NDIA Fuze Conference

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Fuze Technology Integration (FTI) Improved 30 mm

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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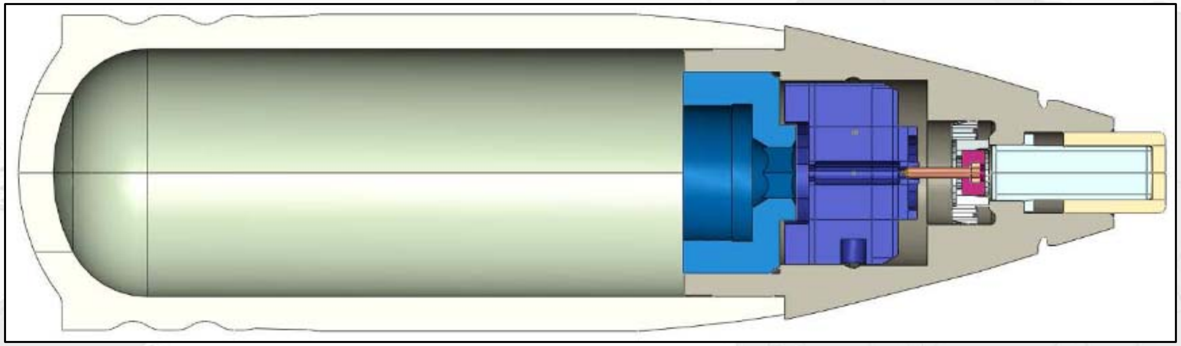
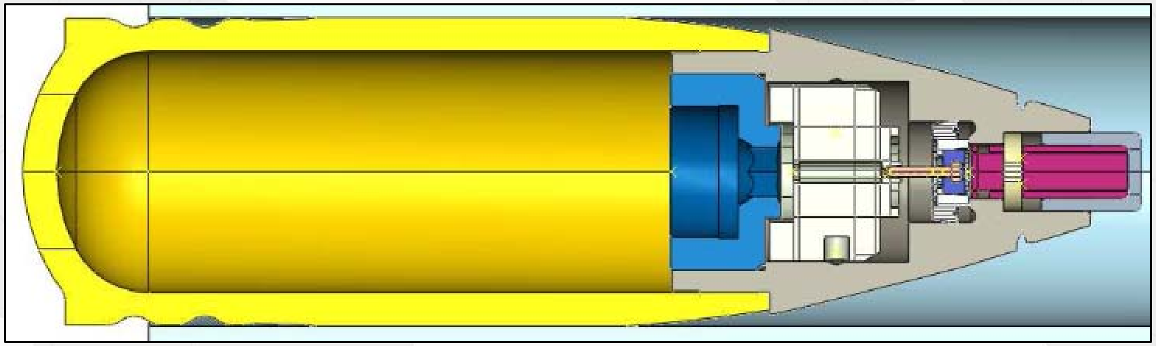
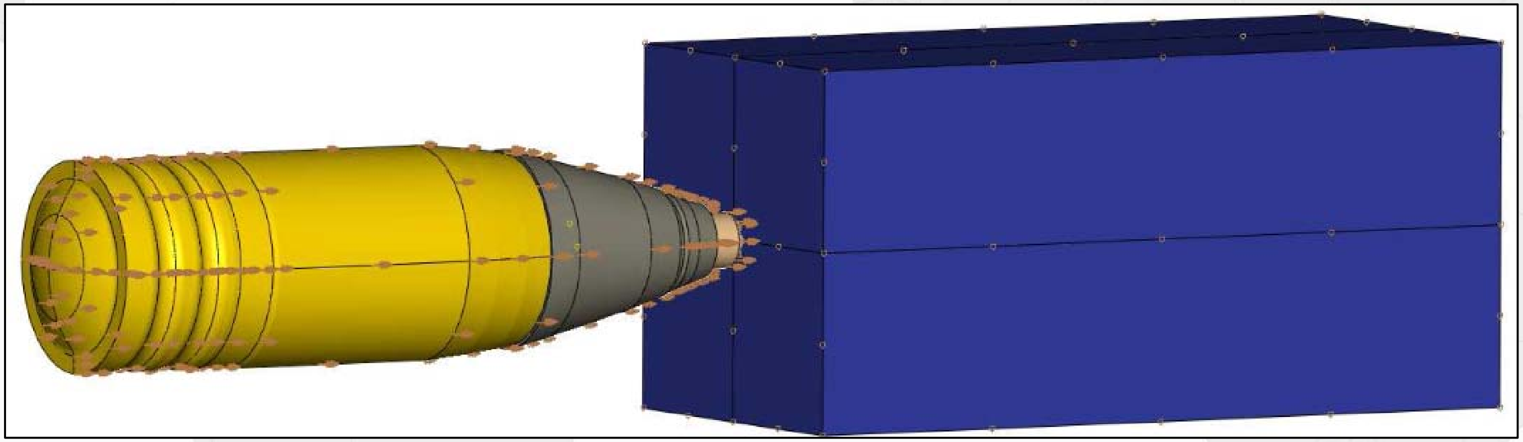
Project Team Members

- John Geaney – Mechanical Design
- Barry Schwartz – Mechanical Design
- Stephen Recchia – Finite Element Analysis


Background

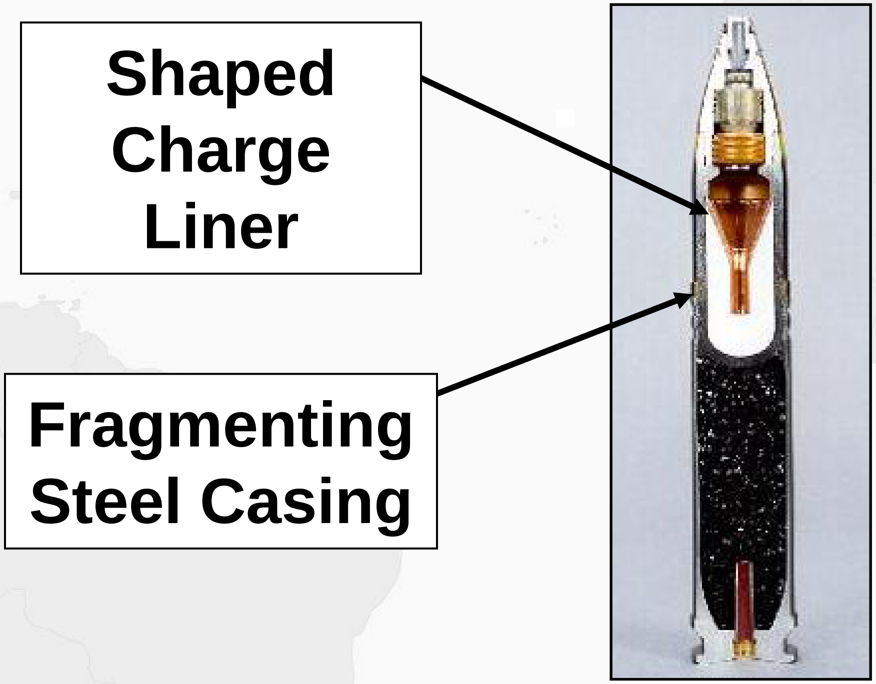
- A Fuze Division FTI project was initiated to improve the stab performance of the M759 fuze on the M789 30mm HEDP round.
- FTI projects apply modern technology to upgrade fuze systems in production
- The M789 30mm round is an Apache helicopter fired round designed primarily for anti-material and light armored targets



Background

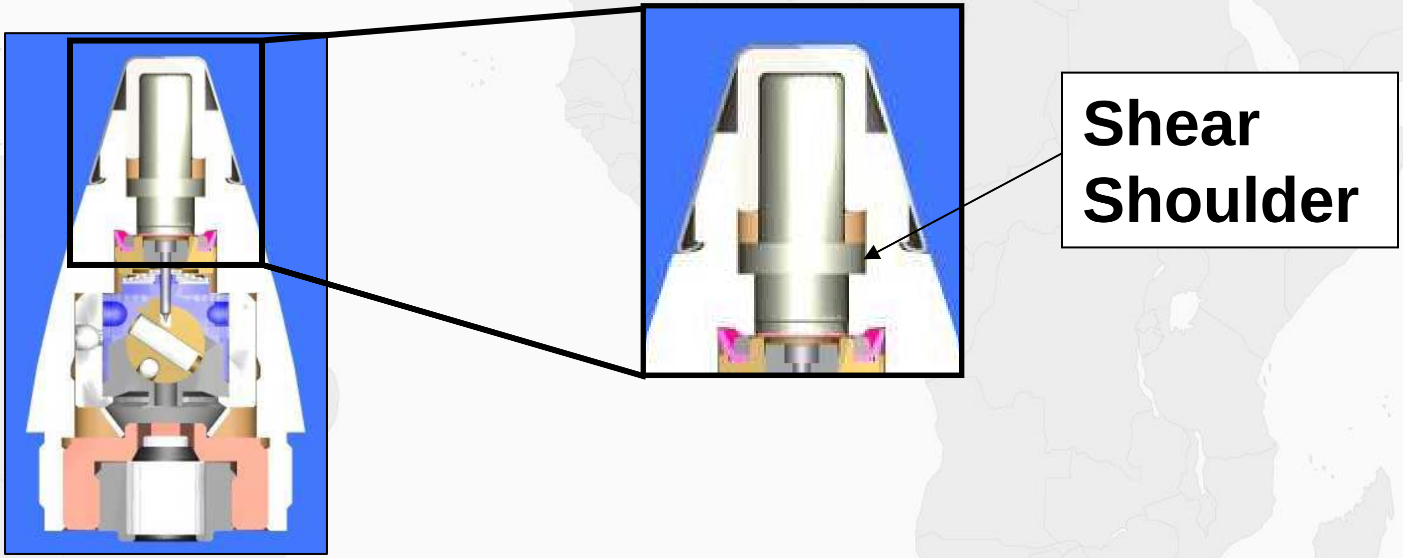
The M789 is a High Explosive Dual Purpose (HEDP) round

- Shape Charge effectively penetrates light armor
- Fragmenting steel casing neutralizes unarmored targets



Problem Statement

- Current design requires shearing a nylon shoulder on impact.
- Soft target impacts do not shear the shoulder, resulting in inertial detonation, deeper round penetration, and degraded fragmentation effectiveness
- Increased fuze sensitivity will improve impact performance



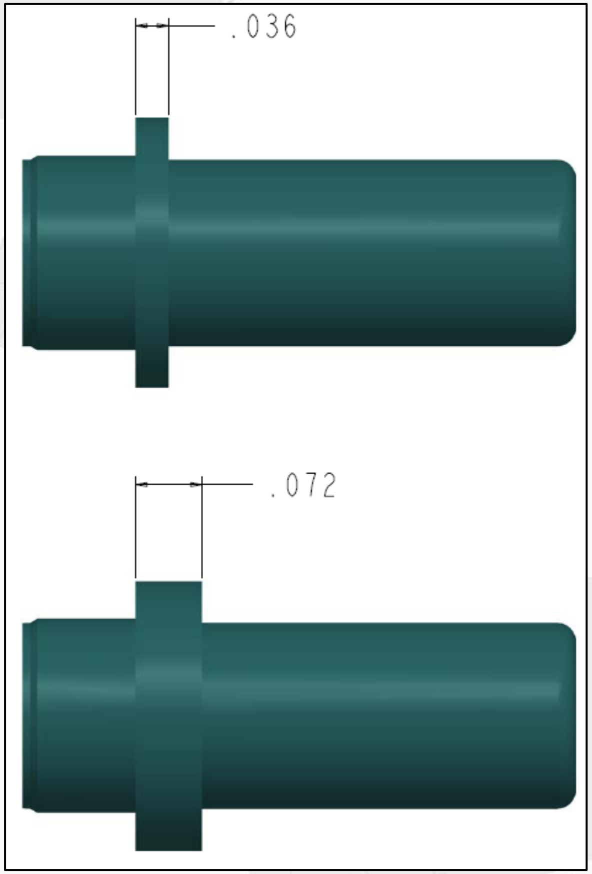
FTI Objective

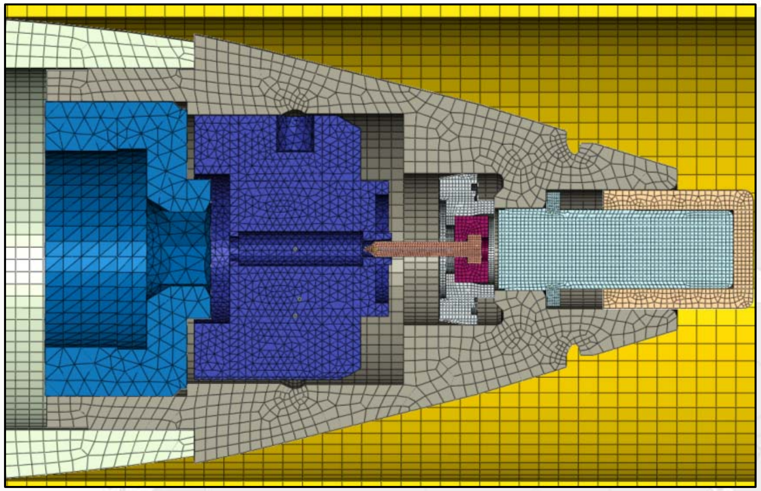
- Design fuze improvements to reduce impact detonation delay time in order to improve fragmentation in an anti-personnel application
- Utilize low cost components
- Minimize retooling impact to existing fuze

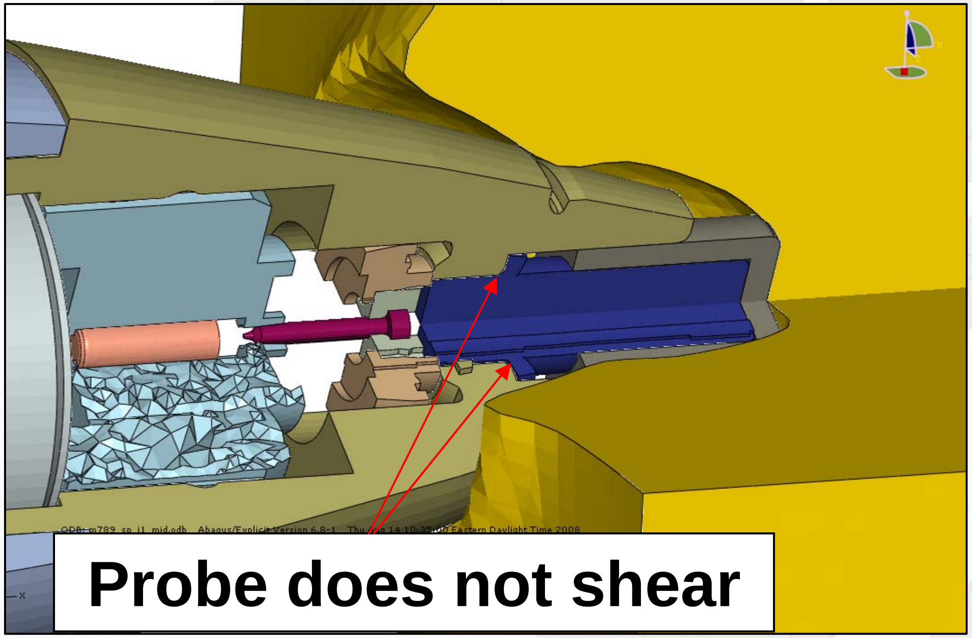
Concept Solution

Concept #1:

Reduce shear shoulder thickness to increase impact sensitivity





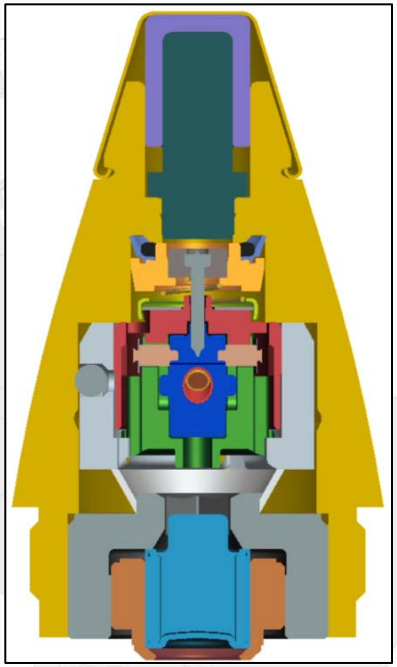


Concept Analysis

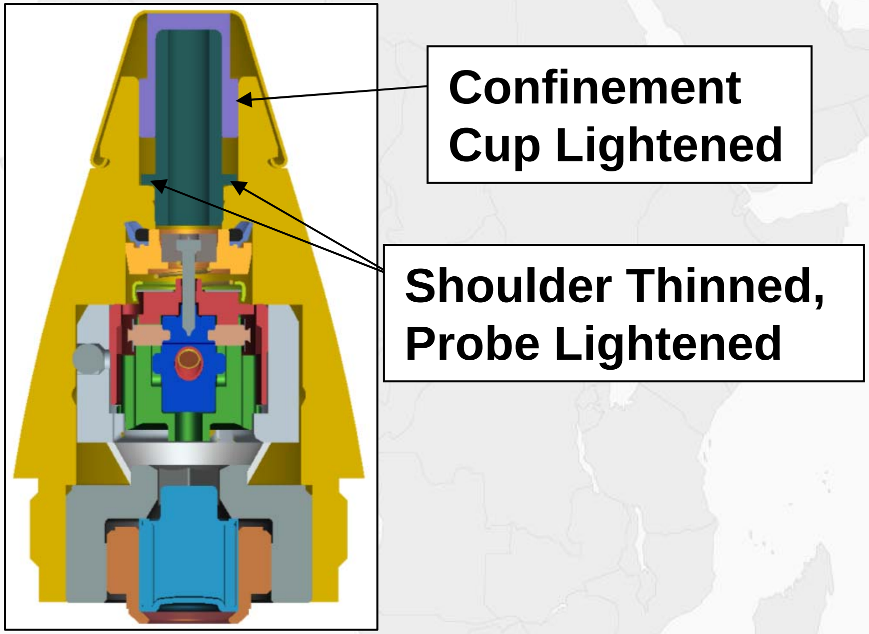
Concept #1

- Probe and confinement cup could be lightened to survive 100,000 g's during setback
- M&S analysis shows minimum shoulder thickness will not shear on impact with soft targets

Original Design



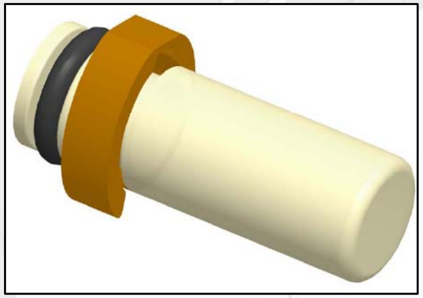
Concept #1

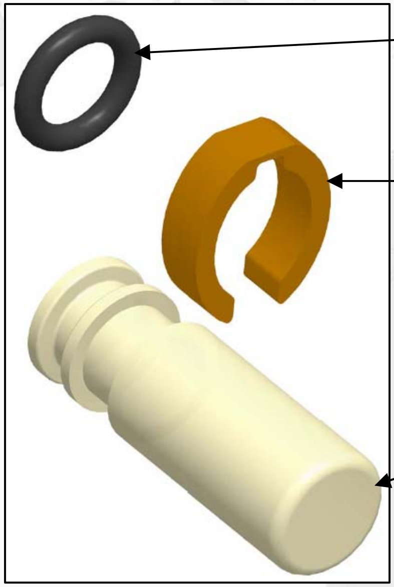


Concept Solution

Concept #2:

Replace shear shoulder with cartridge brass spin clip

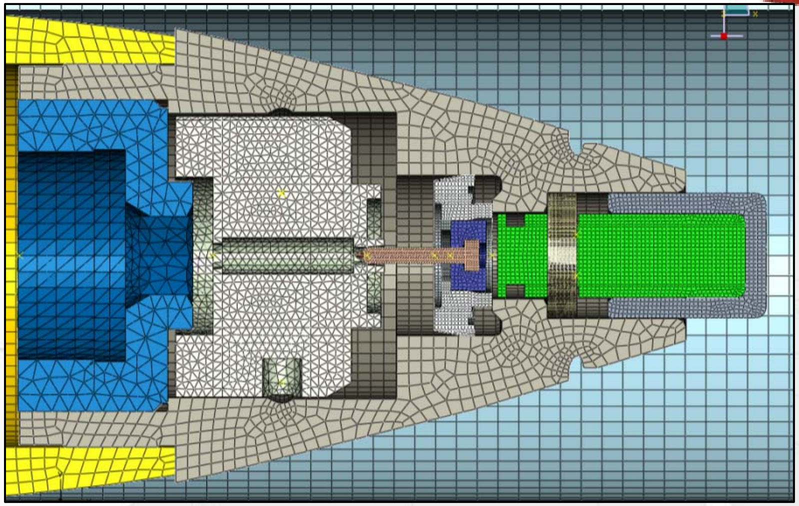


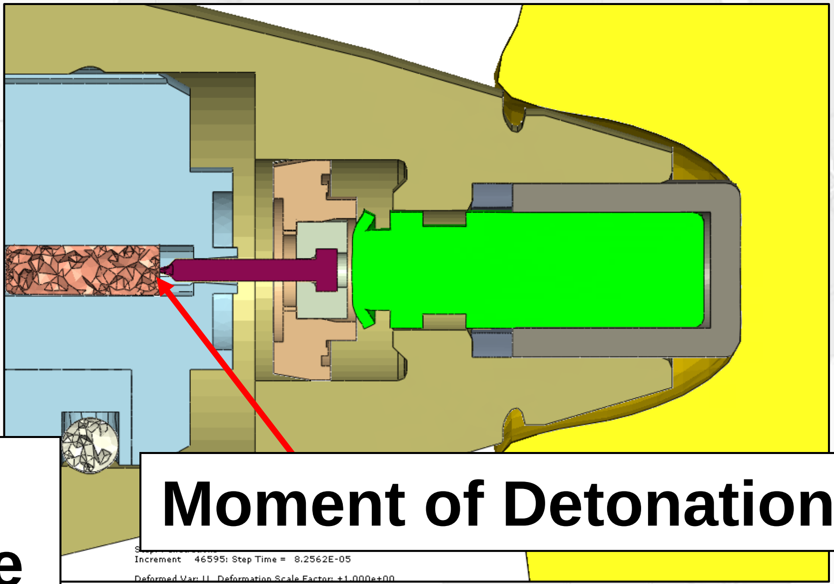


3.5mm O-Ring

Cartridge Brass Spin Clip

Improved Polycarbonate Probe





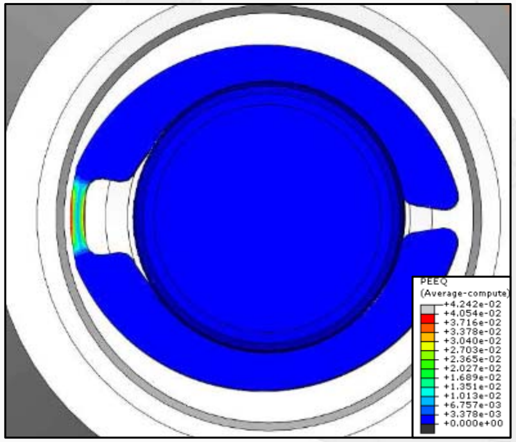
Moment of Detonation

Concept Analysis

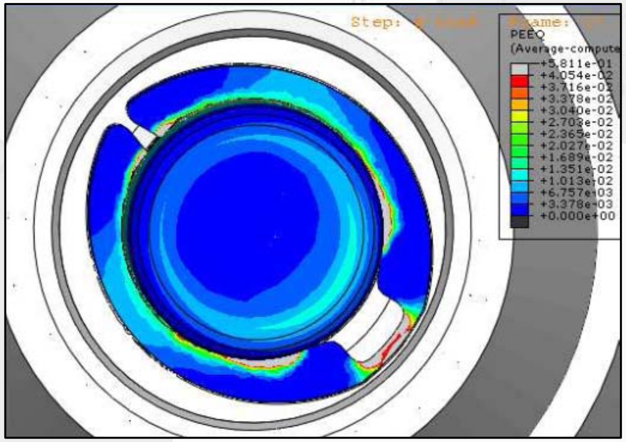
Concept #2

- M&S analysis shows
  - Spin clip survives peak setback acceleration of 100,000 g’s
  - Spin clip opens at muzzle spin rate, 60,000 rpm

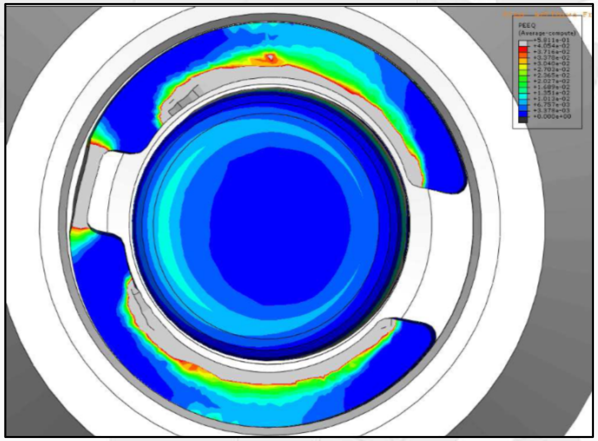
Pre Gun Launch



100,000 g Setback



60,000 rpm Muzzle Spin Rate



FTI Objective Analysis

Program objective was to reduce impact detonation delay time to improve fragmentation

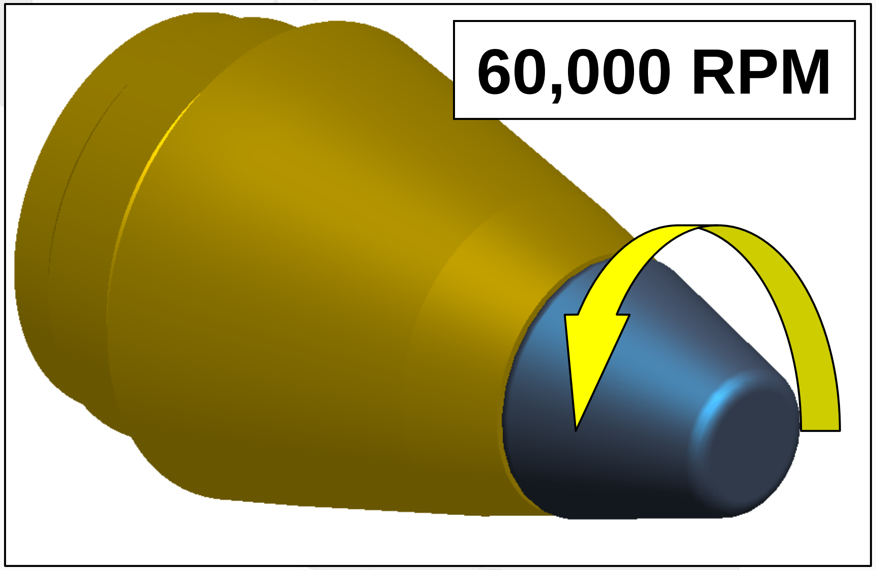
	Muzzle Velocity (2,670 ft/s)	Half Range Velocity (1,083 ft/s)	End Range Velocity (450 ft/s)
Current Design			
Detonation Time (ms)	0.048	0.200	>0.200
Penetration Depth (in)	1.500	4.000	>4.000
Improved Design			
Detonation Time (ms)	-	-	0.083
Penetration Depth (in)	-	-	0.280

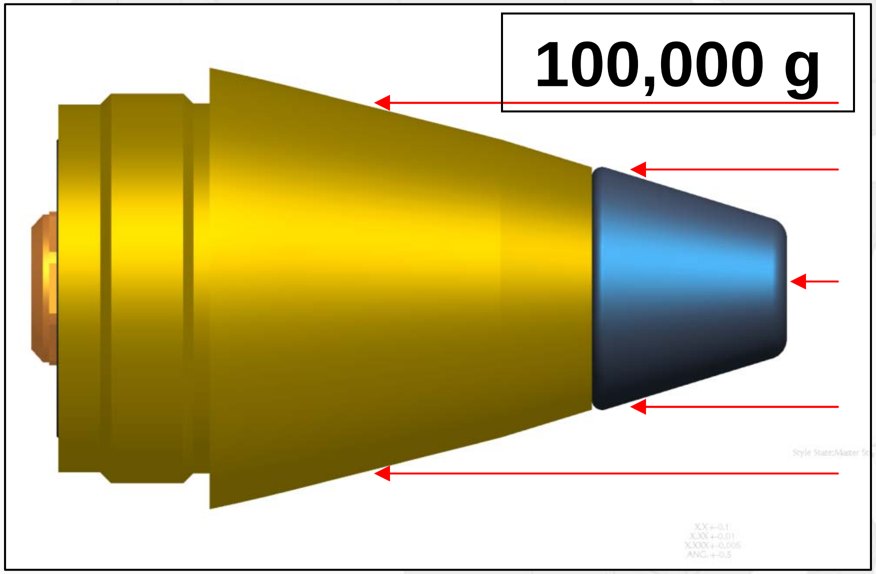
Fuze improvements decrease impact detonation delay time by a factor >2.4:1

Laboratory Testing

Laboratory testing performed at Picatinny Arsenal

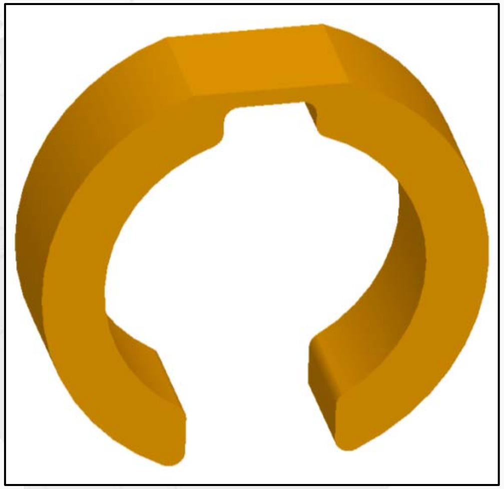
- High speed spin to tests confirm spin clips open at 60,000 RPM
- High g force air gun tests to confirm spin clips and probes can withstand 100,000g acceleration loads

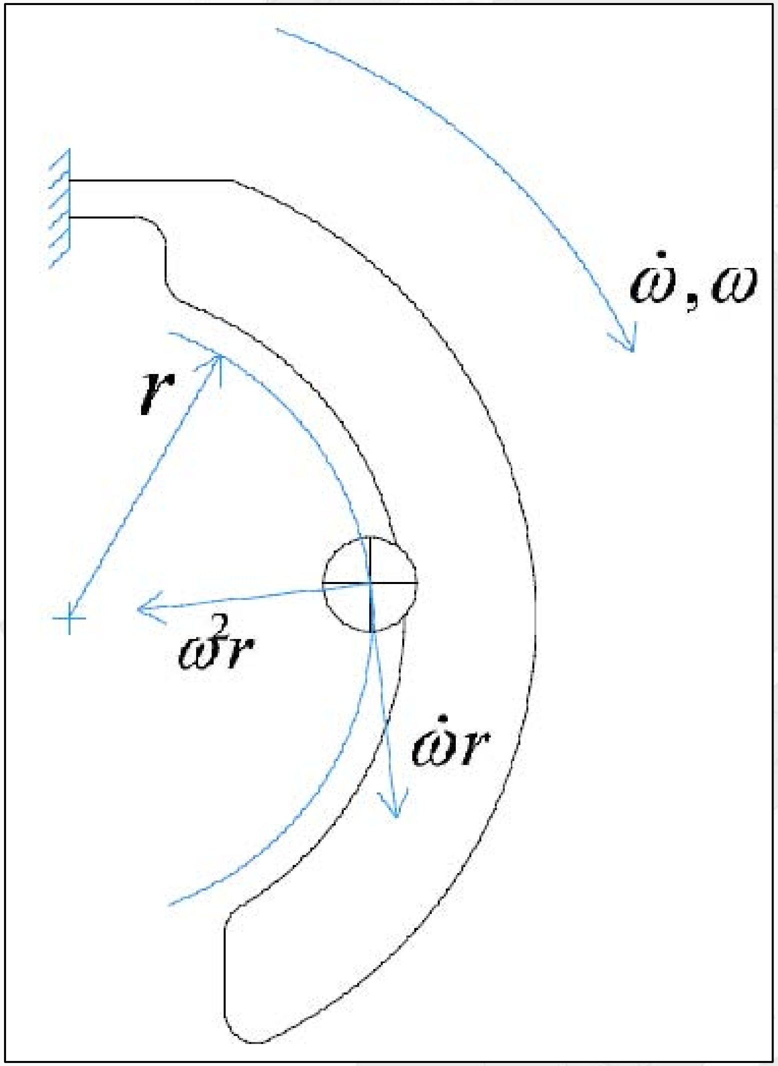




Spin Testing

- Spin clip operation is a function of angular velocity ($\omega^2 r$)
- Testing will verify clip opens at operating velocity, and determine operating velocity margin

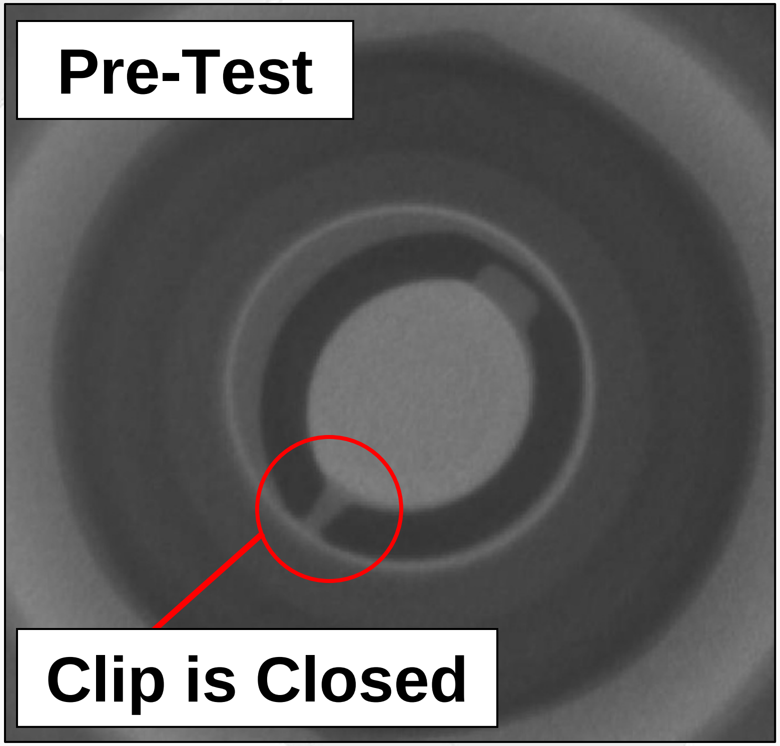


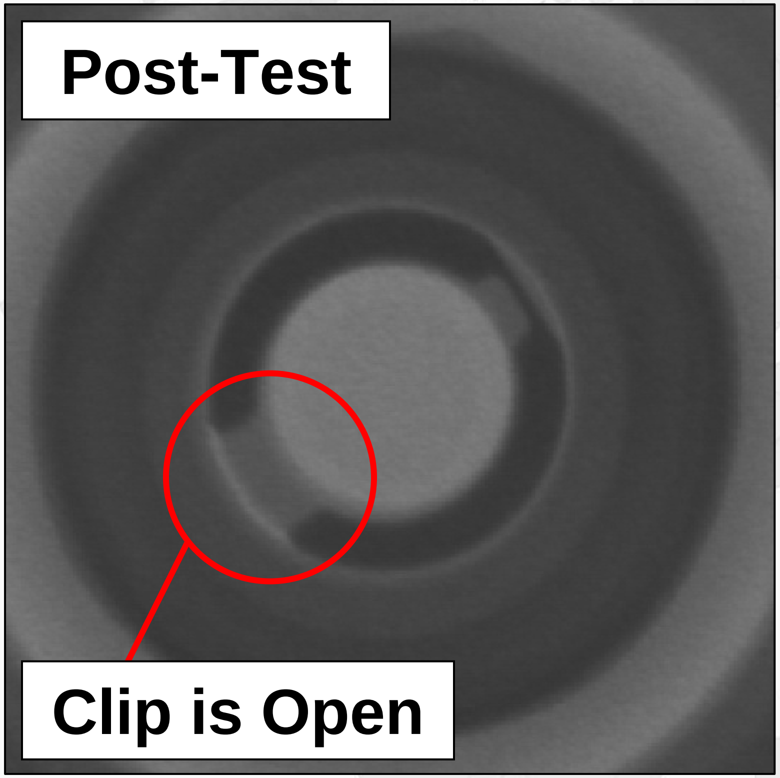


Spin Testing

Operating velocity spin tests performed on 5 samples

- **60,000 RPM**
- **100% success, all clips opened at operating velocity**

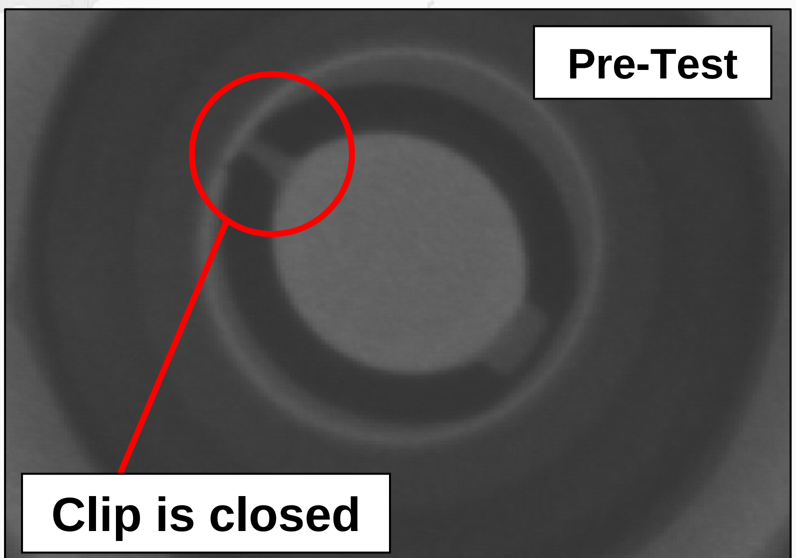


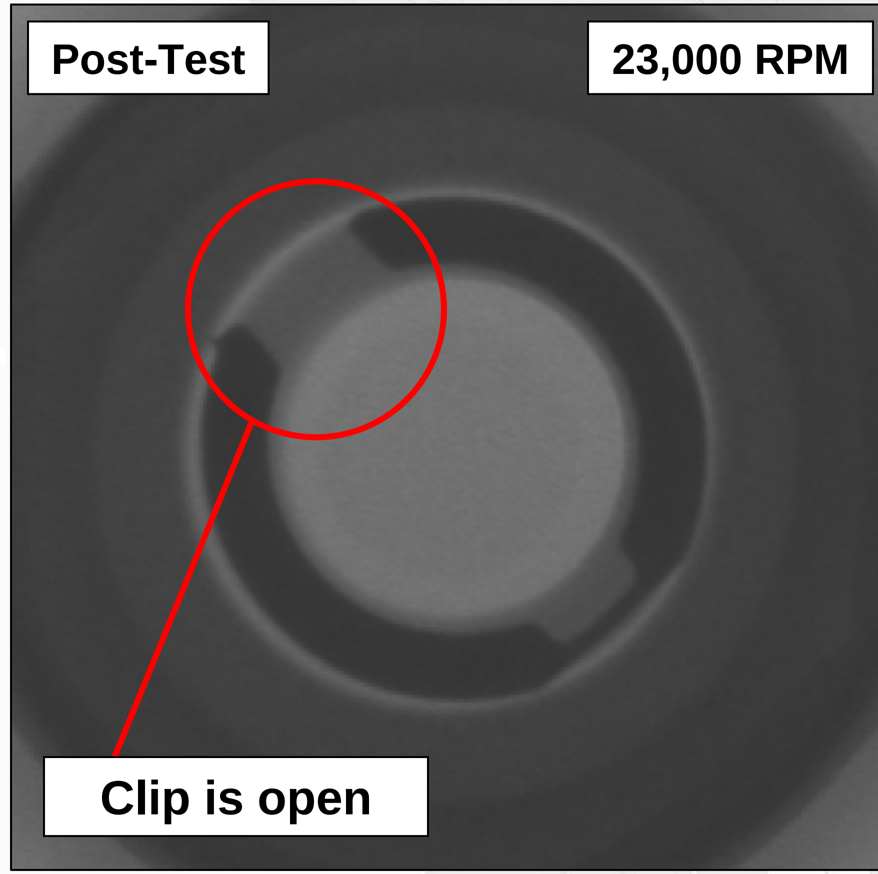


Spin Testing

Spin tests performed below 60,000 RPM operating environment to determine operational margin

RPM	Clip Operation
50,000	Opened
23,000	Opened
20,000	Did Not Open
15,000	Did Not Open
5,500	Did Not Open





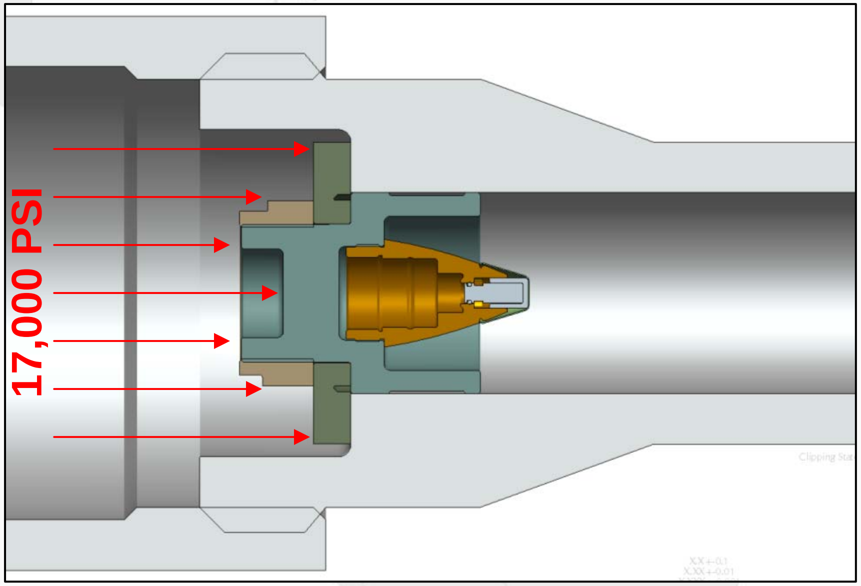
Spin Testing Conclusions

- Spin clip opens at operating velocity of 60,000 RPM
- Margin spin testing shows spin clip stops opening below ~25,000 RPM
- Design Margin is 2.40:1

Air Gun Testing

Air gun testing performed on 5 fuzes

- Test designed to accelerate fuze to 100,000g's
- Spin clip and probe were tested to ensure shear failure would not occur during setback

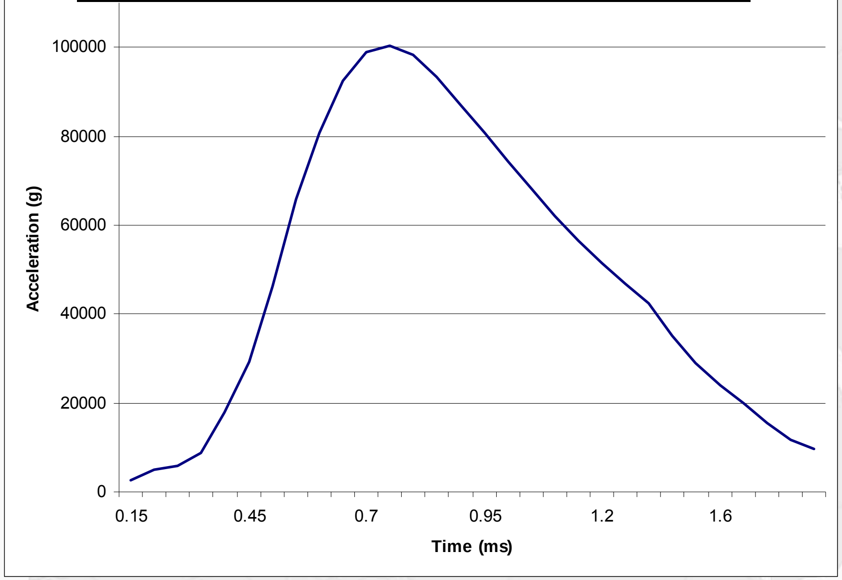


Air Gun Testing

Air Gun Test Data

	Pressure	Acceleration
#1	16,800 psi	103,235g's
#2	16,871 psi	103,627g's
#3	16,910 psi	103,911g's
#4	17,020 psi	104,587g's
#5	16,820 psi	103,358g's

Actual Ballistic Data



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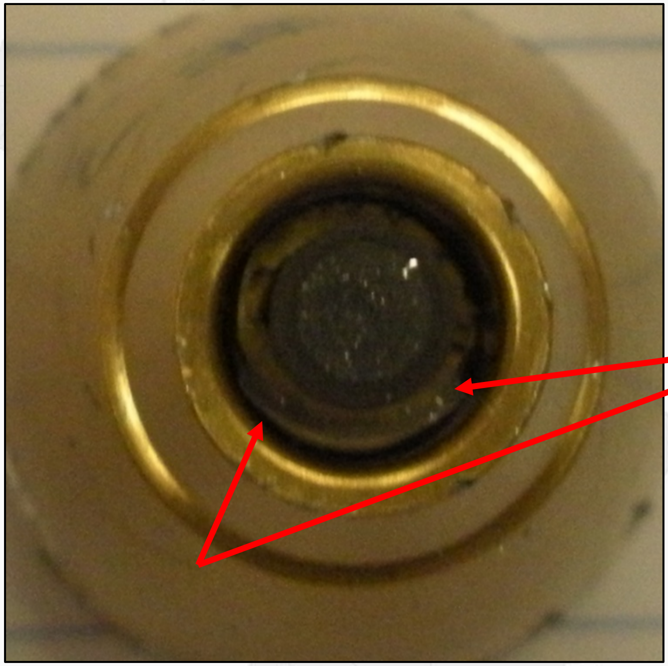
Air Gun Testing

Results

- Spin Clip survived 5 of 5 tests
- Improved Probe yielded under setback loads in all 5 tests



Probe Yielding

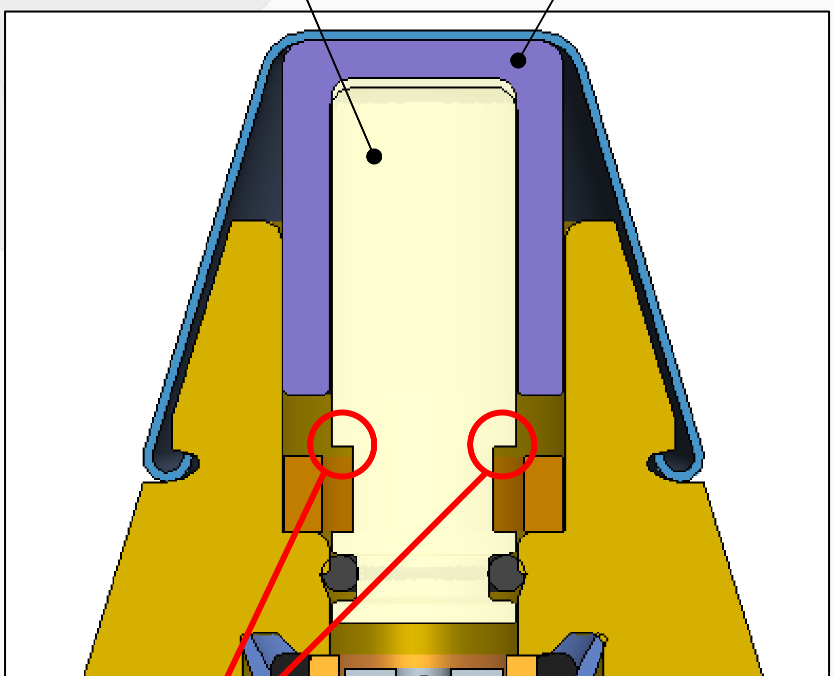
Design Refinement

Improved Probe Design

Polycarbonate probe is subject to yielding at spin clip interface

Polycarbonate Probe

Aluminum Probe Confinement Cup

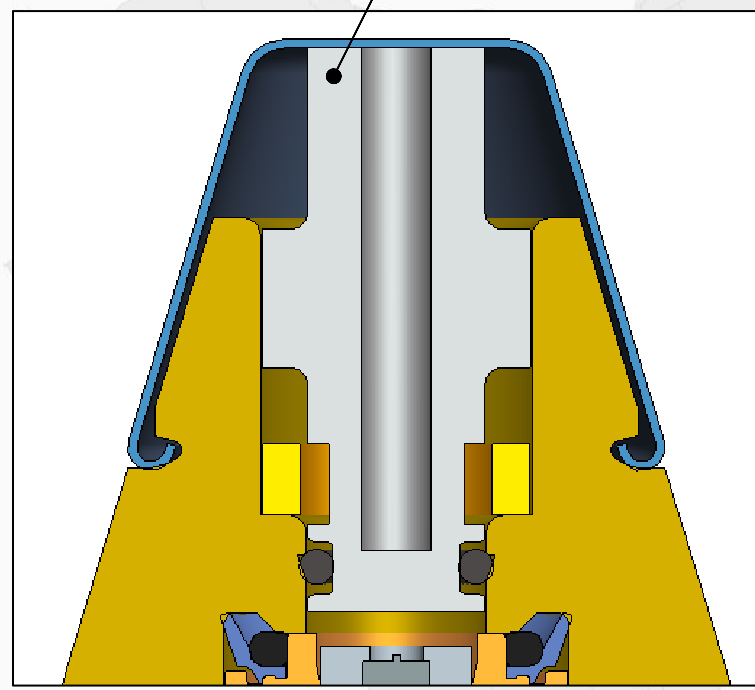


Area Subject to Yielding

Refined Design

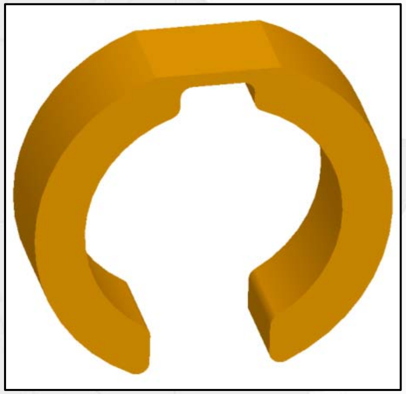
Aluminum probe resists yielding during setback

One Piece Aluminum Probe



Design Refinement

- Improved probe design refined to survive setback loads
  - Material: Aluminum Alloy 7075-T735
  - Probe and probe confinement cup combined into single aluminum piece to reduce cost/complexity
- Spin clip design refined to aid in setback survival
  - Clip height reduced to provide more uniform “grip” on probe
- Probe & spin clip mass matches original probe & confinement cup mass
- Initial lab tests verified design improvements
  - Static tests show aluminum probes survive setback, 100,000g’s
  - Initial spin tests show spin clips open at 60,000 RPM



Air Gun Testing

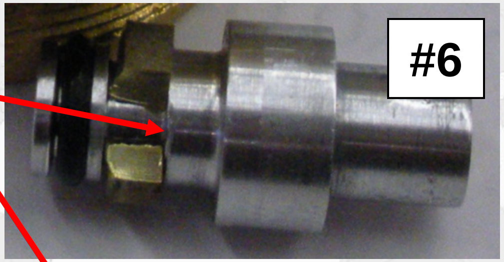
Tested Refined Design Under Setback Environment

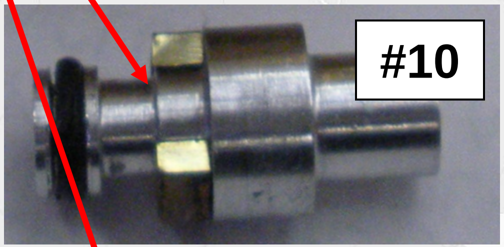
Air Gun Test Data

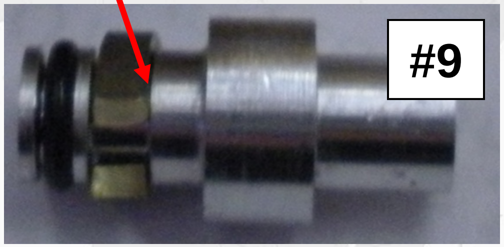
	Pressure	Acceleration
#1	18,823 psi	115,712g's
#2	18,863 psi	115,937g's
#3	18,748 psi	115,370g's
#4	18,398 psi	113,339g's
#5	17,769 psi	109,270g's
#6	20,437 psi	125,439g's
#7	19,592 psi	120,377g's
#8	19,677 psi	120,831g's
#9	19,692 psi	120,944g's
#10	20,076 psi	123,292g's

No Evidence of Probe Yielding

25% margin over tactical environment







Refined Probe design survived **10 of 10** tests with up to a 25% margin, no probe yielding observed

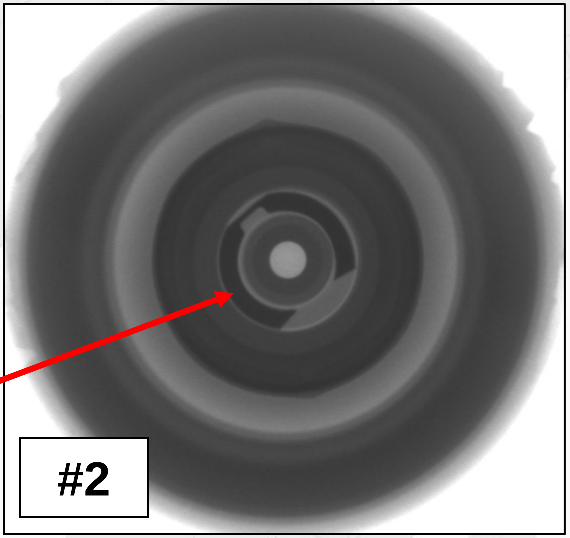
Spin Testing

Tested Refined Design Under Spin Environment

Spin Test Data

	RPM	Air gun Acceleration	Spin Clip Operation
#1	60,000	115,712g	Opened
#2	60,000	115,937g	Opened
#3	60,000	115,370g	Opened
#4	60,000	113,339g	Opened
#5	60,000	109,270g	Opened
#6	40,000	125,439g	Did Not Open
#7	46,000	120,377g	Did Not Open
#8	60,000	120,831g	Did Not Open
#9	60,000	120,944g	Did Not Open
#10	60,000	123,292g	Opened

Test data shows that spin clip opens at spin environment, 60,000 RPM.



Clip opened at 60,000 RPM after 115,937g's

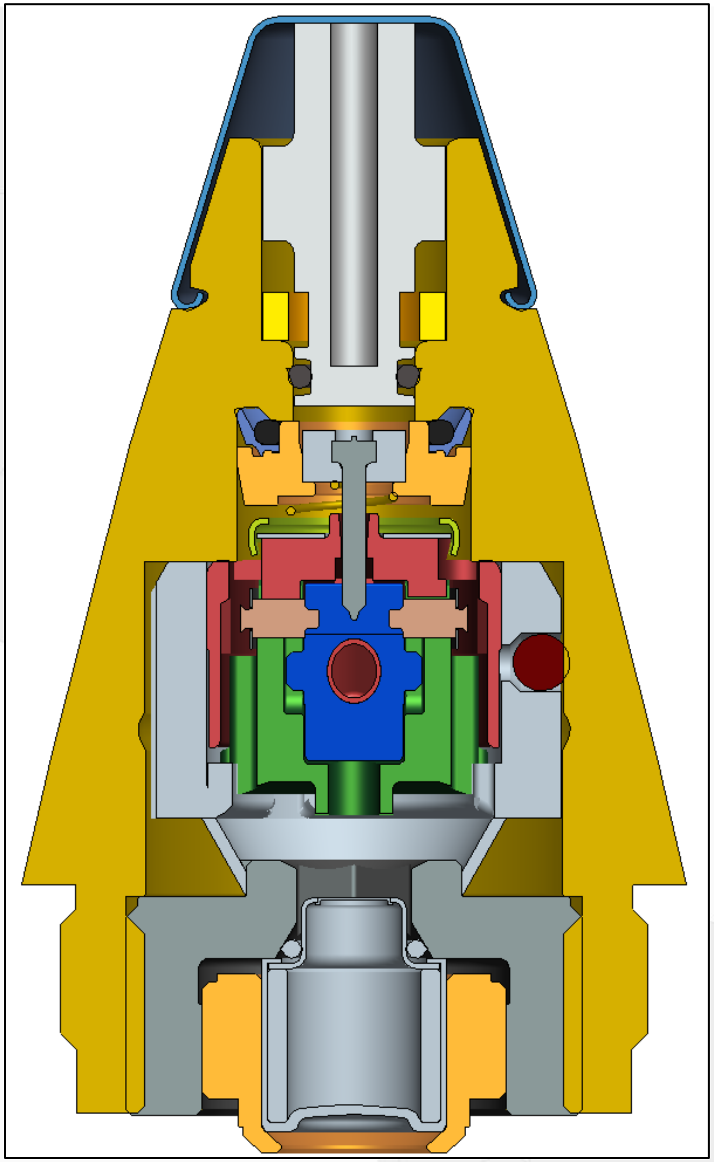
Testing Results

- Air gun tests performed on refined design
  - Probe yielding eliminated at g-levels up to 125,000g's
- Spin tests performed on air gun test fuzes
  - Fuzes accelerated to <116,000g's resulted in spin clips opening at 60,000 RPM
  - Fuzes accelerated to ≥120,000g's resulted in spin clips not opening at 60,000 RPM
  - More spin tests required to determine operational margin
- Lab testing shows a survival margin of up to 25%, and an operational margin of up to 16%

Planned Ballistic Testing

- Ballistic tests planned for 06/2009
- 100 improved rounds to be tested with 100 control rounds to compare detonation time
- Soft targets to be used at a range of 2000 meters
- High speed video to verify improvement over current design

Summary



- Modeling and simulation has predicted improvement in fuze sensitivity
- Lab testing has verified the operation of the fuze improvements at the tactical environment
- Ballistic rounds are being fabricated to test improvements over the current design
- The FTI improvements to the M579 fuze will provide the War Fighter with an HEDP round that is more effective against soft targets.