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RECENT ADVANCES IN THE DSTO EVALUATION OF FOX-7

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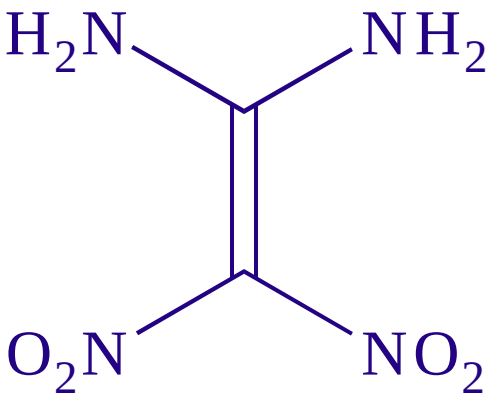
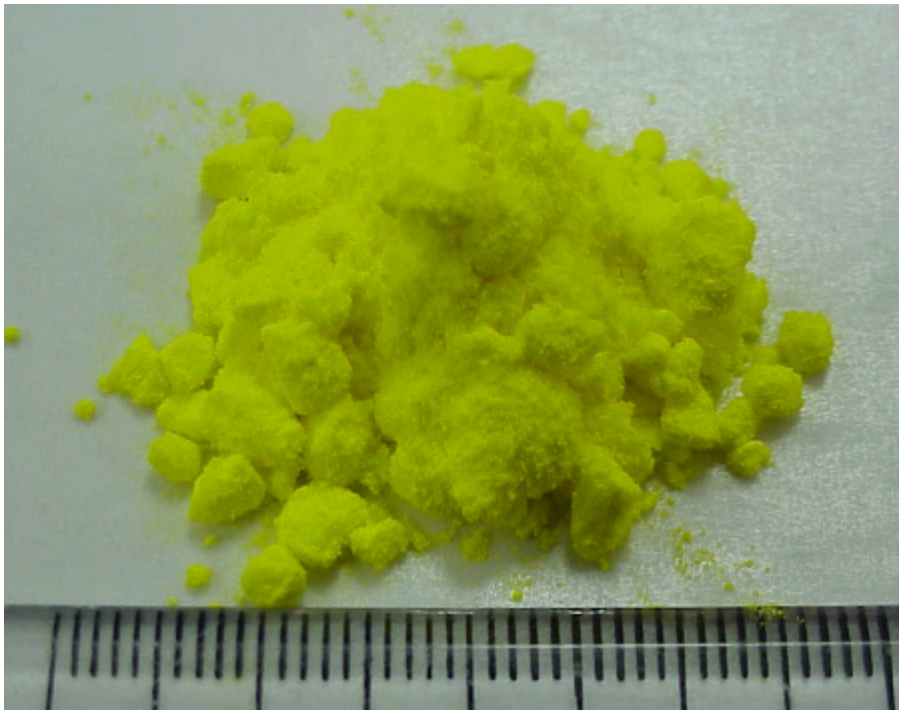
Outline

- Introduction
- Sensitiveness
- Cook-off
- Shock Sensitivity
- Performance
- Fragmentation Studies
- Summary

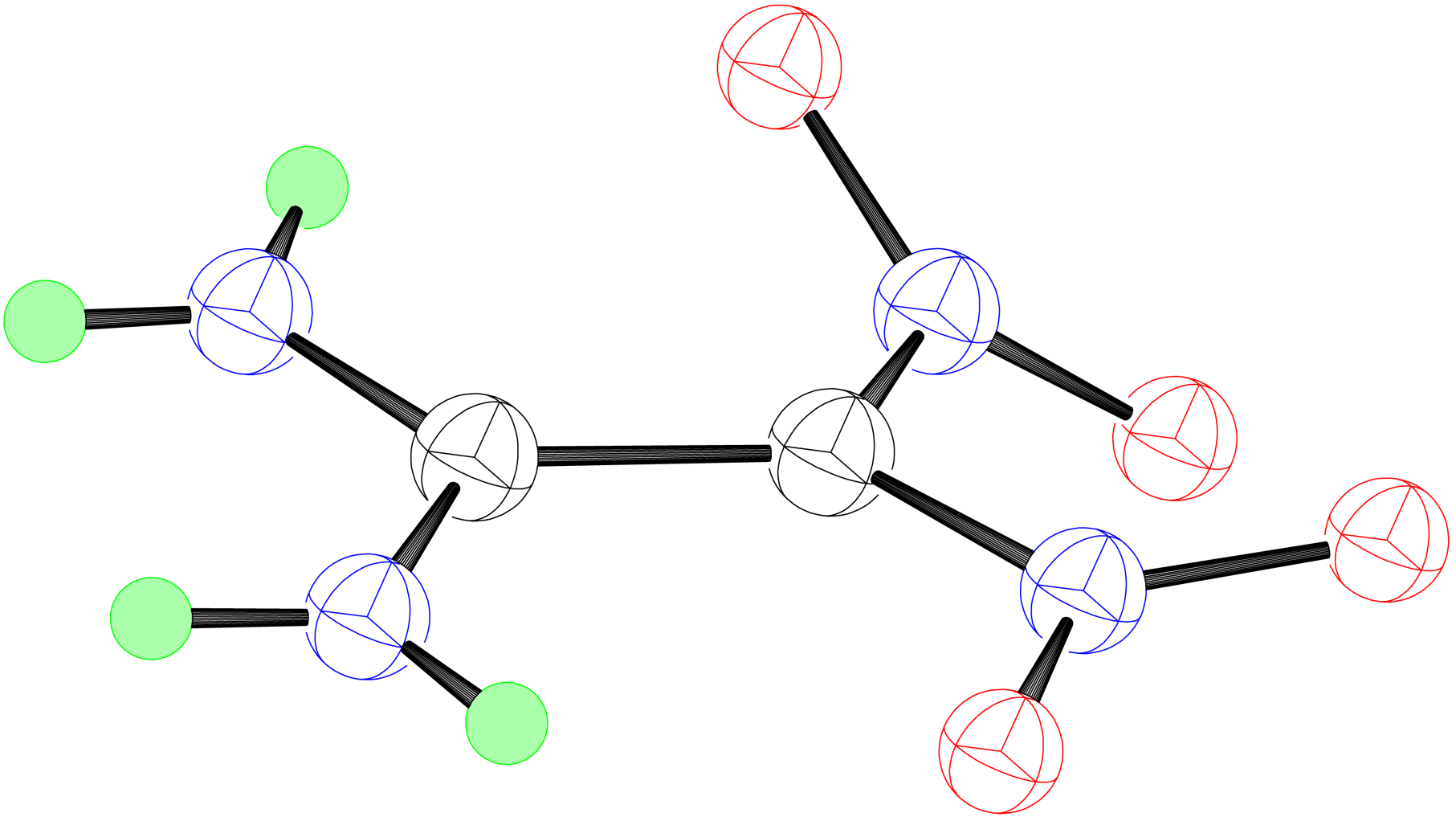
Introduction

- FOX-7 developed by FOI
- 1,1-diamino-2,2-dinitroethene
- Low sensitivity
- Performance ~ RDX





Structure



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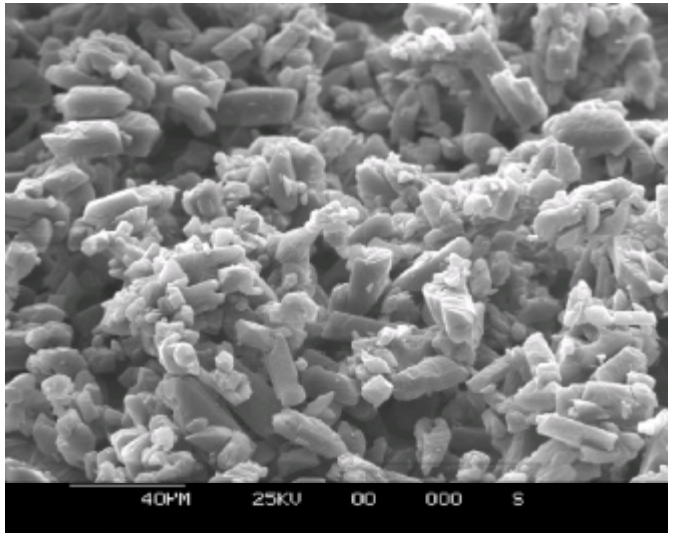
FOX-7 Sample

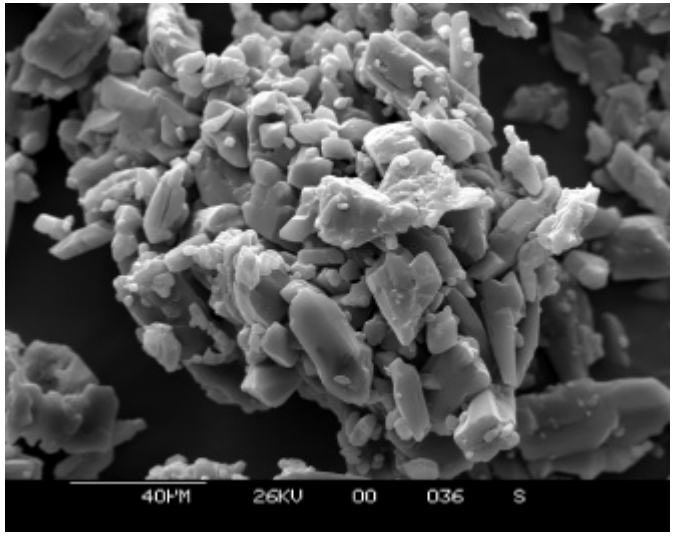
- **Non-recrystallised FOX-7** from NEXPLO Bofors AB

  - particle size = 25-30 microns

  - DSC = 260ºC exotherm



FOX-7 (DSTO)



FOX-7 (Bofors)

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Sensitiveness Testing

Test	FOX-7 (Bofors)	FOX-7 (DSTO)	RDX
Rotter Impact (F of I)	100	110-140	80
BAM Friction (N)	240	168-288	~ 120
ESD [1] – Ignition (J)	4.5	4.5	4.5
ESD [1] – No Ignition (J)	0.45	0.45	0.45
Thermal Stability [2] (mL/g)	0.28	0.1	0.1
Temp. of Ignition (ºC)	217	226	223
Bickford Fuse	Ignition	Fails to ignite	Fails to ignite
Train Test	Ignition	Ignition	Ignition

[1] Electrostatic Discharge

[2] Vacuum Thermal Stability, performed at 100ºC/48h

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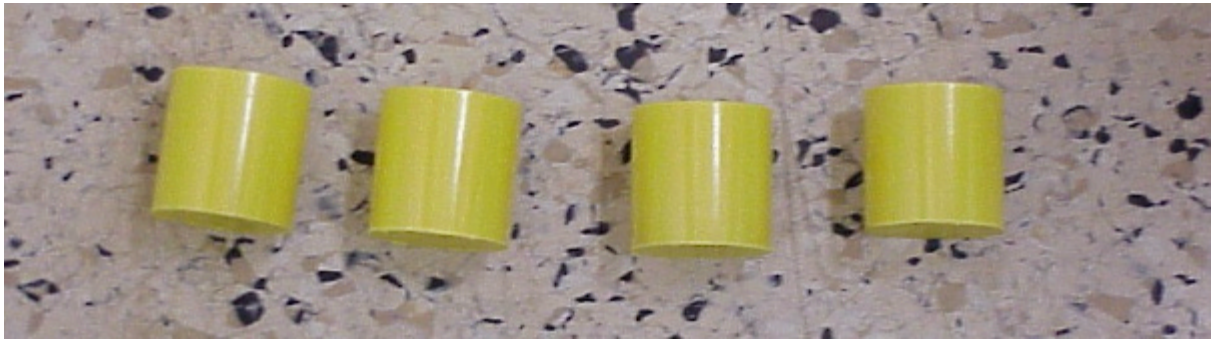
Pressed Formulation

- Objective – pressed charges for evaluation of FOX-7
- FOX-7/EVA (95:5)
  - EVA = *poly*(ethylene-co-vinyl acetate)
- Prepared in water slurry with EVA added in solvent
- Cylindrical pellets pressed individually on Instron
- RDX/EVA (95:5) prepared for comparison



Cookoff

- MRL Super Small-Scale Cookoff Bomb (SSCB)
  - based on China Lake SSCB
  - 4 pressed pellets per test, 16 mm D x 16 mm L, NEQ ~ 20.2 g

Explosive	% TMD	Rate	Temp. (ºC)	Reaction Type
FOX-7/EVA	93	Fast	235	Burn x 3
RDX/EVA	96	Fast	220	Detonation x 2, deflagration x 1
FOX-7/EVA	93	Slow	240	Burn x 3
RDX/EVA	96	Slow	209	Deflagration x 3

Actual densities: FOX-7/EVA = 1.659 g/cm^3
RDX/EVA = 1.655 g/cm^3

Shock Sensitivity

- MRL Small Scale Gap Test (SSGT)
  - 2 pressed pellets per test, 12.7 mm D x 12.7 mm L, NEQ ~ 5.2 g
  - gap material = brass shims
  - donor = EBW detonator

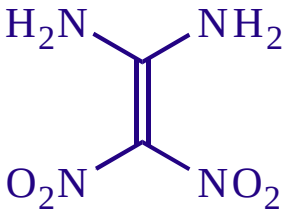
Explosive	% TMD	50% Point ($m_{50\%}$)
FOX-7/EVA	93.1	62
RDX/EVA	94.0	77
RDX/EVA	94.4	66

Actual densities: FOX-7/EVA = 1.666 g/cm^3
RDX/EVA = 1.621 g/cm^3
RDX/EVA = 1.627 g/cm^3

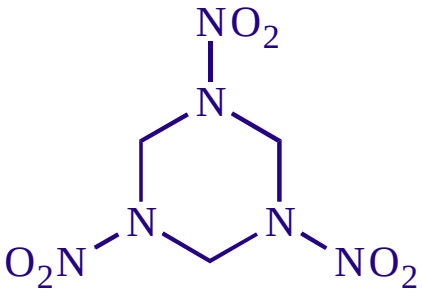
Performance - Theoretical

Detonation Parameters [1]	FOX-7	RDX	NTO	TATB
Velocity (m/s)	8849	8940	8564	8108
Pressure (GPa)	33.7	34.7	31.2	31.1

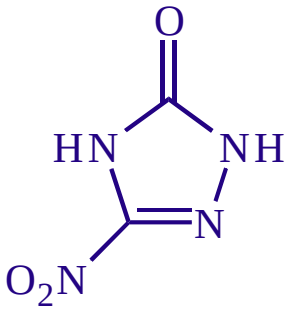
[1] CHEETAH v2.0



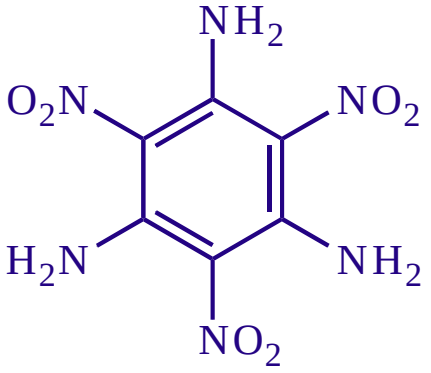
FOX-7



RDX



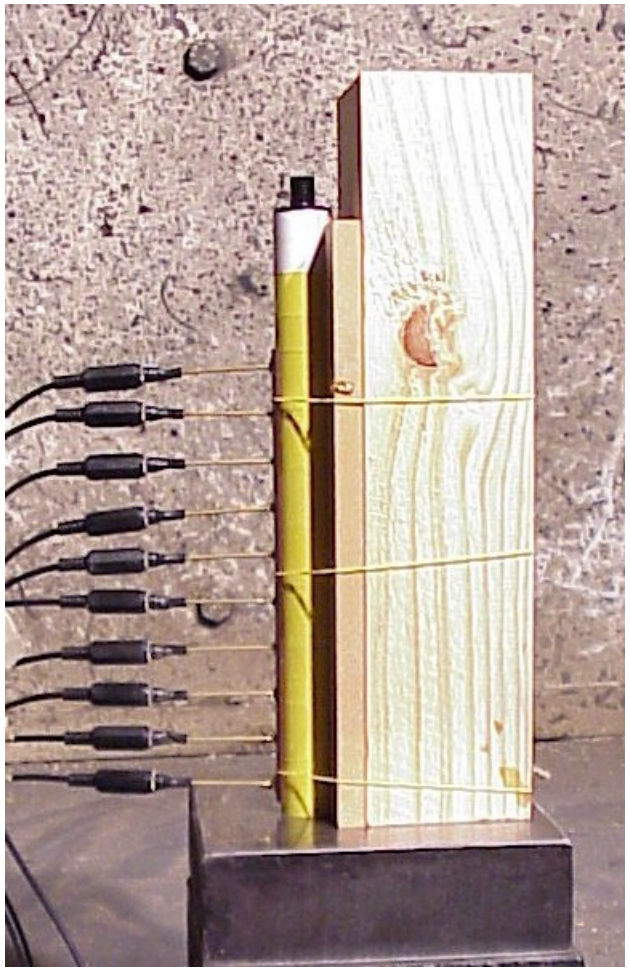
NTO



TATB

Performance

- FOX-7/EVA pellets 25mm D x 25mm L
- RDX/EVA booster
- VoD by ionisation pins
- Relative detonation pressure by dent test
- RDX/EVA for comparison



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Performance

Explosive	Diameter	%TMD	Experimental		Theoretical [1]	
			VoD (m/s)	P (GPa)	VoD (m/s)	P (GPa)
FOX-7/EVA	25	94.3 [2]	8110	24.6	7845	24.4
RDX/EVA	25	94.4 [2]	8248	26.4	8008	25.7
FOX-7/EVA	12.7	92	7730 [3]	24.1 [3]	7691	22.9
RDX/EVA	12.7	92	7630 [3]		7731	23.0

[1] CHEETAH v2.0

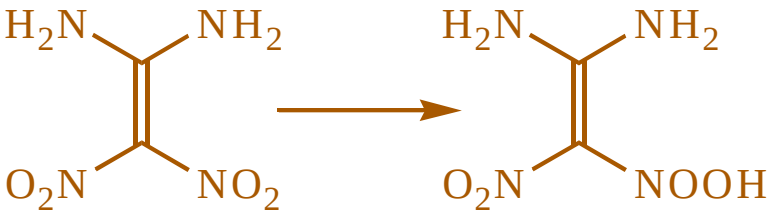
[2] Actual densities: FOX-7/EVA = 1.686 g/cm^3
RDX/EVA = 1.628 g/cm^3

[3] *Lochert, I. J. DSTO-TR-1238*

Fragmentation Studies

• Modelling and literature suggest various possible decomposition pathways for FOX-7 including:

- Hydrogen transfer

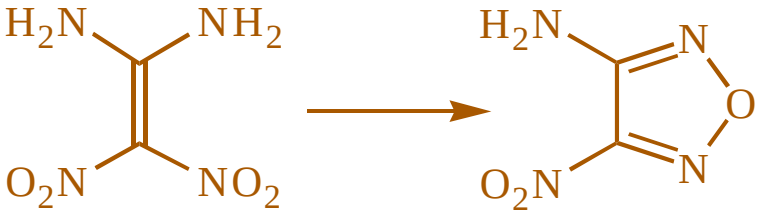


  · HONO formation

  · Formation of furazan and furoxan derivatives

- Nitro-nitrite rearrangement

- C-nitro bond scission



-Dorsett, H. DSTO-TR-1054

Fragmentation Studies

- Collaborative project with University of South Australia
  - Laser Ablation Mass Spectroscopy (LAMS)
    - Thermal decomposition
  - Time of Flight - Secondary Ion Mass Spectroscopy (TOF-SIMS)
    - "Ion impact"
    - Gallium ions, range of incident energies
    - Caesium ions

Summary

- FOX-7 is less sensitive than RDX in small scale sensitiveness testing
- FOX-7 has higher temperatures of reaction and lower violence of reaction in SSCB
- Shock sensitivity of FOX-7 = RDX in SSGT
- Performance ~ RDX confirmed experimentally
- **FOX-7 has potential for use in IM formulations**

Future Work

- Fragmentation studies
- Recrystallised FOX-7
- Insensitive booster formulations

Acknowledgements

• Dr Jing Ping Lu – CHEETAH calculations

• Dr Helen Dorsett – fragmentation studies

• Dr Bruce Wedding (UniSA) – fragmentation studies

• Danielle Gilboy and Mark Champion – SSCB, SSGT and sensitiveness testing

• Dave Harris and Jared Freundt – performance testing

• Dr Per Sjöberg (NEXPLO Bofors AB)


Innisfail
Stirling
Edinburgh
Pyrmont
Canberra
Melbourne
Scottsdale

QUESTIONS?

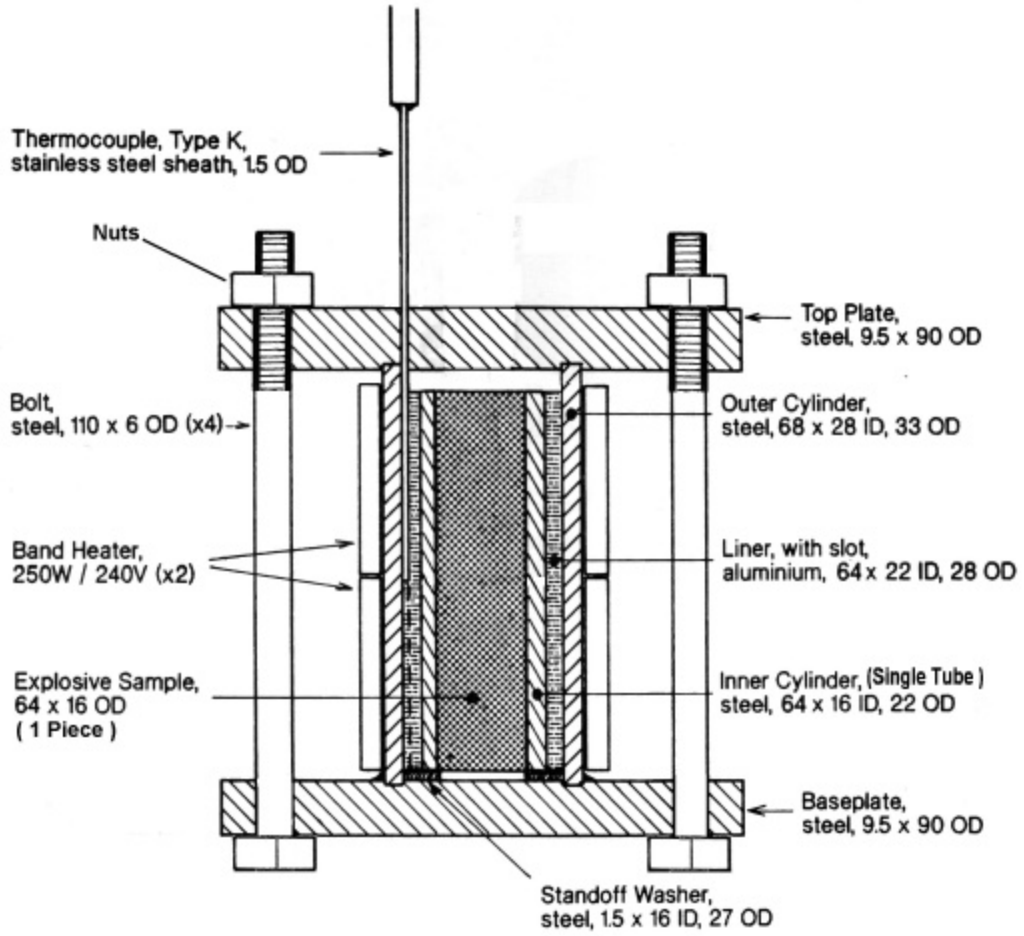
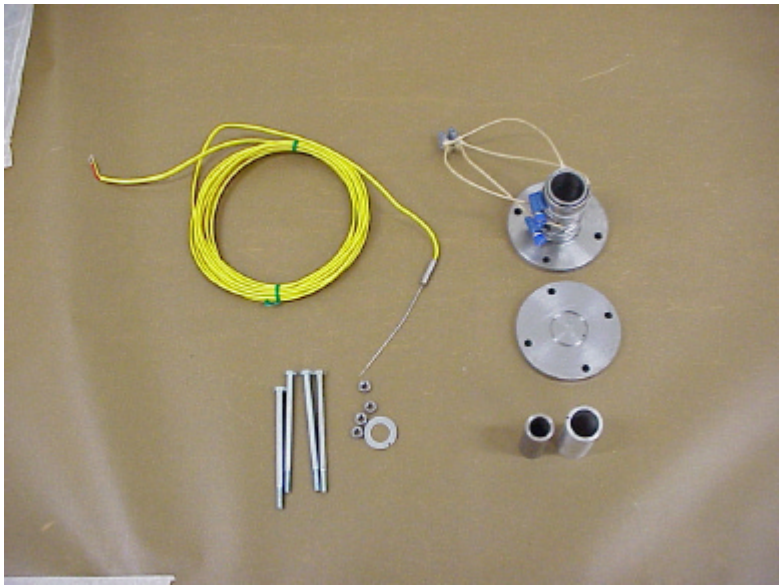
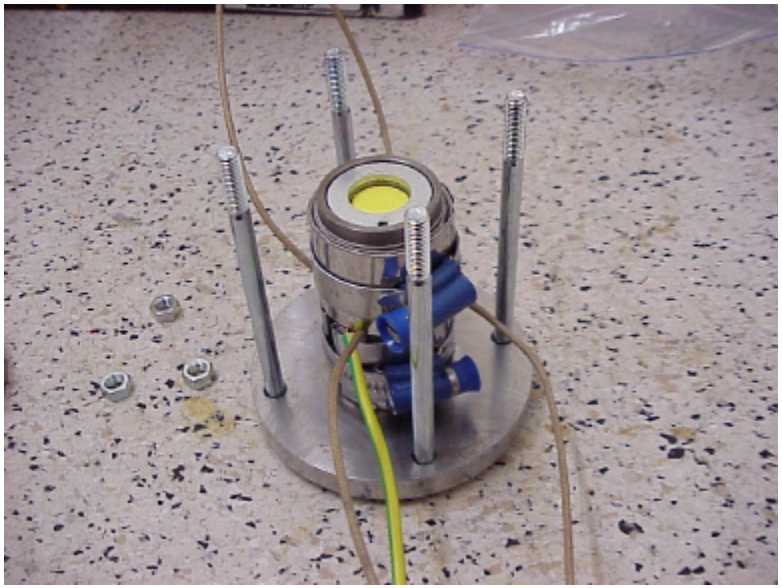
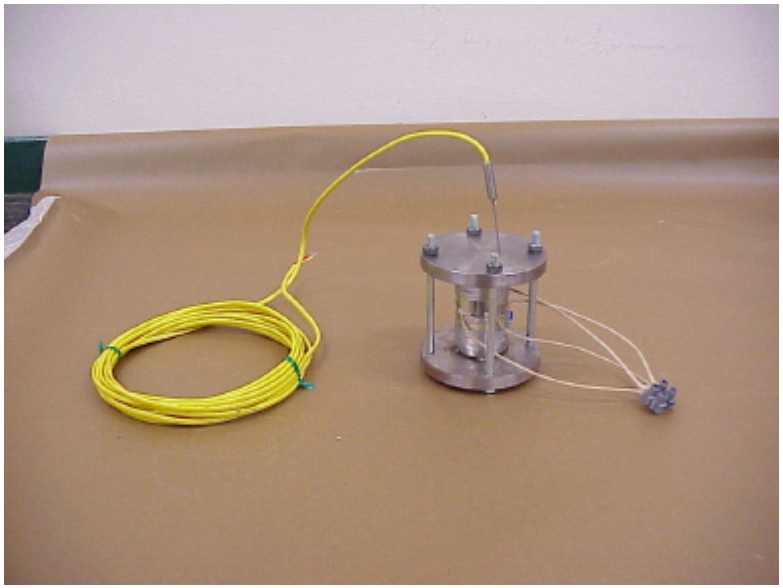
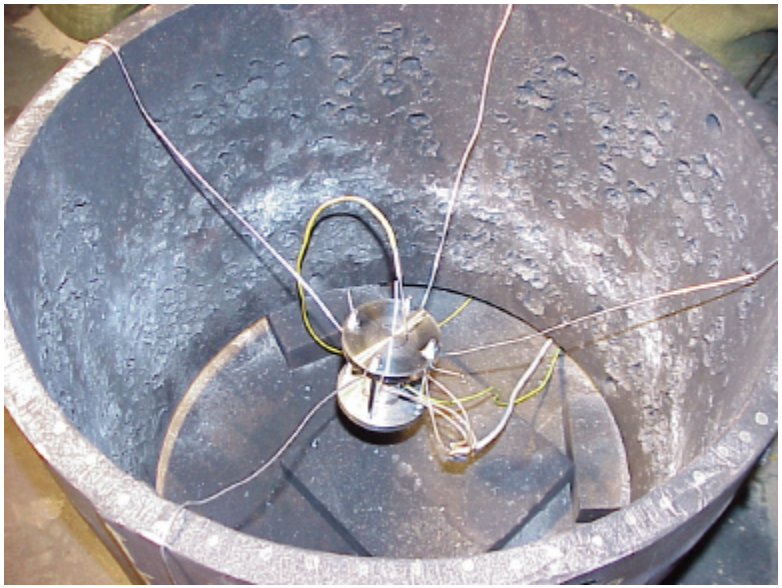


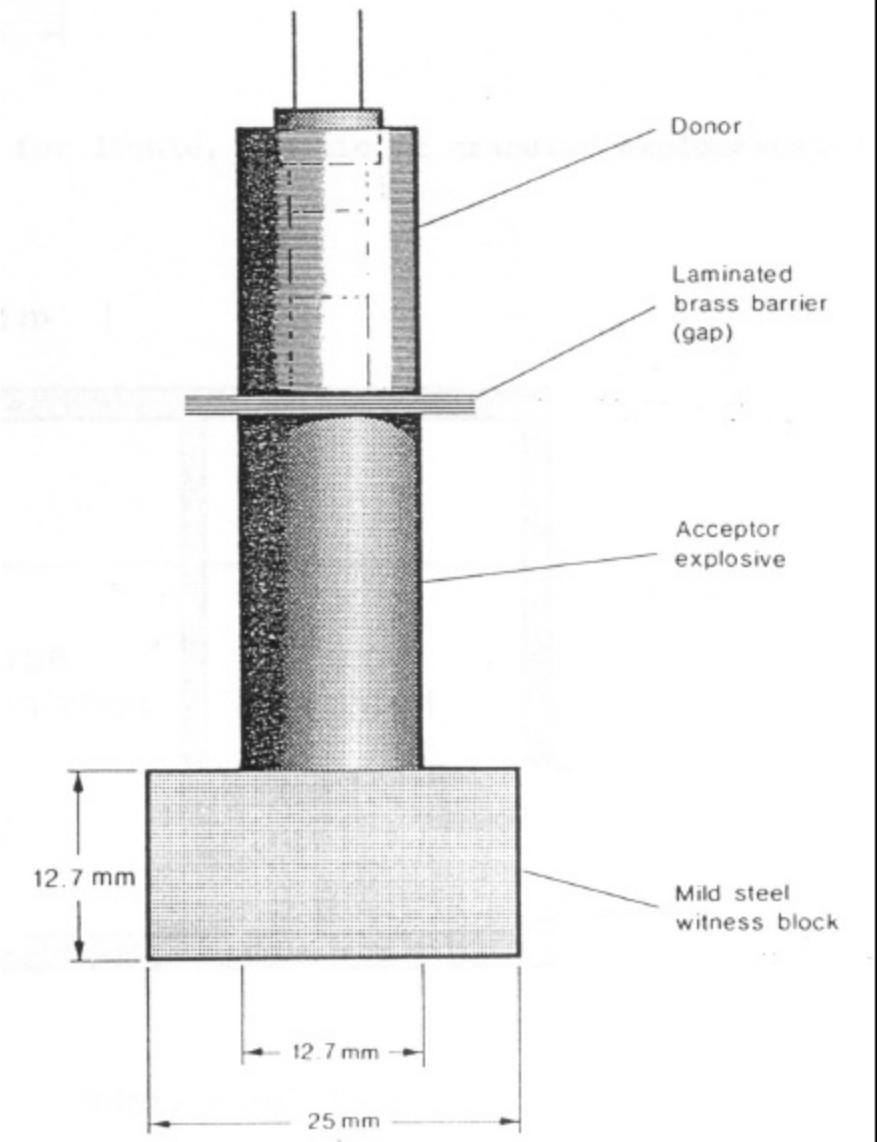
Figure 1 Super Small-scale Cookoff Bomb Test Vehicle Components










Donor
Laminated
brass barrier
(gap)
Acceptor
explosive
12.7 mm
Mild steel
witness block
12.7 mm
25 mm