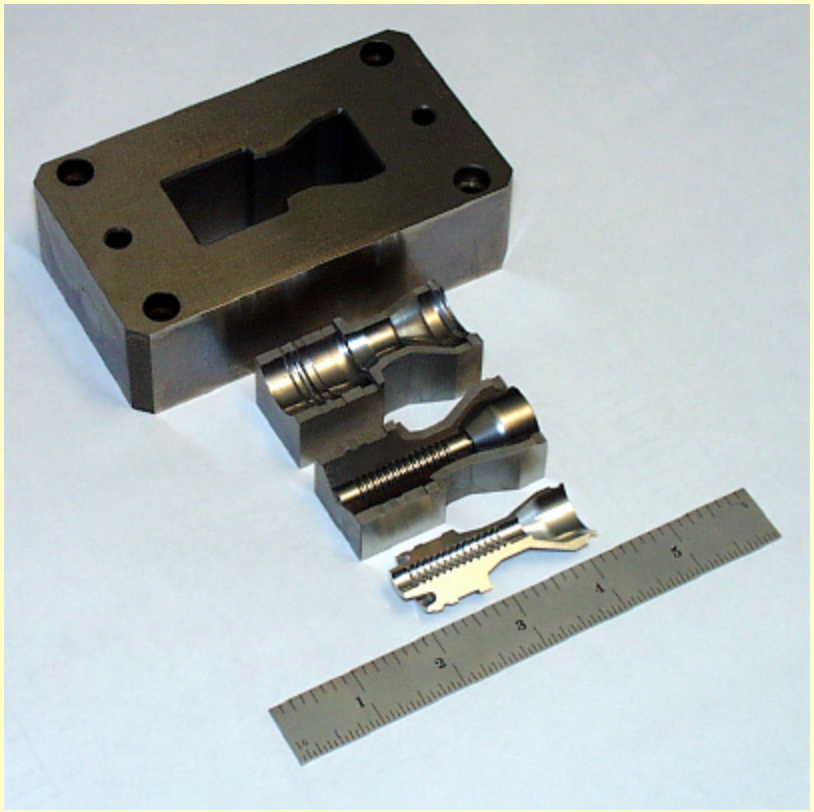
- Although parasitic, sabot critical to launch subprojectile successfully
- Modeling indicated stress loads on 1st and last three buttress teeth to approach 127ksi
- The M919 uses a 7075 AL alloy (w/ T6 temper) that is CNC machined by the contractor

Background Cont'd

- AMCOM MANTECH identified High Precision Metal Forming (HPMF) as capable of molding high strength, high precision AL millimeter wave housings
- Computer-controlled 100 ton press equipped w/ heated die set

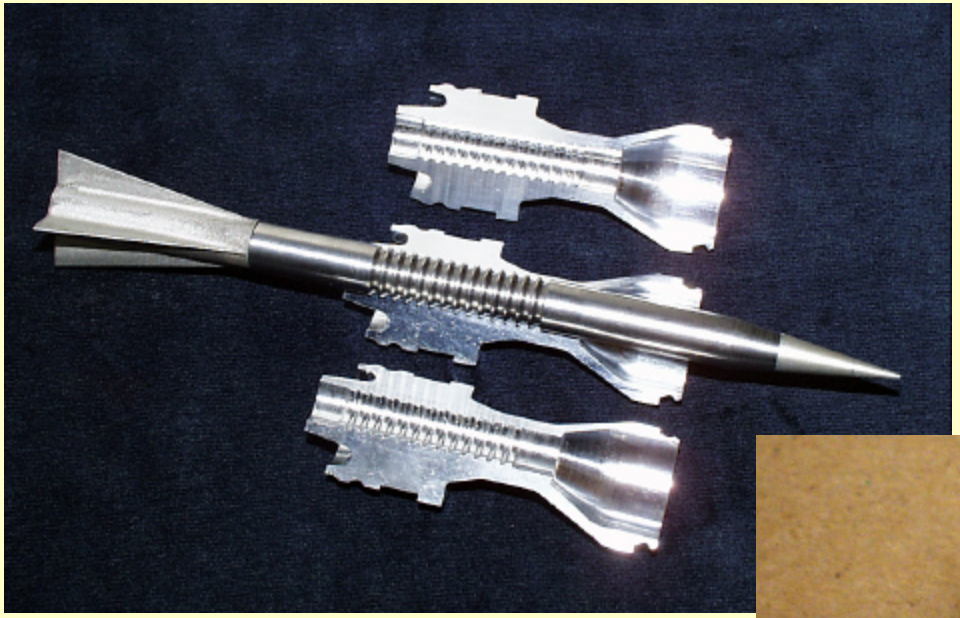


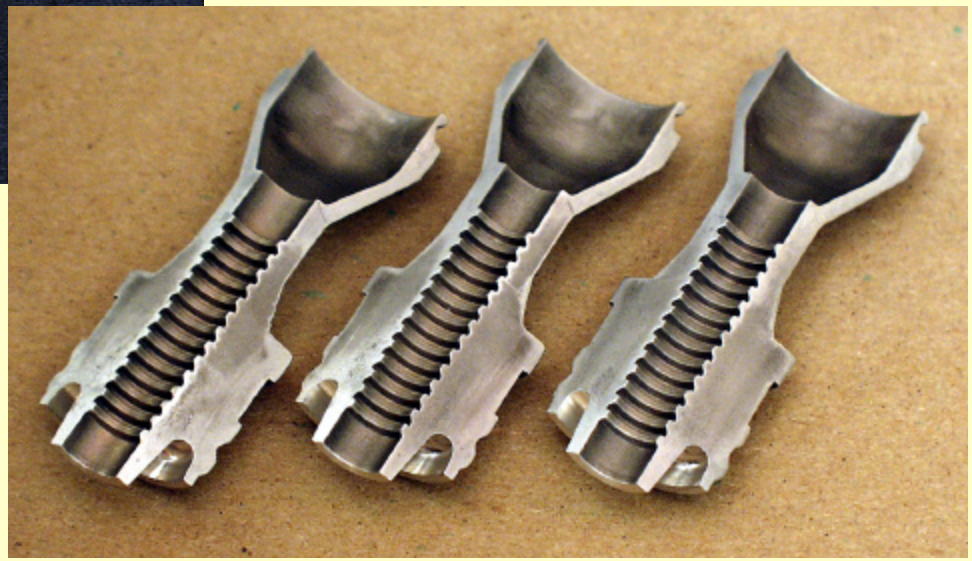
Molded Sabots



- Die set built to mold M919 Sabots
- Fixed volume 7075 Al billet heated to 450°C
- Die closes under timed control
- Reliefs cut for flashing
- Proprietary die lube

Machined vs. Molded Sabots





ARDEC Analysis

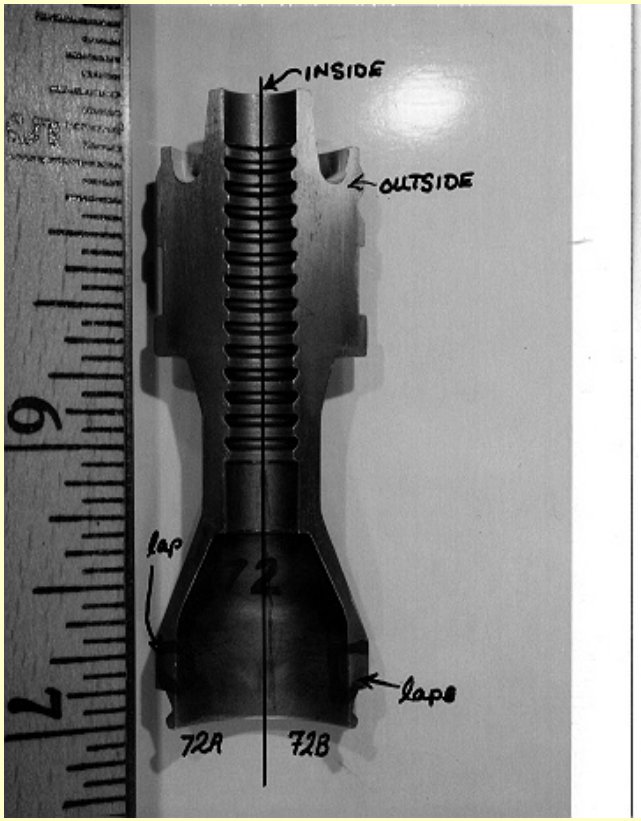


Figure 1a. Sabot No. 72 in the "as -received" condition, teeth facing up.

Figure 1b. Sabot No. 72 in the "as-received" condition, outer surface.

ARDEC Analysis

Figure 2a. Cross-section of Sabot No. 72A inside. The circled area is a lap that corresponds to Figure 2b.

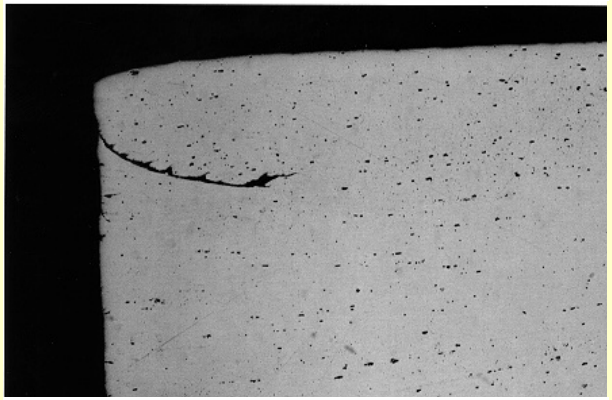


Figure 2b. Lap noted in Sabot No. 72A inside, mag. 100x.

- ARDEC WECAC sectioned formed sabots to observe grain structure and flaws
- Laps found in non-critical
- Difficult to move metal thru cap groove

ARDEC Analysis Cont'd

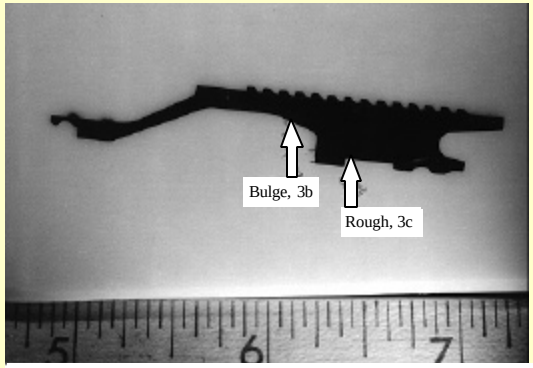


Figure 3a. Cross-section of Sabot No. 72B outside wall. Arrows point to anomalies in the structure and correspond to Figures 3b & 3c below.

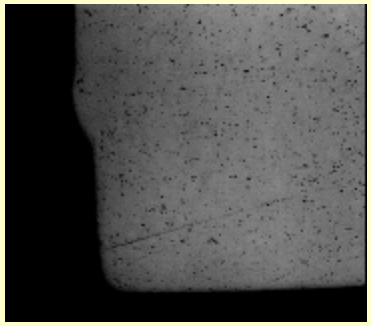


Figure 3b. Bulge found in Sabot No. 72B outside wall, 40x.

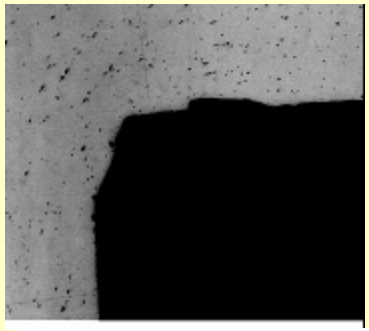


Figure 3c. Rough area found in Sabot No. 72B outside wall, 75x

- Additional flaws identified
- Bulges found in saddle area
- Rough sections found in band seat

ARDEC Analysis Cont'd

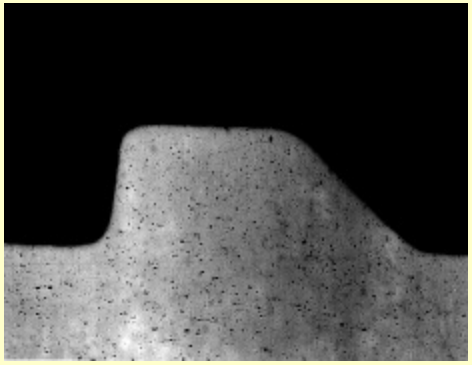


Figure 9. Tooth from Sabot No. 72A inside, 50x.

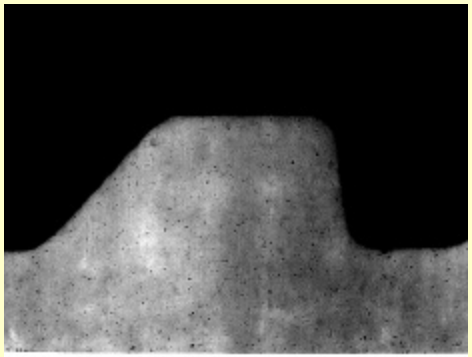


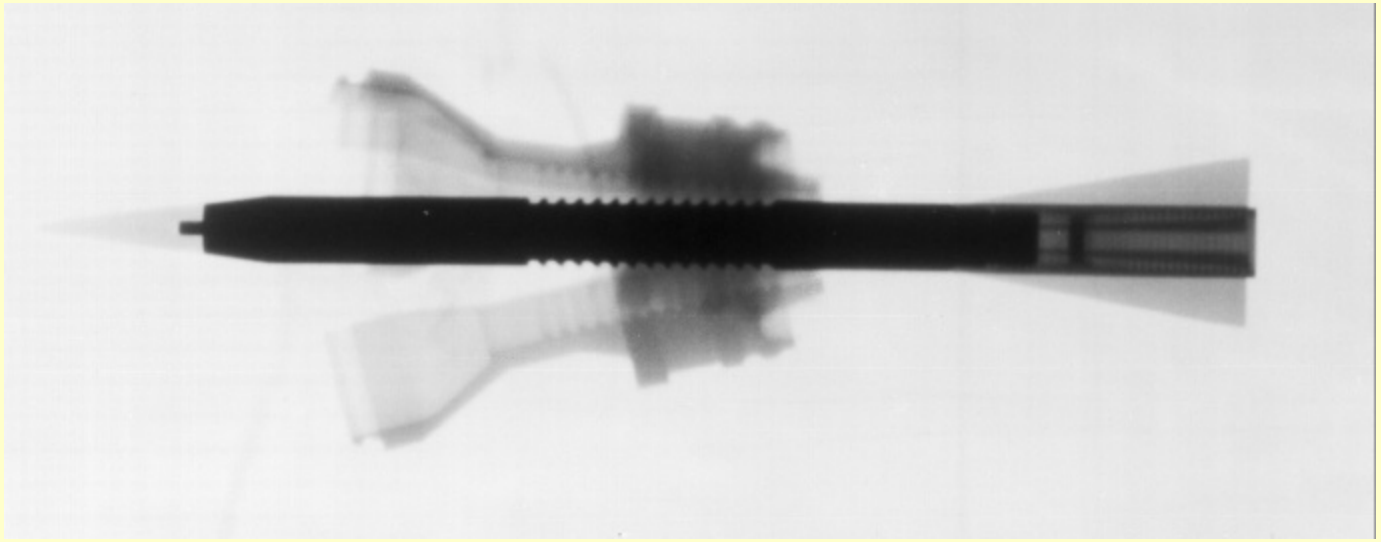
Figure 10. Tooth from Sabot No. 73B inside, 50x.

- Teeth fully formed, no laps or other flaws noted in teeth area that would result in weakened structure
- Go ahead given to produce ballistic test hardware

Ballistic Test Build

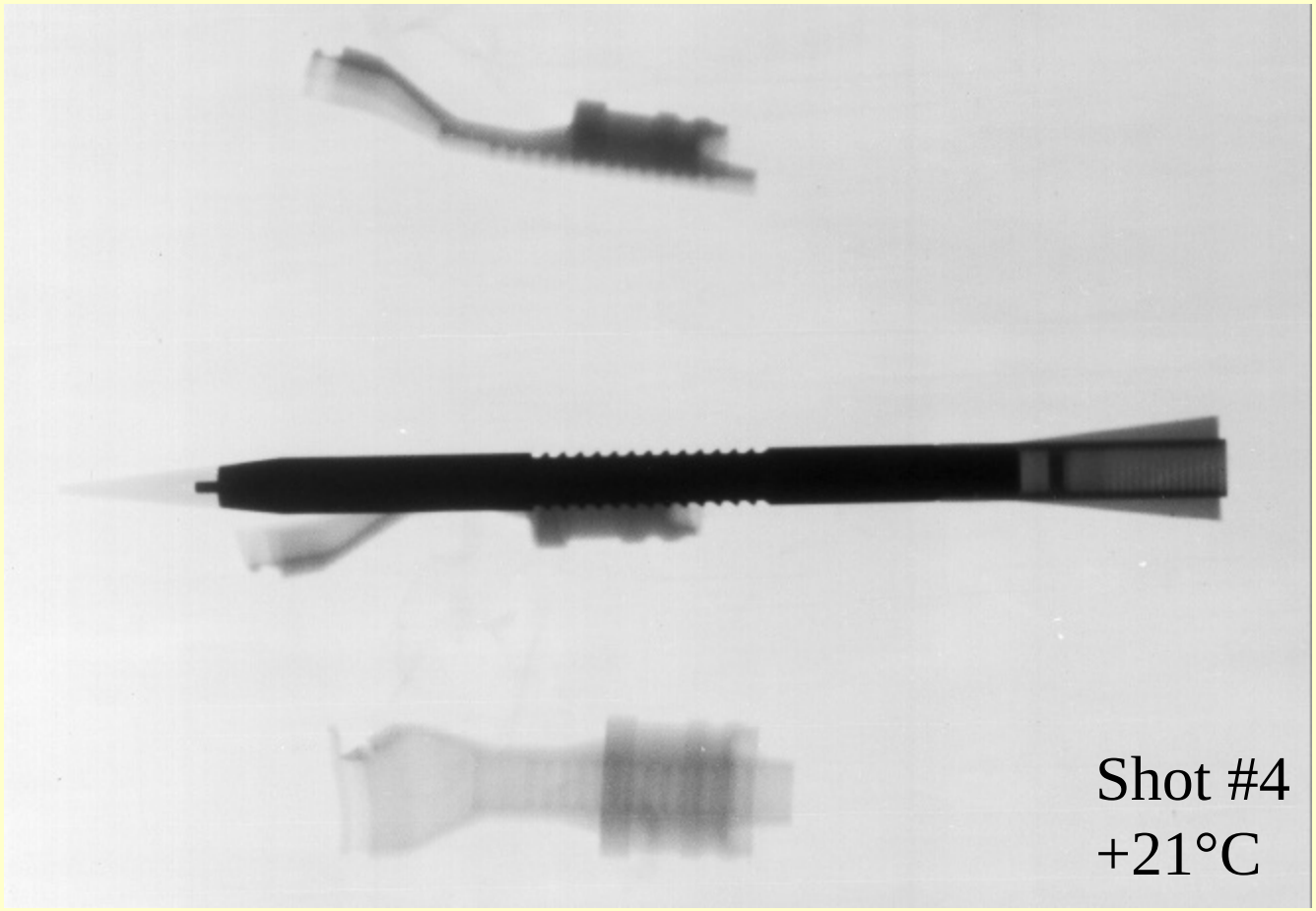
- During forming, die set not closing in parallel
- Inspection noted that aft section slightly oversized
- Thought not to have dramatic effect on finished assembly
- Twenty four sets fabricated
- Aft scoop machined, heat treated and cleaned
- Finished parts provided to GD-OTS to anodize and assemble into M919 cartridges

Machined Sabot Projectile

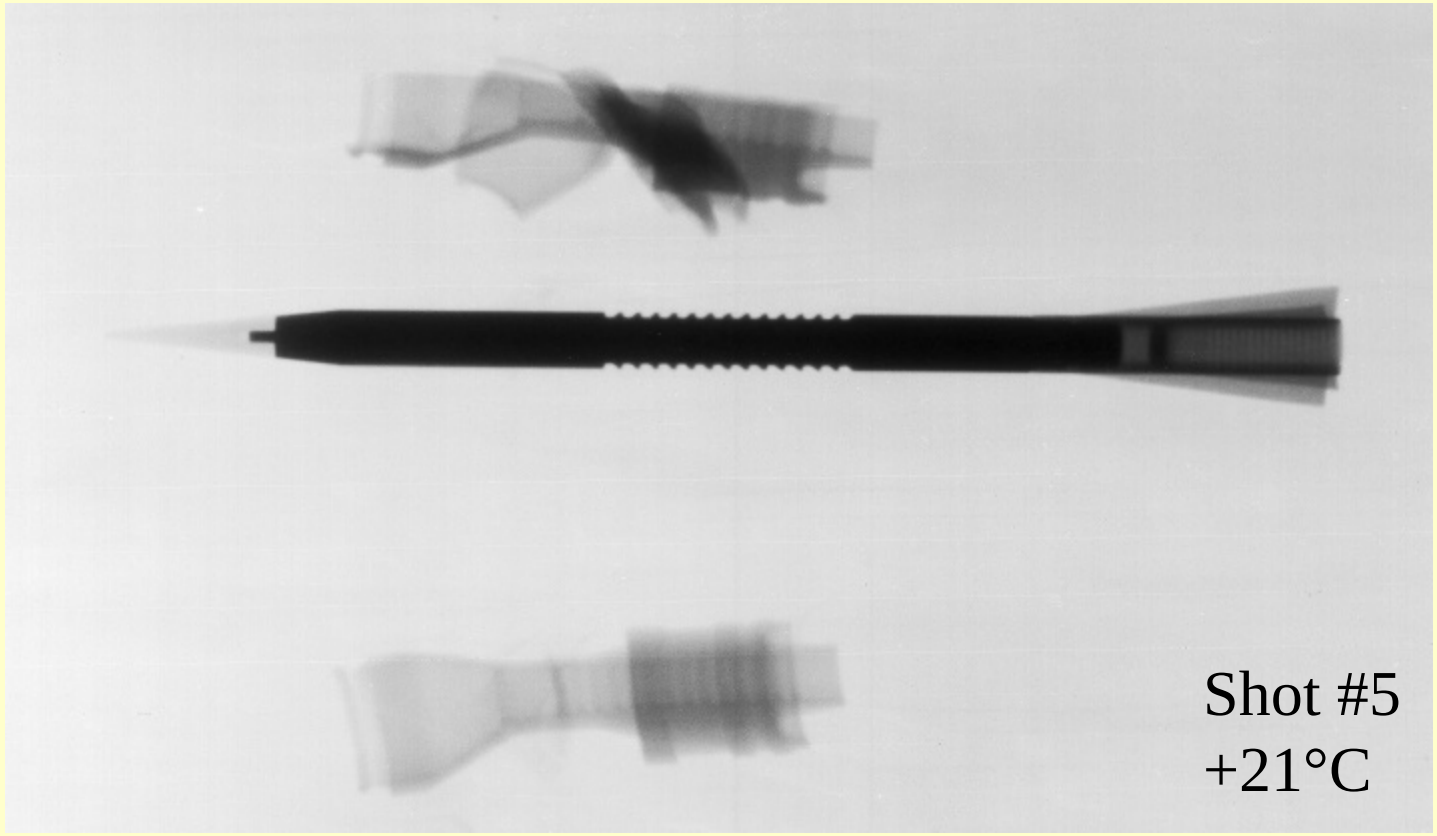


X-rays at 20” from Muzzle @ +21°C

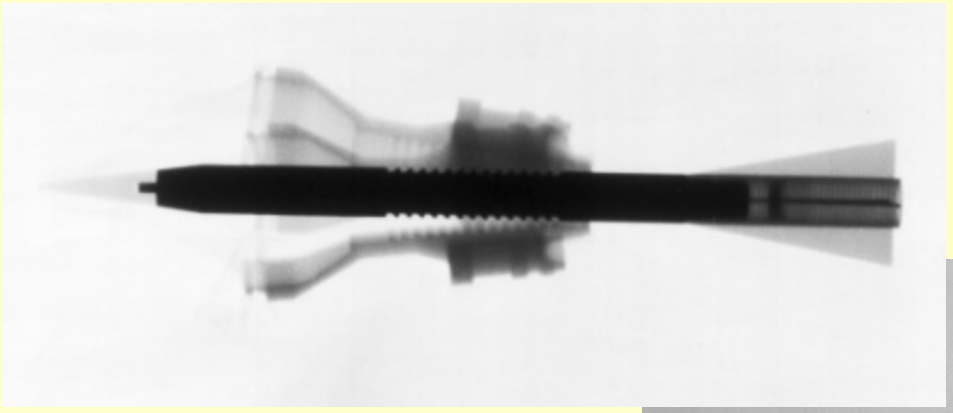
Molded Sabot Projectile



Molded Sabot Projectile

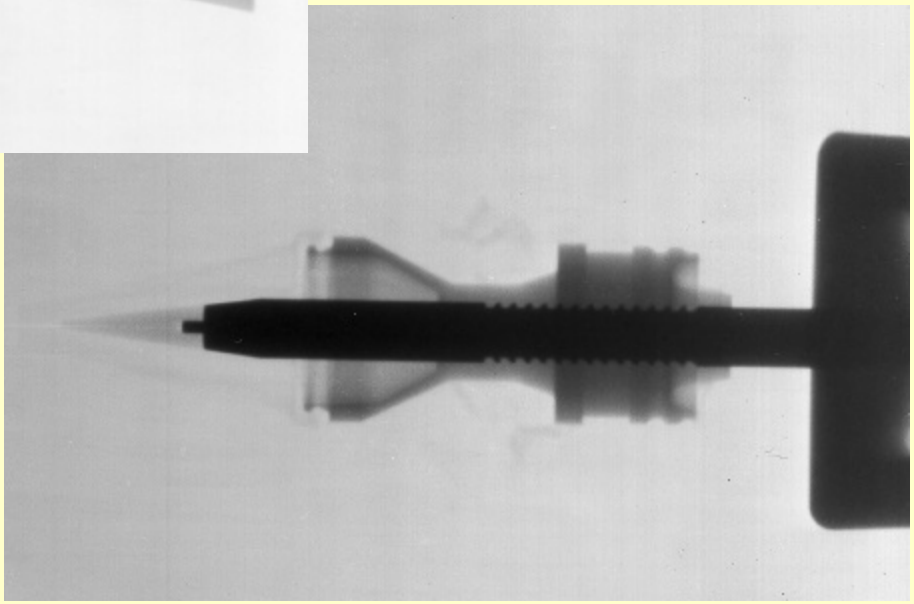


Machined Sabot Projectile



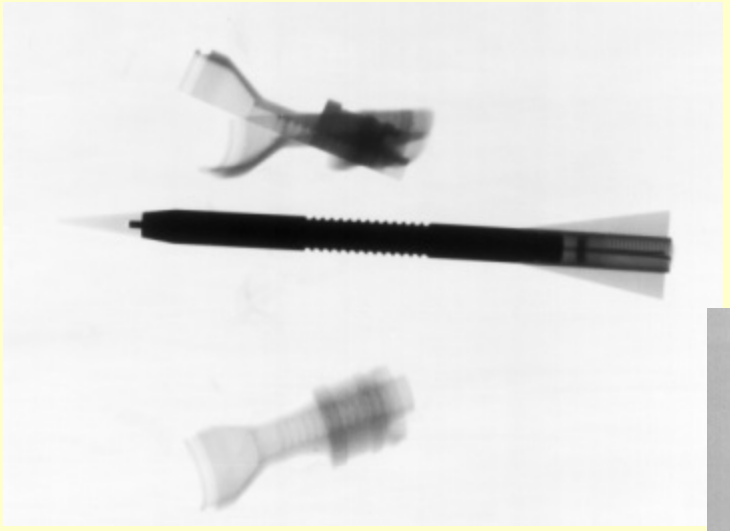
20” from muzzle

At muzzle



Shot #9
-32°C

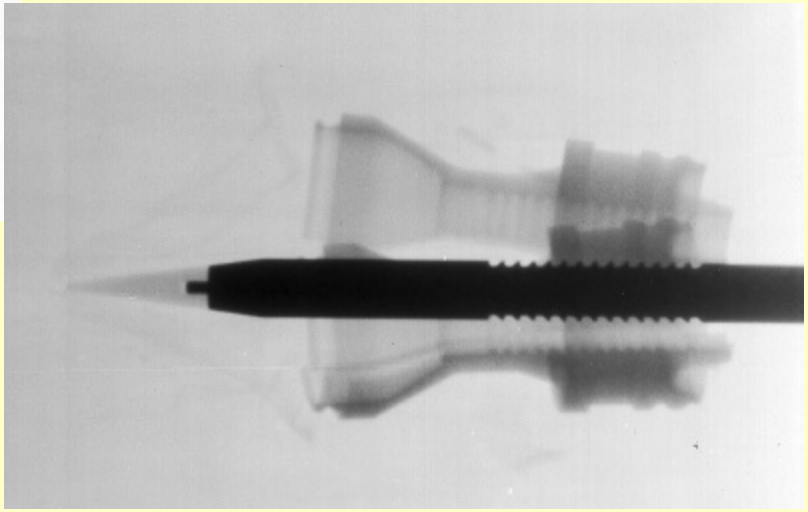
Machined Sabot Projectile



20” from muzzle

Shot #10
-32°C

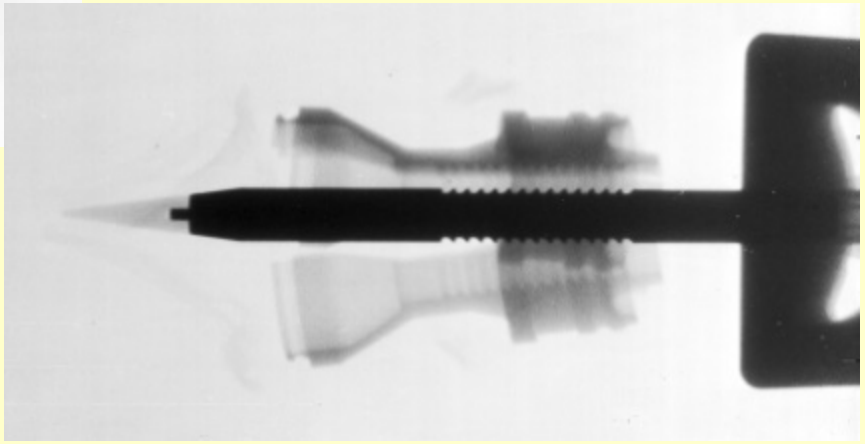
At muzzle



Machined Sabot Projectile

20” from muzzle

At muzzle



Shot #11
-32°C

Conclusions

- Oversized aft DIA resulted in excessive spin
- Excessive spin may have contributed to structural failures noted
- Buttress teeth survived launch
- Additional effort required to optimize
- Process could have direct benefit to other DoD programs