Baselining of the 40mm Family of Ammunition

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Overview

- Reason for 40mm Grenades Baselining
- Spark Range Testing
- Firing Tables Testing
- EPVAT Testing with Soft Recovery
- Warheads Testing
- System Effectiveness Modeling & Simulation

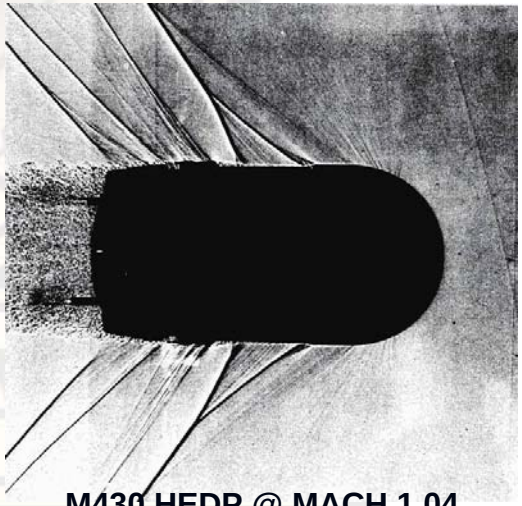
Reason for 40mm Baselining

- Need for testing born out of several sources
  - Desire to know ballistic similitude between M433 HEDP and M781 TP projectiles.
  - Desire to know max trail angle of M433 HEDP to max possible QE of M203 for LOS/BLOS concept.
  - Desire to study M433 impact & liner retaining ring.
  - Desire to determine match accuracy of M203 & Mk19 sights to M433 & M430A1 trajectories, respectively.
- Could not field calls for information
  - Peak pressure from M433 HEDP
  - Firing Table for M781 TP or M406 HE

Spark Range Testing

- Spark Shadowgraph Range Testing employs orthogonal cameras placed at fixed intervals along trajectory to photograph the positional and angular orientation of the projectile.
  - Performed indoors with no ambient lighting.
  - Each station provides a "spark" to back light the projectile.
- 6-DOF motion models used to reduce data.
  - Provides aero coefficients, stability parameters and other characteristics.
  - Parameters needed for projectile design, diagnostic studies and firing table construction.

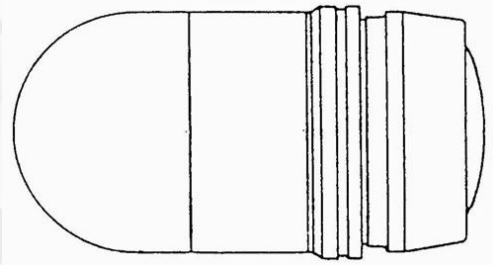
ARL Spark Shadowgraph Range



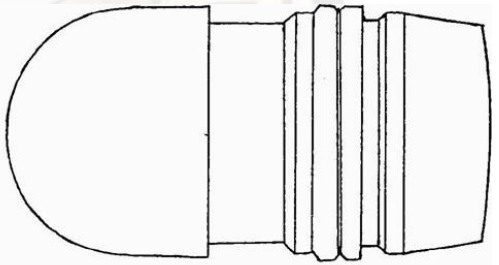
M430 HEDP @ MACH 1.04

Spark Range Testing

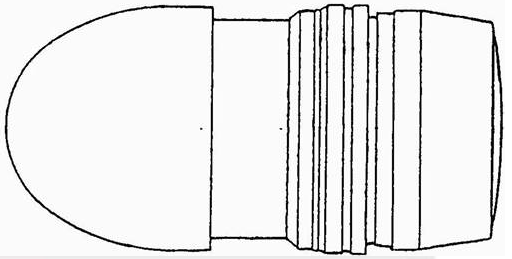
- Only known 40mm spark range testing performed on high velocity cartridges.
  - "BRL-MR-3788 Aero Characteristics of 40mm Ammo for the Mk19 GMG", Robert McCoy & Andre Sowa, November 1989.
  - Characterized M430 HEDP, M385E4 TP, M385 TP & M384 HE cartridges.
  - M384 & M385 no longer in service
  - M430 changed (now M430A1)
  - M385E4 remained unchanged (now M385A1)



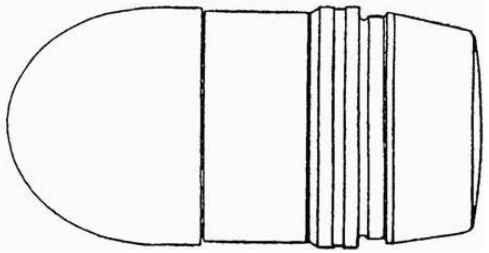
M430 HEDP



M385E4 TP



M385 TP



M384 HE

Spark Range Testing

- Performing Spark Range Testing at ARL and Eglin AFB
- Testing both Low & High Velocity projectiles
  - M433 HEDP (M203 GL)
  - M781 TP (M203 GL)
  - M430A1 HEDP (Mk19 GMG)
  - M918 TP (Mk19 GMG)
  - M385A1 TP (Mk19 GMG)
- Using both 12” & 9” M203 GL barrels

Firing Tables Testing

- Testing performed by ARDEC Firing Tables Team at Aberdeen Test Center
- Firing M433 HEDP & M781 TP cartridges from M203 GL (both 12” & 9” barrels).
- Testing to be performed:
  - Physical Characteristics of Ammunition
  - Muzzle Velocity vs. Propellant Temperature Test
  - Ballistic Match & Firing Tables Verification Test
  - Maximum Range Aeroballistic Test
  - Maximum Trail Quadrant Elevation Test

Firing Tables Testing

- Ballistic Match & Firing Tables Verification Test
  - Yields firing tables for M433 HEDP & M781 TP ctgs
  - Determines level of match of TP to HEDP
- Maximum Range Aeroballistic Test
  - Objective is to obtain aerodynamic drag data & developing range safety data
- Maximum Trail Quadrant Elevation Test
  - Determine QE above which M433 HEDP & M781 TP will not trail
  - Assumes maximum trail angle will be different between M433 HEDP & M781 TP

EPVAT Testing with Soft Recovery

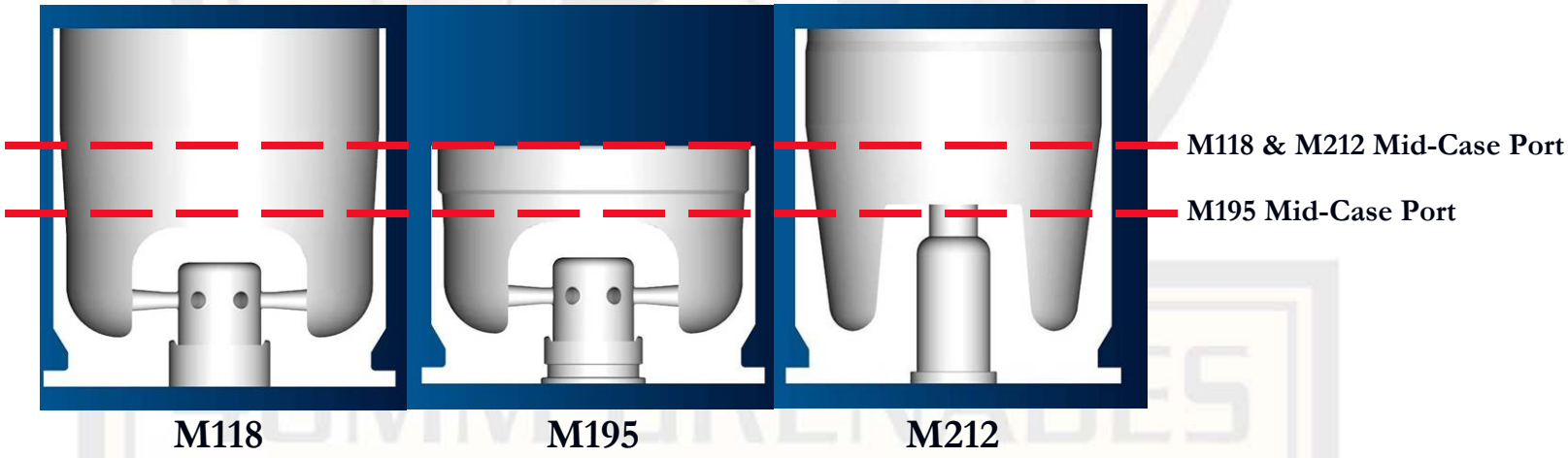
- Electronic Pressure, Velocity & Action Time is scarce for 40mm Grenades
  - High Velocity (Mk19) P-t data exists for M169 Cartridge Case Assembly firing M430 HEDP, M385E4 TP & XM918 TP (March 1987)
  - High Velocity Action Time taken during LAT using M129 GMG (not Mk19 GMG)
  - Low Velocity P-t data exists for M118 Cartridge Case Assembly firing M406 HE (March 1971)
- No established method for EPVAT testing during production or development

EPVAT Testing with Soft Recovery

- ARDEC developed Low Velocity Mann barrel
  - Designed for recording P-t data from both mid-case and case-mouth positions on both long and short cartridge case assemblies
  - Development occurred at same time as NATO Mann barrel establishment
  - Breech Assembly for ARDEC LV Mann Barrel leverage from ARDEC High Velocity Mann Barrel
    - ARDEC HV Mann Barrel meant for stabilized firing and cannot be ported for pressure
  - LV Mann barrel fabricated and ported by Colt Defense
- Planning in place to acquire an ARDEC High Velocity Mann Barrel for EPVAT

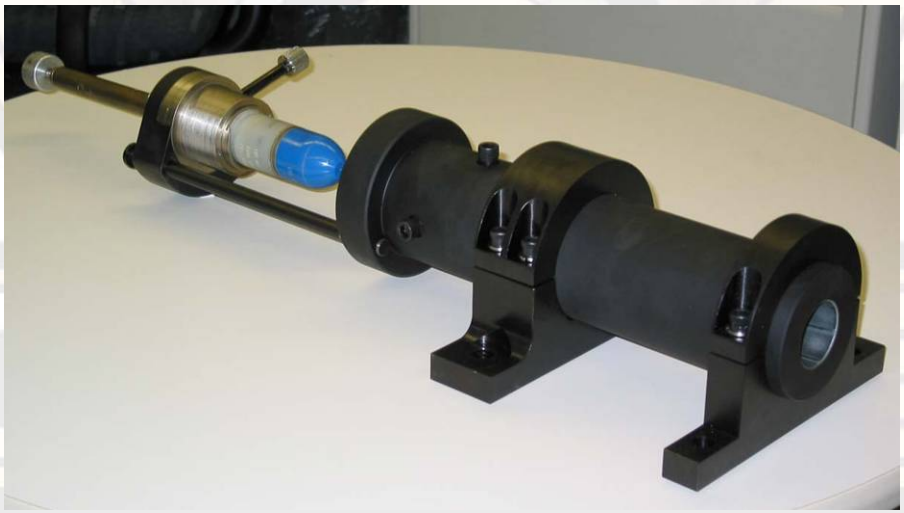
EPVAT Testing with Soft Recovery

- Testing involves shooting the following cartridges at hot, cold & ambient temperatures
  - M433 HEDP (M118 Ctg Case)
  - M583A1 Whitestar Parachute (M195 Ctg Case)
  - M781 TP (M212 Ctg Case)



EPVAT Testing with Soft Recovery

- Current breech assembly not instrumented for action time start signal
  - Using high speed digital video to capture start and stop points for action time
  - Planning in place for an improved breech assembly and add action time sensor



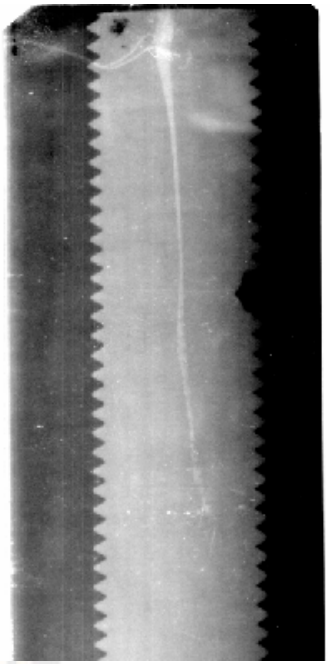
ARDEC 40mm
Low Velocity
Mann Barrel Setup

Warheads Testing

- Decades of production has resulted in minor changes which may have severely impacted lethality
- LATs test for perforation, but do not check fragmentation effects
- Speculation of poor lethality requires a definitive evaluation be performed
- ARDEC Warheads team performing tests on M433 HEDP & M430A1 HEDP projectiles to characterize fragmentation and penetration performance
  - Results translated into JMEMS format & run through CASRED
  - CASRED output (Probability of Incapacitation) compared to data on file at AMSAA

Warheads Testing

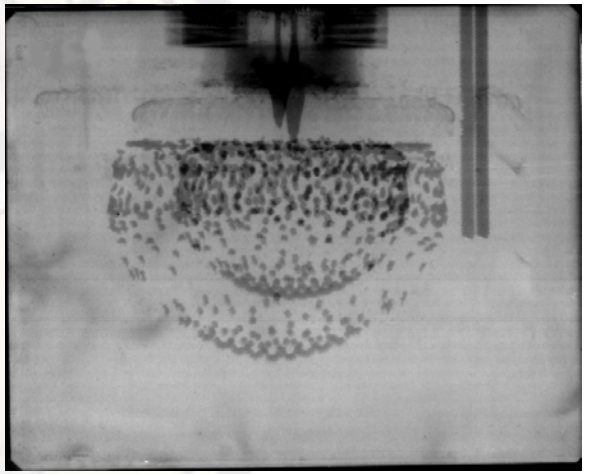
- Penetration Performance Characterization
  - Shaped Charge Jet Characterization
    - Utilize flash X-ray to capture jet formation, straightness and determine tip velocity
      - Tested projectiles while spinning and not spinning
    - Fired warheads into RHA to determine average penetration and characterize hole geometry
    - Modeled and simulated shaped charge function
      - Validated by test results
  - Picture shows warhead fired from top of picture downward



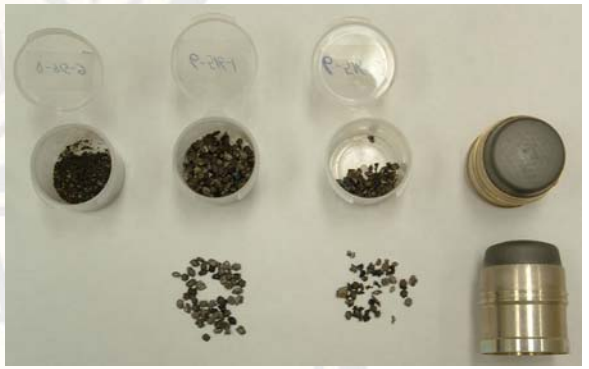
X-Ray of Jet Formation

Warheads Testing

- Fragmentation Performance Characterization
  - Fragment Velocity
    - Utilize flash X-ray to capture fragmentation for later determination of fragment velocity
      - Tested projectiles without spin
  - Fragment Collection
    - Detonate test assets in sawdust filled container to capture majority of material
      - Typical recovery of magnetic & non-magnetic material over 96%
      - Fragments sorted by material type, size & mass



X-Ray of Fragmentation



Fragment Recovery

System Effectiveness M&S

- Model the collection of system parameters & errors in order to run them through a Monte Carlo type simulation
  - Output is Probability of Hit & Probability of Incapacitation given a Hit
  - Study being applied to M433 HEDP & M430A1 HEDP
  - Intent is to determine improvements with highest return on investment

Current Status

- Spark Range Testing:
  - Fired M781 TP cartridges at Eglin AFB and currently reducing data.
  - M385A1 TP projectiles fabricated, modified with spin pins by ARL and awaiting LAP.
  - ARDEC M&S group modeled M550 Escapement Assembly (a.k.a. S&A) in ADAMS to determine CG shift during arming.
- Firing Tables Testing
  - Awaiting M433 HEDP and M781 TP test assets
- EPVAT Testing with Soft Recovery
  - Awaiting inert M433 HEDP, inert M583A1 Whitestar Parachute and M781 TP test assets with holes drilled for pressure tapping

Current Status

- Warheads Testing
  - M433 HEDP testing complete
  - Awaiting M430A1 HEDP test assets
- System Effectiveness Modeling & Simulation
  - M433 HEDP Modeling, Simulation & Go Forward Plan complete
  - M430A1 HEDP study awaiting results of warhead testing