3,3-Diaminoazoxyfurazan (DAAF) Survey of Performance Testing and Characterization

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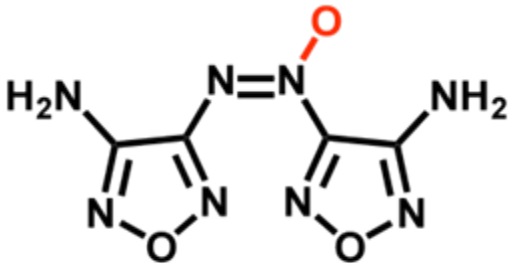
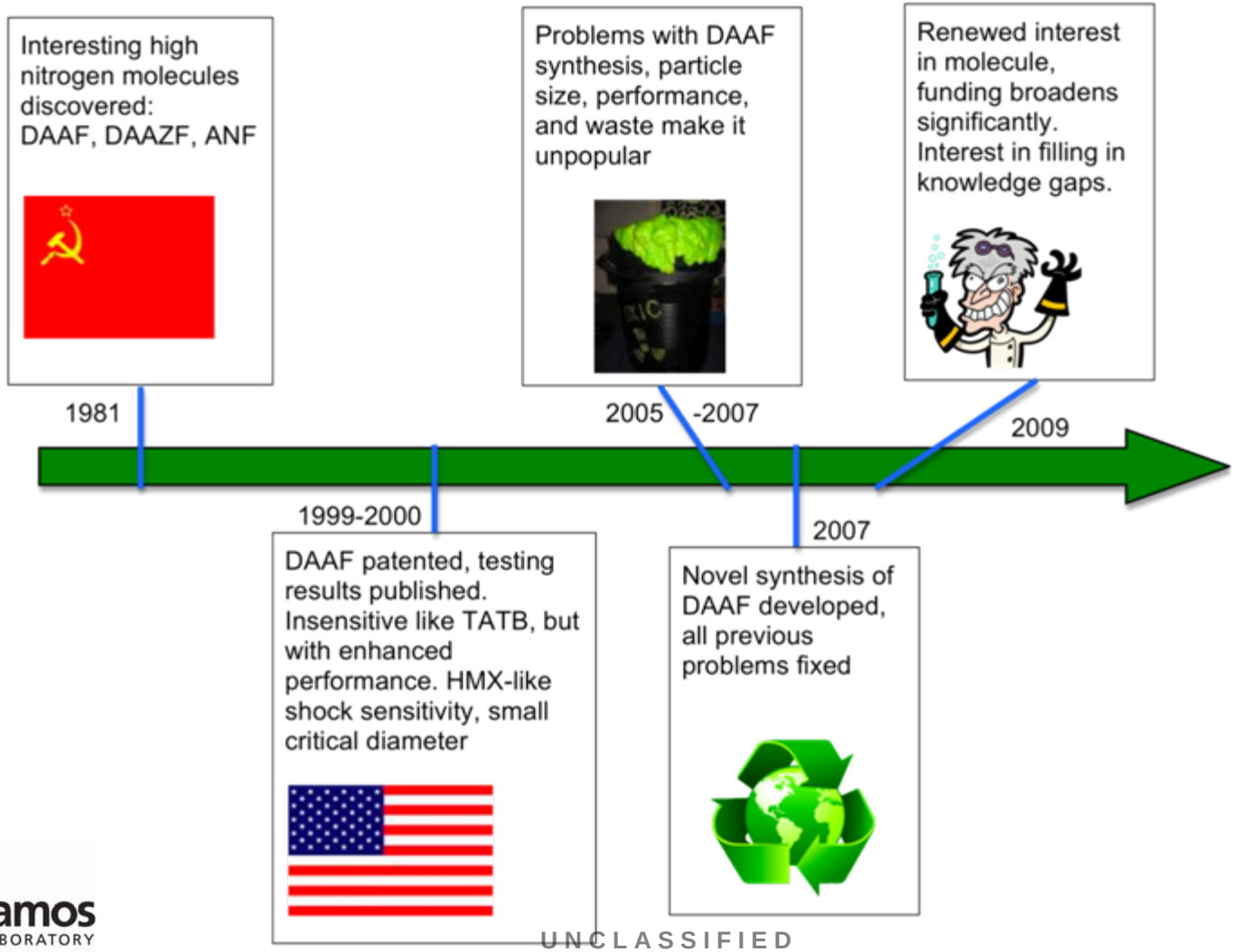
Outline

- DAAF highlights (aka why bother)
- DAAF shock sensitivity
  - Pop Plot
  - LANL SSGT
  - IHE Gap test
- DAAF critical diameter, detonation spreading, and corner turning
  - Floret
  - Onionskin
  - Modified Mushroom Test
- DAAF cook-off observations



DAAF Timeline to illustrate the “why bother”



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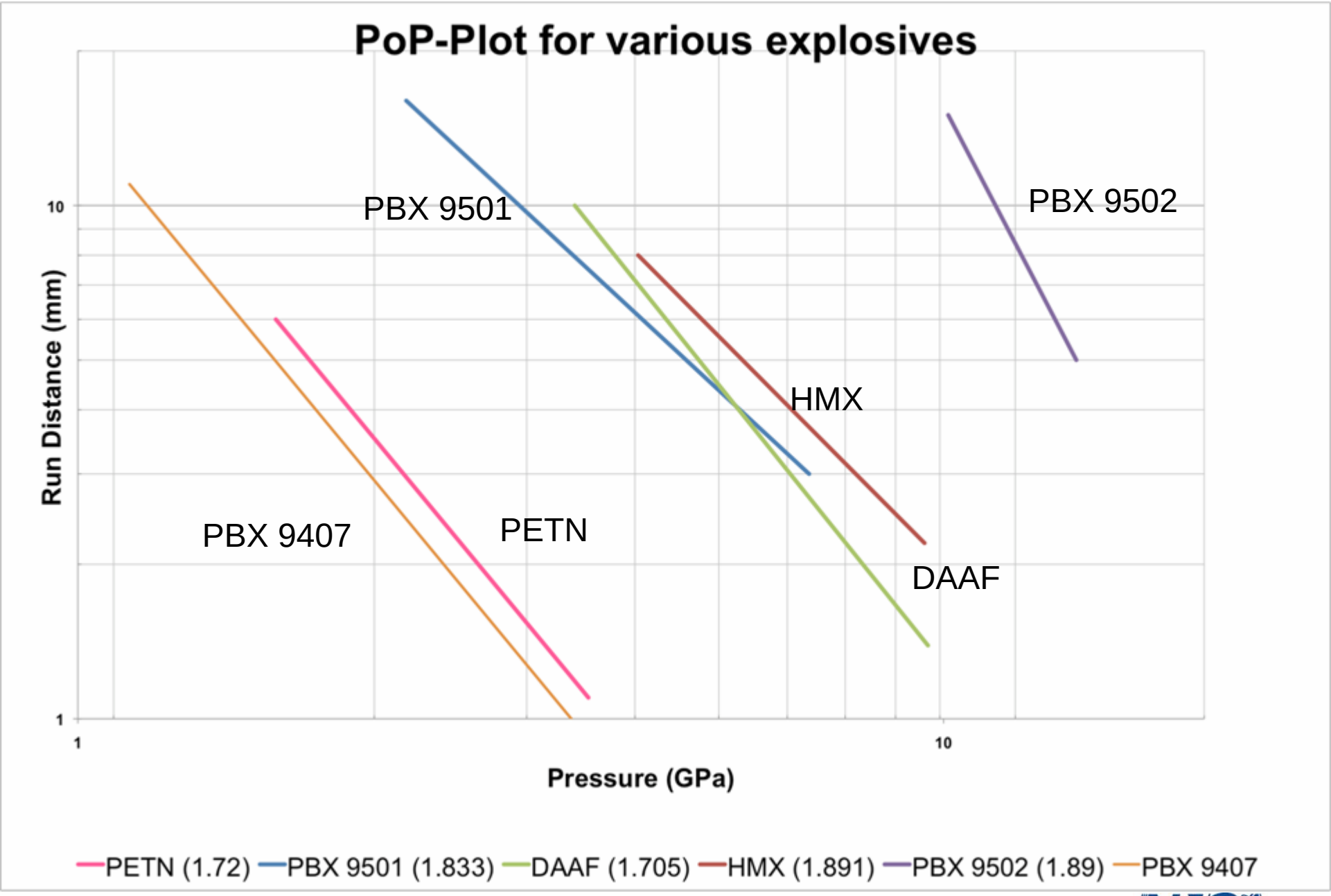
DAAF gaps in knowledge

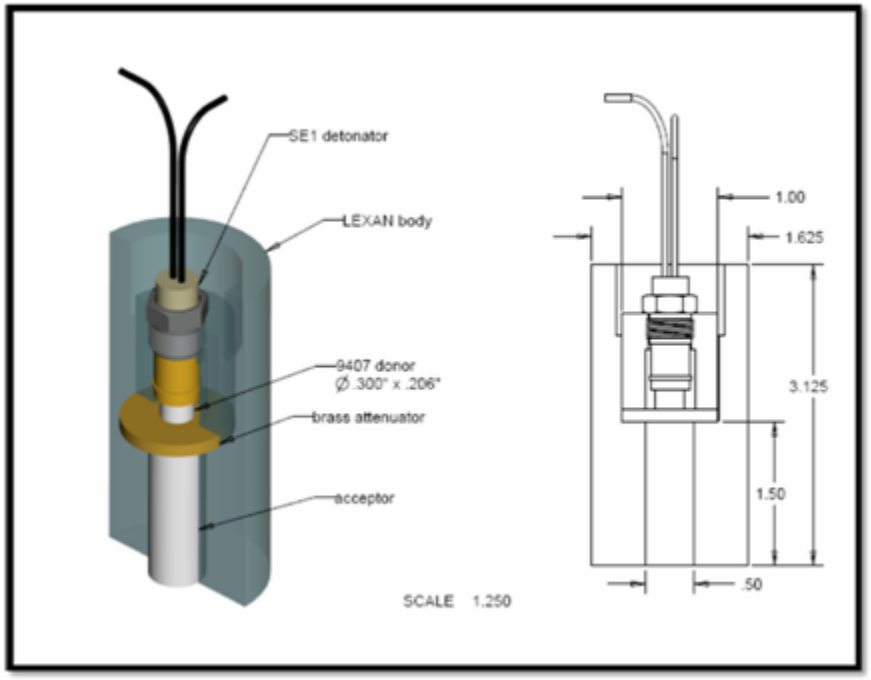
- Given Pop-plot data, what would gap testing reveal about shock sensitivity of DAAF?
- What is the critical diameter really? Previously published as “<3mm”.
- How well does DAAF perform cold (-55^{o}C) and how well does DAAF “corner turn”
- What sort of cook-off behavior does DAAF exhibit, and does it DDT?

DAAF compared to TATB and HMX

	DAAF	TATB	HMX
Density	1.747 g/cc	1.93 g/cc	1.902g/cc
H_{50} on Type 12 DWI apparatus	>320 cm	>320cm	26cm
Friction	>36 Kg	>36 Kg	22.4 Kg
Spark	0.0625 J	0.25 J	0.125 J
Detonation Velocity at 96.5 % TMD	7.93 km/s	7.62 km/s	9.05 km/s
CJ Pressure at 96.5 % TMD	306 kbar	259 kbar	361 kbar


PoP-Plot for various explosives
PBX 9501
PBX 9502
HMX
PBX 9407
PETN
DAAF
10
1
1
10
Run Distance (mm)
Pressure (GPa)
PETN (1.72)
PBX 9501 (1.833)
DAAF (1.705)
HMX (1.891)
PBX 9502 (1.89)
PBX 9407

Shock sensitivity as evaluated by the LANL Small scale gap test



Material	Density (g/cc)	50% point (mm)	Initiation Pressure (GPa)
DAAF 40μm	1.69	1.91	8.3
	1.59	3.12	4.5
DAAF 80μm	1.69	2.74	4.8
	1.59	3.35	4.5
DAAF <5μm	1.69	NA	
	1.59	3.02	4.5
HMX (hot pressed)	1.84	3.43	
	1.79	4.27	
PBX 9501 (hot pressed)	1.843	1.3-1.8	
	1.825	1.52	
PETN	1.757	5.21	
RDX (hot pressed)	1.735	5.18	

IHE Gap Test DAAF results

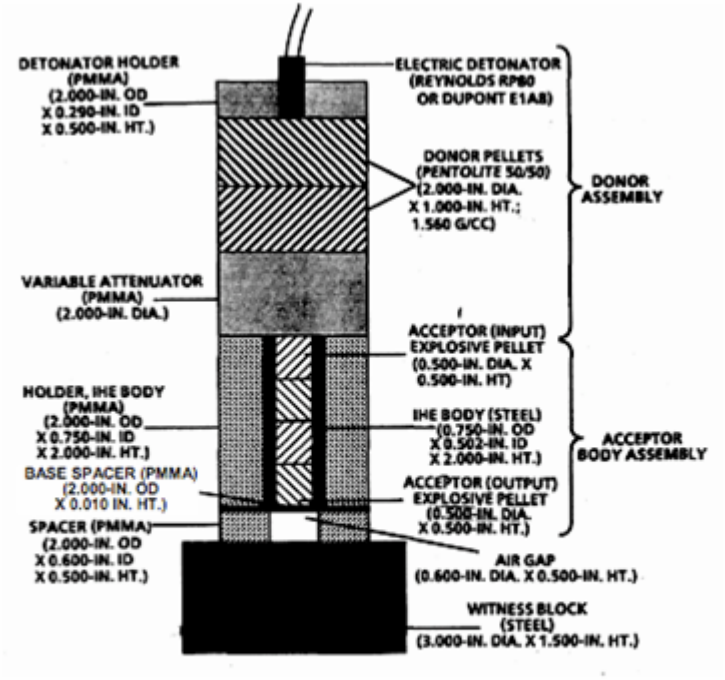


Figure 3. IHE Gap Te st Configuration with Spacer Mo dification

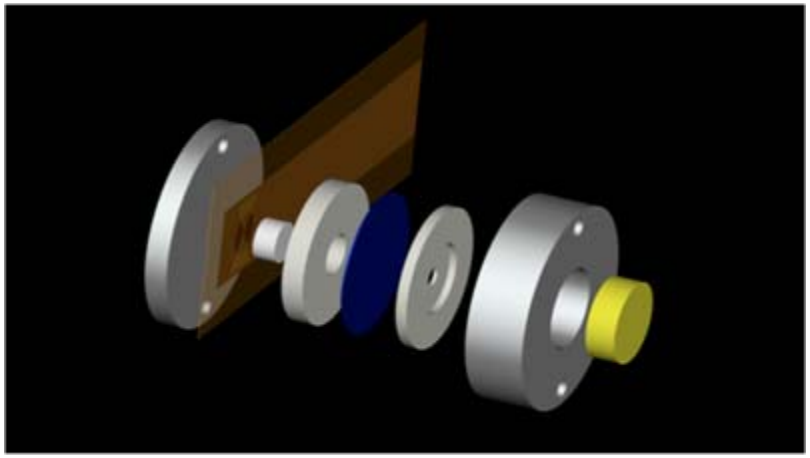
- Widely used DoD test
- Measures an explosive's sensitivity to shock initiation.
- Data can be used to assess safety and reliability of explosive interfaces in fuzes.

Gap Test results

Formulation	Gap Thickness (inches)	Pressure (kbar)
PBXN-7 (60% TATB, 35% RDX, 5% Viton)	2.05	19.6
80%DAAF, 15% RDX, 5% Viton	1.84	25.1
60%DAAF, 35% RDX, 5% Viton	2.00	20.7
80%DAAF, 15% HMX, 5% Viton	1.63-1.75	32.7-28.0
60%DAAF, 35% HMX, 5% Viton	1.96	21.7
95%DAAF, 5% Viton	1.59	34.4

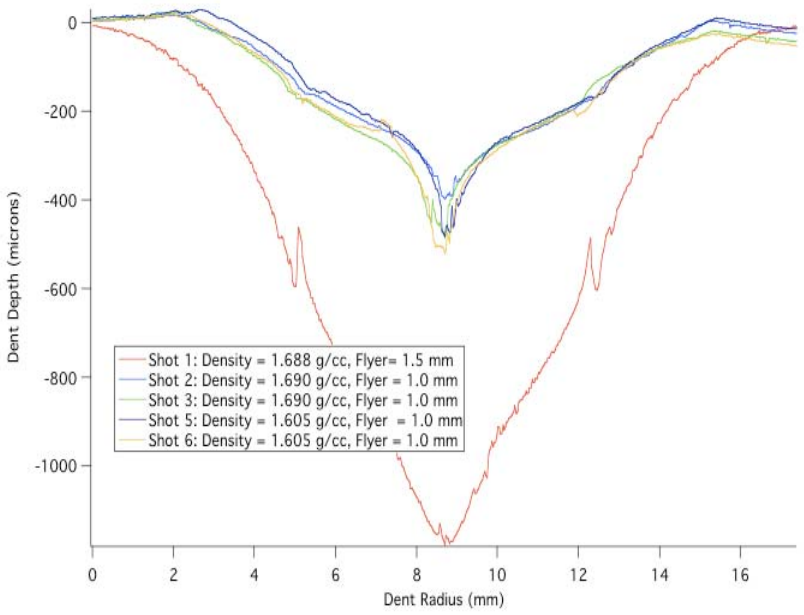
- PBXN-7 is surprisingly shock sensitive.
- TATB contributes nothing towards shock insensitivity.
- DAAF (with binder) is surprisingly shock insensitive

Floret test



- Measures detonation spreading or “corner turning”.
- Requires 100mg per shot
- Test evaluates a material at or around it’s critical diameter
- Test can evaluate a variety of material parameters: density, binder content, particle size etc..

DAAF Critical Diameter

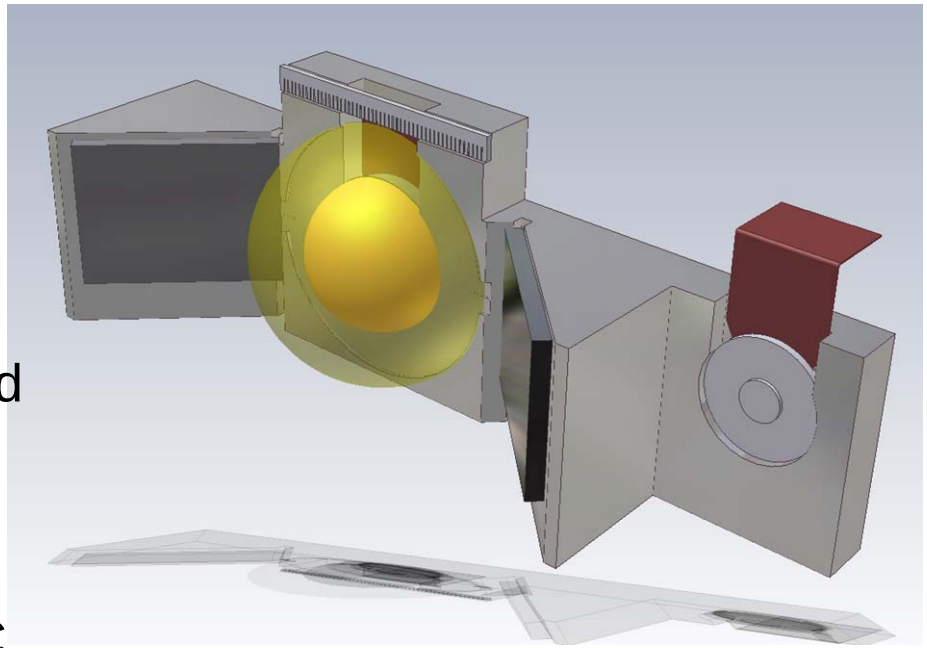


Critical Diameter of DAAF:
1 to 1.32mm

- At DAAF acceptor pellet dimension ¼" diameter, 2mm tall:
  - Aluminum flyers always caused a complete detonation at 1mm diameter.
  - Stainless flyer caused full detonation at 1.5mm, an uniformly incomplete detonation at 1mm.
- At DAAF acceptor pellet dimension ½" diameter, 2mm tall:
  - Aluminum 1mm flyer caused complete detonation- amazing corner turning!
  - Stainless steel flyer showed failing detonation at 1.32mm

Onionskin Overview

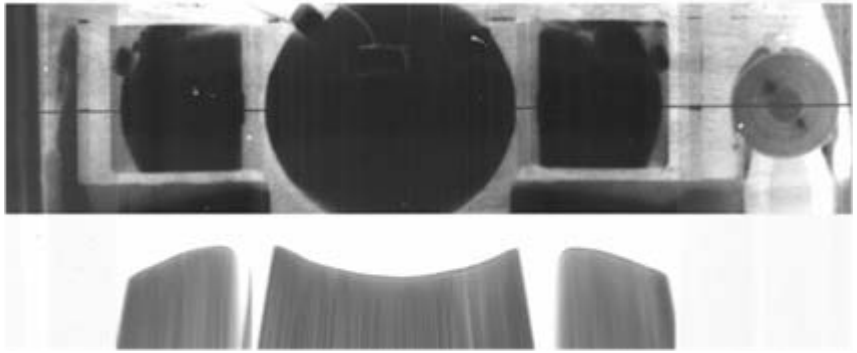
The Onionskin test evaluates the corner turning ability of booster explosives



- The corner turning is observed through PBX 9502
- Dimensions: Booster 30mm, onionskin 50mm
- The shots are cooled to -55°C.
- The goal is symmetric breakout close to the PBX 9502 equator.
- Booster response is compared to LX-07

Previous interesting Onionskin results

LX-07 hemi

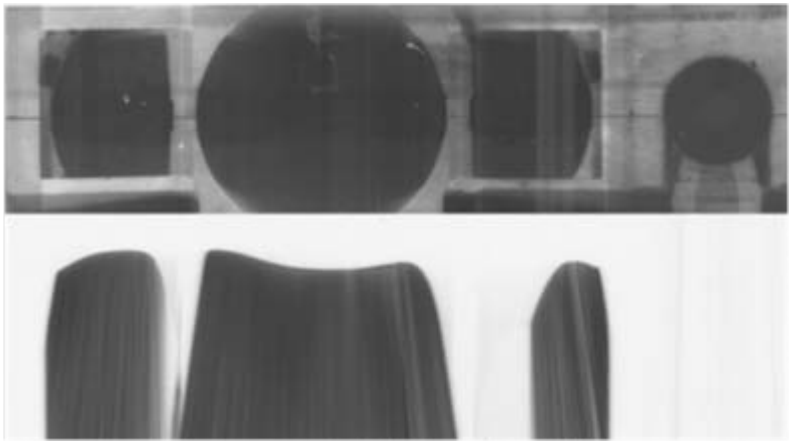


Pressed Hemi, Density: 1.842 g/cc

Breakout angle 74.9

Transit time: 3.58μs

DAAF and 3% KelF hemi



Pressed Hemi, Density: 1.6749

Breakout Angle: 67.0 (estimated)

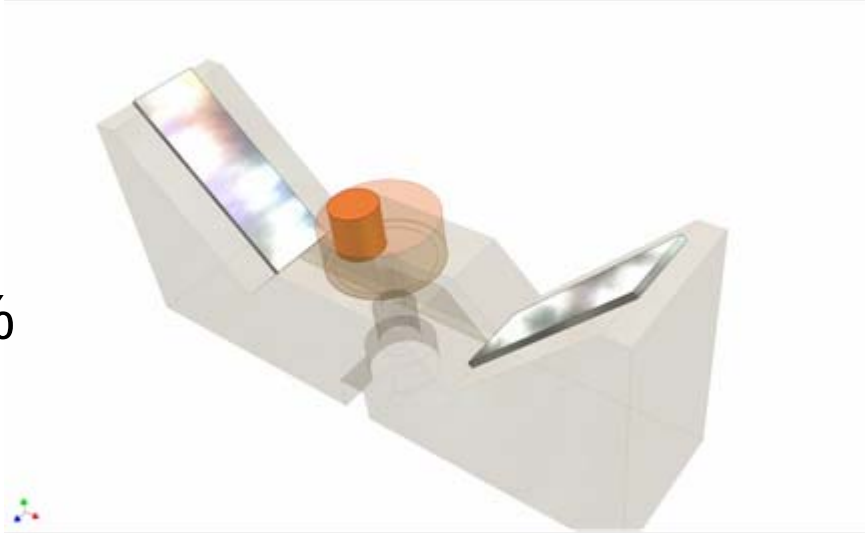
Transit Time: 3.82 μs

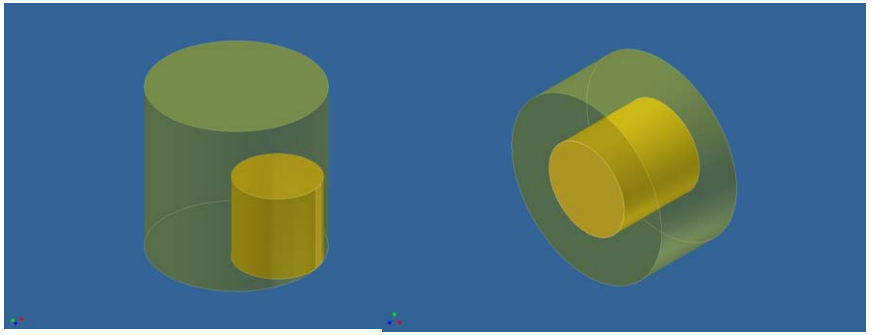
List of causes

- Density gradients within the DAAF pellet
- Non-hemispherical pressed pellet
- Gap between DAAF hemi and PBX 9502 onionskin or other assembly issues
- Density gradients within PBX 9502 onionskin

Modified Mushroom test to investigate engineered density gradients

- Cylindrical Shots
  - High Density center
  - Significant density gradient side-to-side: 7% TMD
  - Subtle gradient side to side

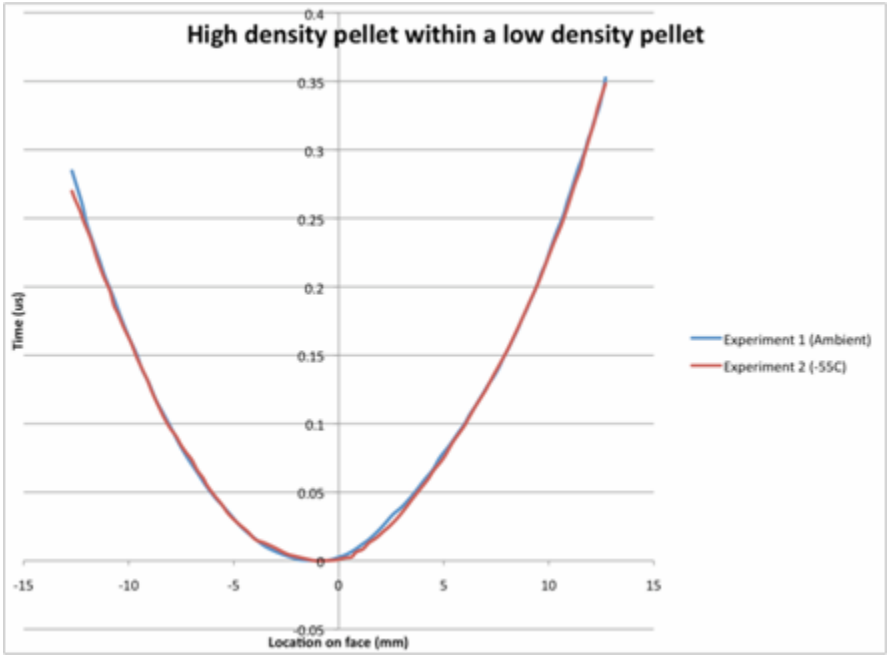




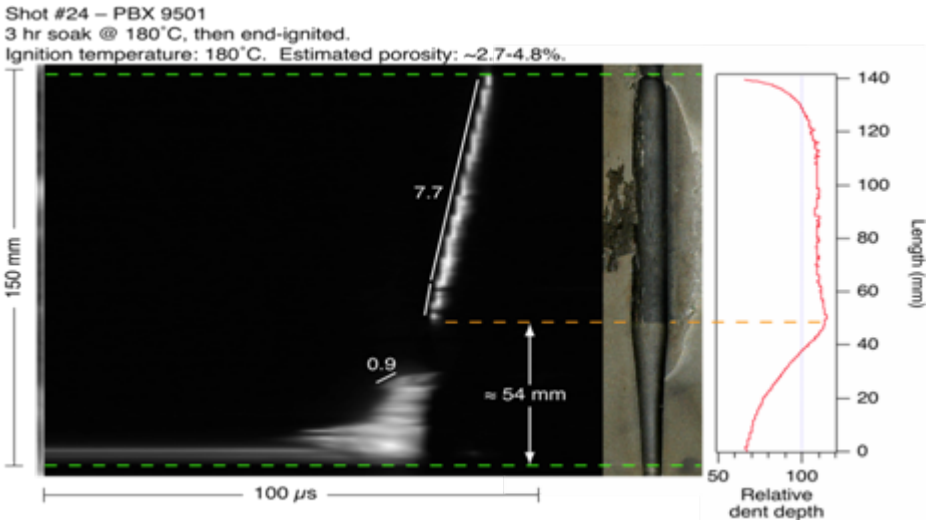
Mushroom test results

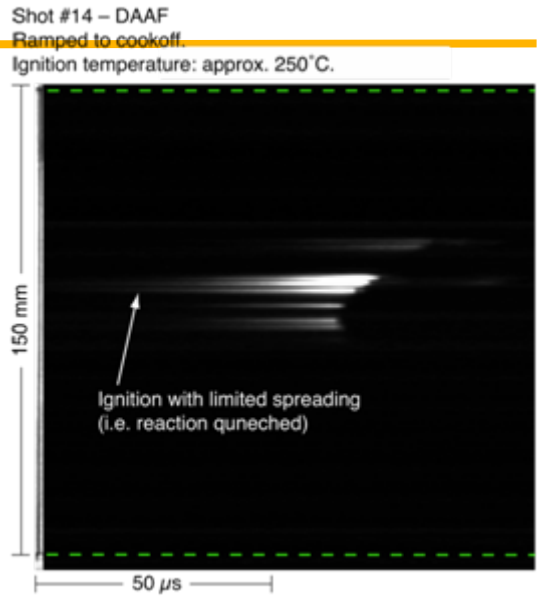
- Identical results at ambient and -55°C.
- Breakout faster on high density side.

Pellet-in-a pellet results: Ambient and -55°C



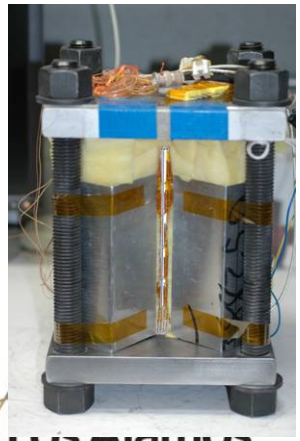
Heavily confined cook-off test

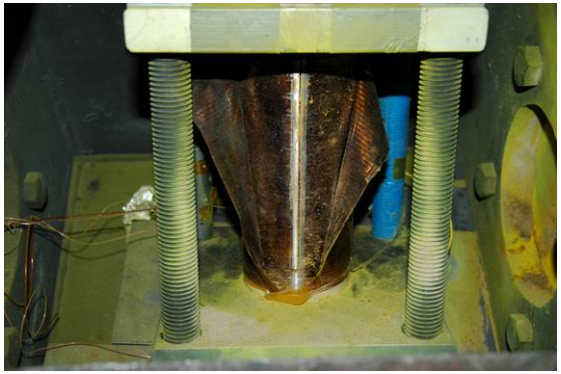




•Conventional HE (e.g. PBX 9501) has been observed to react violently

- Fast convective burns
- Thermal explosions (cookoff)
- Deflagration-to-detonation transition (DDT)





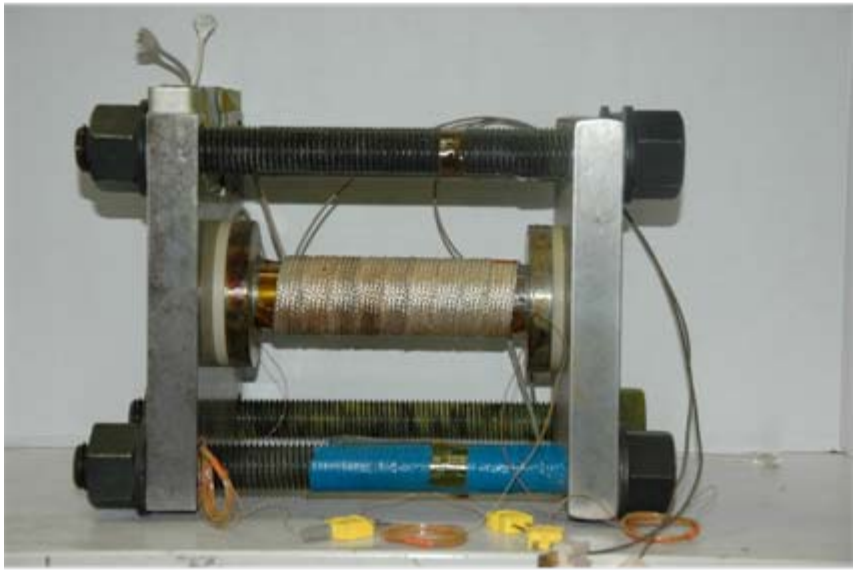
•Ideally, an insensitive HE will not cook off violently

Testing Approach: Heavy confinement

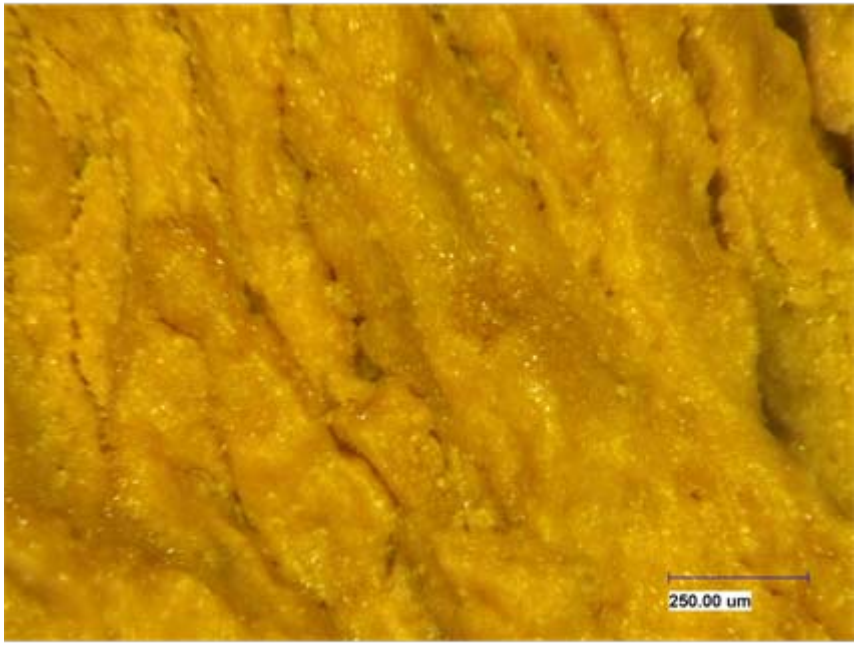
- Isolation from boundary effects
- Worst case scenario
- Case is a diagnostic

Super- Heavily confined cook off test

Pipe bomb configuration where DAAF was completely confined and molten DAAF could not escape. How would this effect violence?



Evidence of surface melting on recovered DAAF. Violence low, no DDT.



Variable Confinement Cook-off Test

- DAAF makes a nice paint!
- DAAF and Viton formulation burns at all confinements and never reacted violently

Conclusions

- Given Pop-plot data, what would gap testing reveal about shock sensitivity of DAAF?
  - DAAF is has similar shock sensitivity as HMX
- What is the critical diameter really? Previously published as “<3mm”.
  - Critical diameter of DAAF is approximately 1.25mm
- How well does DAAF perform cold (-55^{o}C) and how well does DAAF “corner turn”
  - DAAF cold performance is similar to ambient performance
  - DAAF corner turning is very encouraging
- What sort of cook-off behavior does DAAF exhibit, and does it DDT?
  - DAAF has not been seen to react violently
  - DAAF does not DDT

Acknowledgements

- Dan Hooks and Campaign 2
- Pat Baker, Fred Becker and JIMTP
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- Joe Rael: Machining

Questions?

DANGER, DAAFY DUCK?