Andrew Bushy


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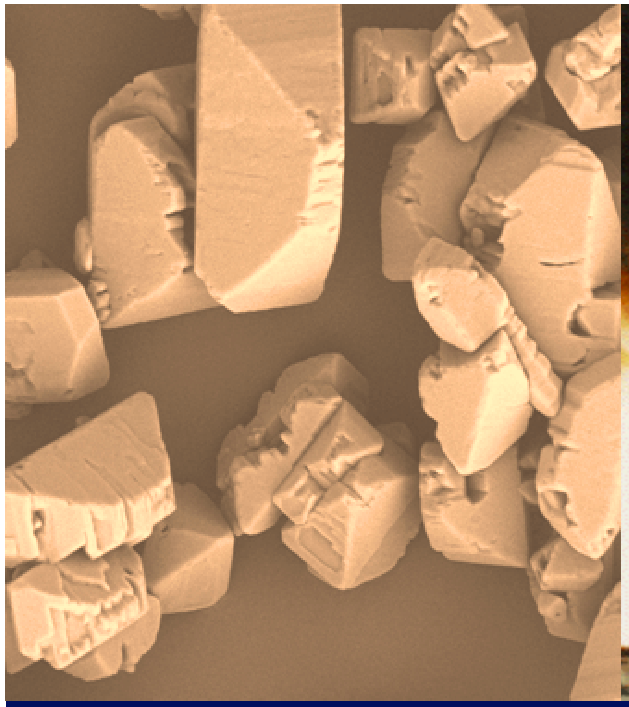
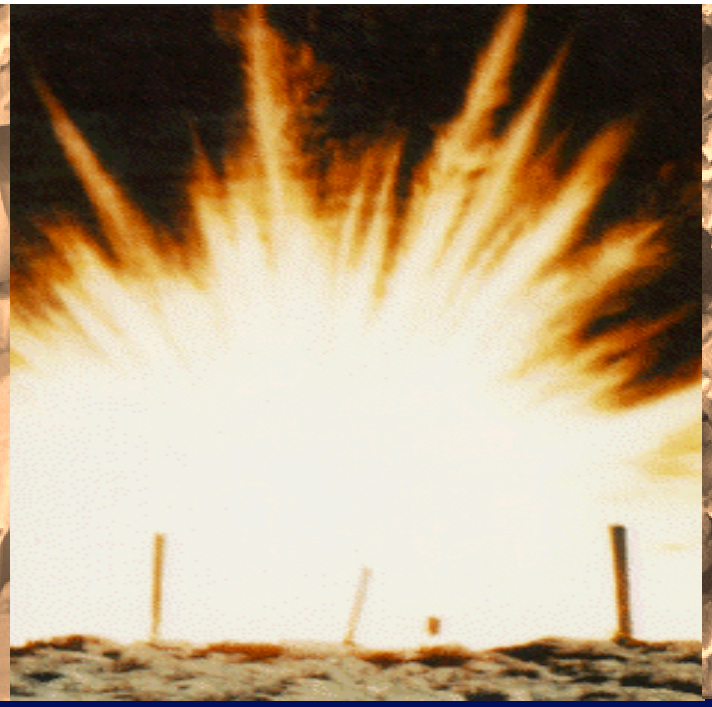
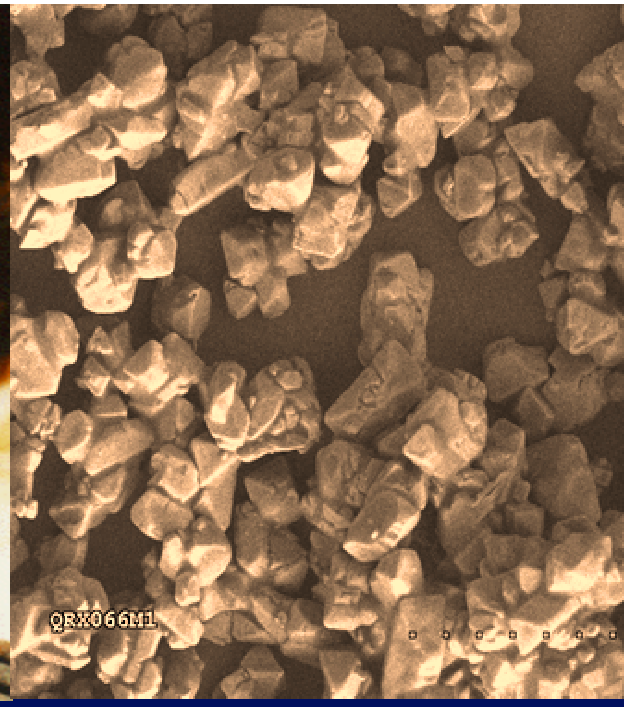

Pressable PBX Formulations Based on FOX-7
Euro Insensitive Munitions & Energetic Materials

Symposium

April 2006

Presenter: A. J. Busby

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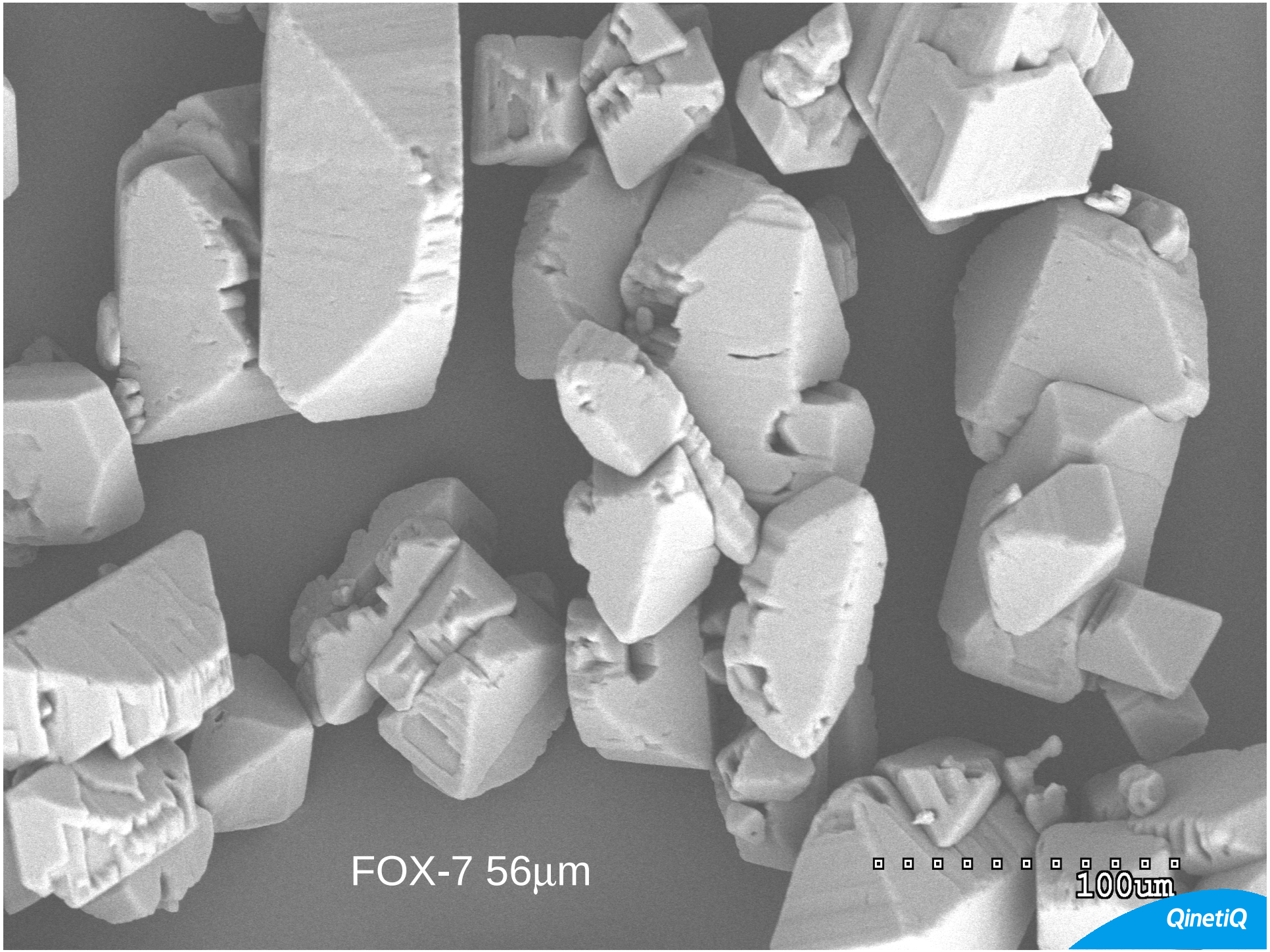
Technical Aims

- To characterise FOX-7 of differing particle sizes obtained from Eurenco
- To produce a range of pressable FOX-7 moulding powders
- To scale up a FOX-7 composition to charge scale
- To measure the performance of FOX-7 pressable composition

FOX-7 Characterisation

- Two batches of FOX-7 obtained from Eurenco Bofors AB
  - Batch 2003 7008 mean particle size 28 microns
  - Batch 2003 7019 mean particle size 56 microns
- Subjected to SEM analysis and small scale hazard tests


FOX-7 56µm
100um
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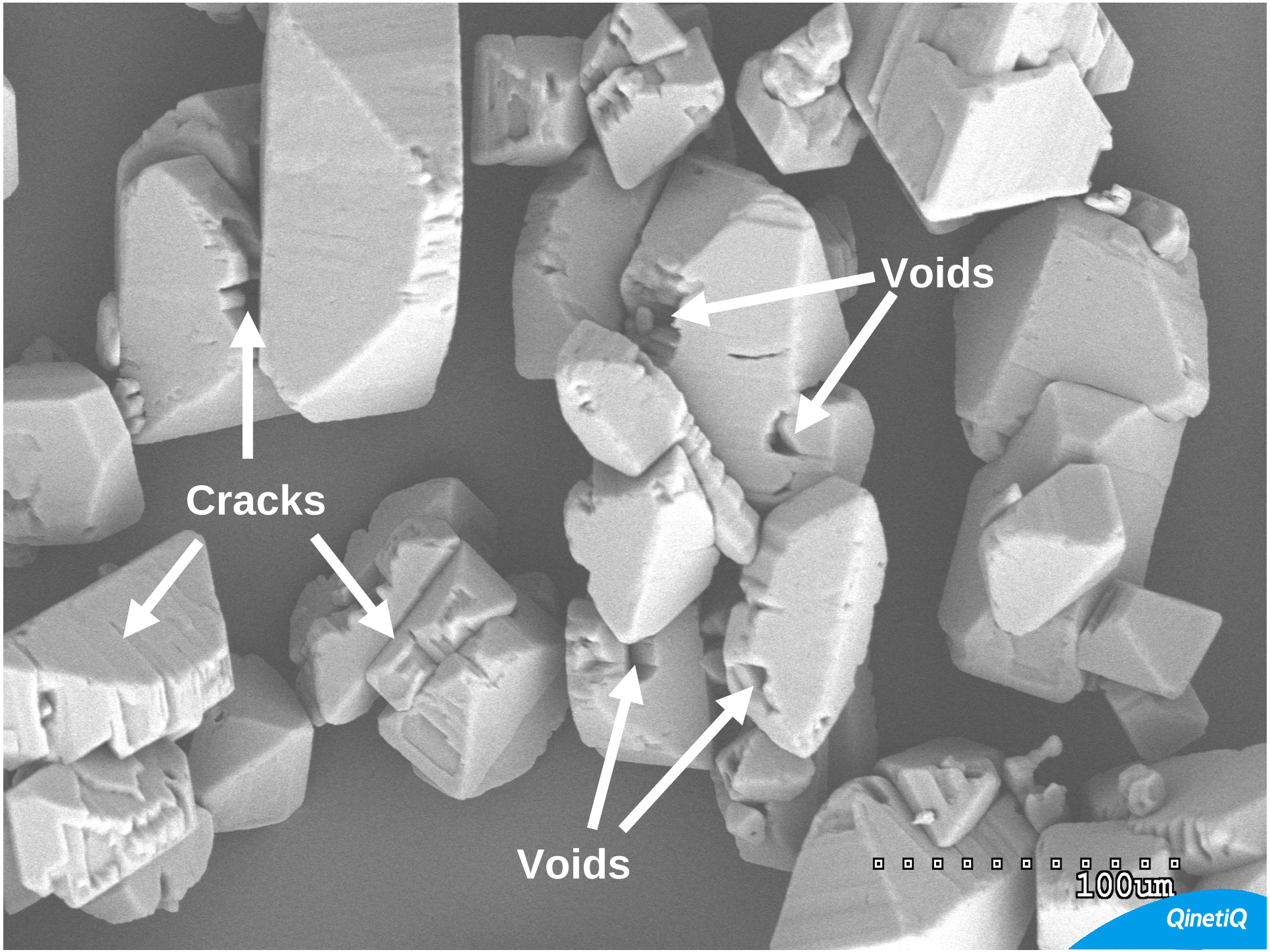
Voids
Cracks
Voids
100um
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FOX-7 Hazard Properties

Test	RDX Standard	FOX-7 (56 μm)	FOX-7 (28 μm)
F of I	80	86	108
Small Scale Explosiveness (X*)	85	44	48
F of F	3.0	>6	>6
Mallet Friction	50-100% on steel	0%	0%
T of I	219 ^{o}C	230 ^{o}C	227 ^{o}C
Ease of ignition	Fails to Ignite	Fails to Ignite	Fails to Ignite
Train Test	ISTS	ISTV	ISTV
Electric Spark	Ignites at 0.45J	Ignites at 0.45J	Ignites at 4.5J

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FOX-7 – Modelling Studies

- Modelling of performance conducted using Cheetah 2
  - 95% FOX-7 predicted to have similar performance to 92% HMX (i.e. PBXN-9)
  - Available hazard data suggest this would be insensitive
- Formulation with FOX-7 and HMX to trade-off safety for performance
  - Using a 50:50 mix of FOX-7 and HMX in 92% loaded formulation results in loss of 2% in VoD, 7% in detonation pressure cf 92% HMX

CHEETAH 2.0 Calculations

Composition	Detonation Pressure (GPa)	Detonation Velocity (ms^{-1})
100% FOX-7	34.20	8888
95% FOX-7 5% Inert Binder	28.46	8219
92% FOX-7 8% Inert Binder	25.44	7862
92% HMX 8% Inert Binder	28.39	8151
46% FOX-7 46% HMX 8% Inert Binder	27.36	8049

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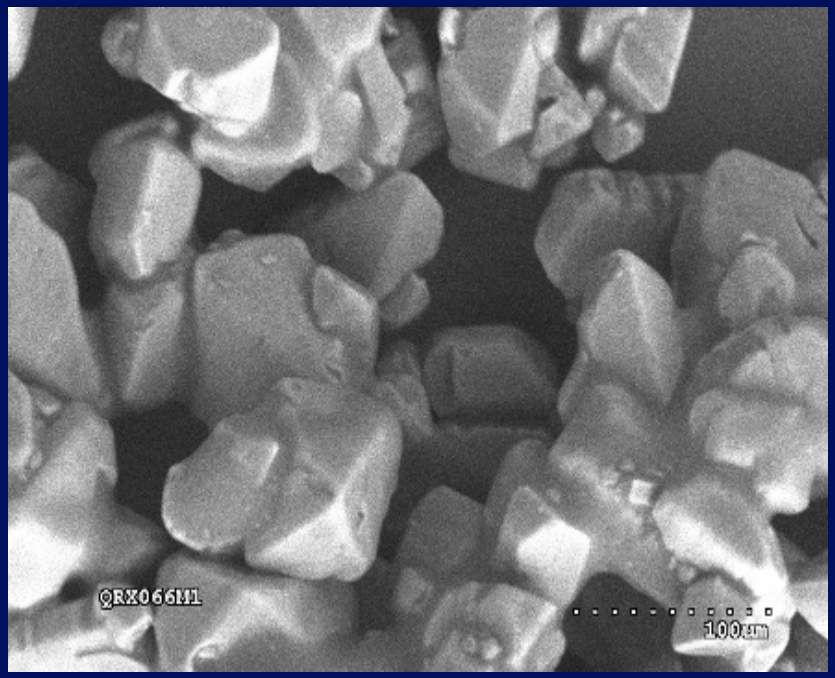
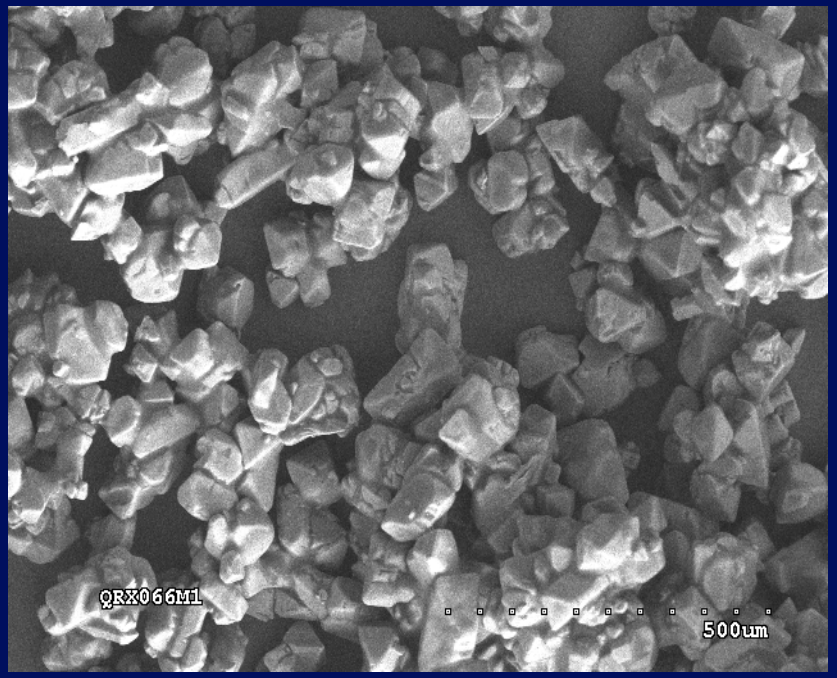
FOX-7

- Formulations containing up to 95% FOX-7 and mixed HMX/FOX-7 were manufactured and tested
- Pressing studies on 95% FOX-7 completed
  - vacuum pressing a requirement
  - Scaled up to 2 kg batch size
  - Pellets pressed for LSGT, cylinder expansion and V of D measurement
- Modelling work has been carried out to demonstrate trade-off of safety for performance for mixed explosive fillers

SEM of FOX-7 Composition





92% FOX-7 / 8% Hytemp Binder

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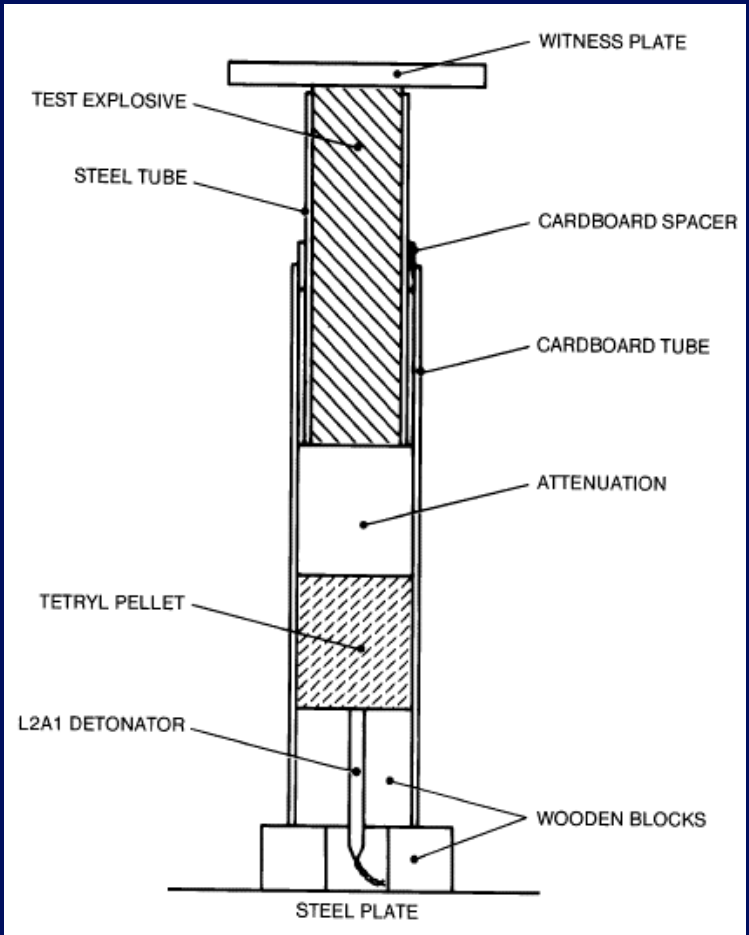
FOX-7 Compositions – Hazard Data

	QRX 055	QRX 080	QRX 066	QRX077
Composition	90% FOX-7	95% FOX-7	92% FOX-7	46% FOX-7 46% HMX
F of I		144	120	100
F of F	>6	>6	>6	>6
Mallet Friction	0%	0%	50% Steel 0% Others	0%
T of I	230 ^{o}C	229 ^{o}C	232 ^{o}C	229 ^{o}C
Ease of ignition	IBQ	Fails	Fails	IBQ
Train Test	ISTST	ISTS	ISTS	ISTF
Electric Spark	Ignites at 0.45 J	Ignites at 0.45 J	Ignites at 0.45 J	Ignites at 4.5 J

FOX-7 – Charge Scale Testing

- QRX 080 (95% FOX-7/5% Binder) chosen for scale-up
- 2 kg of composition batch mixed and pressed into pellets
- Tests conducted
  - VoD
  - Shock Sensitiveness
  - Detonation Characteristics

FOX-7 – Charge Scale Testing



- Results of testing on QRX 080 (95% FOX-7)
  - Large Scale Gap Test result: 33.3mm
    - Comparable to RF-38-09 (Rowanex 1100) & CPX 413
  - VoD on 25mm diameter pellets: 8630 m/s
    - *cf* PBXN-9 8490 m/s
    - Cheetah value of 8219 m/s
  - Cylinder expansion test
    - Gurney Velocity 2567 m/s
    - *cf* PBXN-9 2841 m/s
    - Lower than expected

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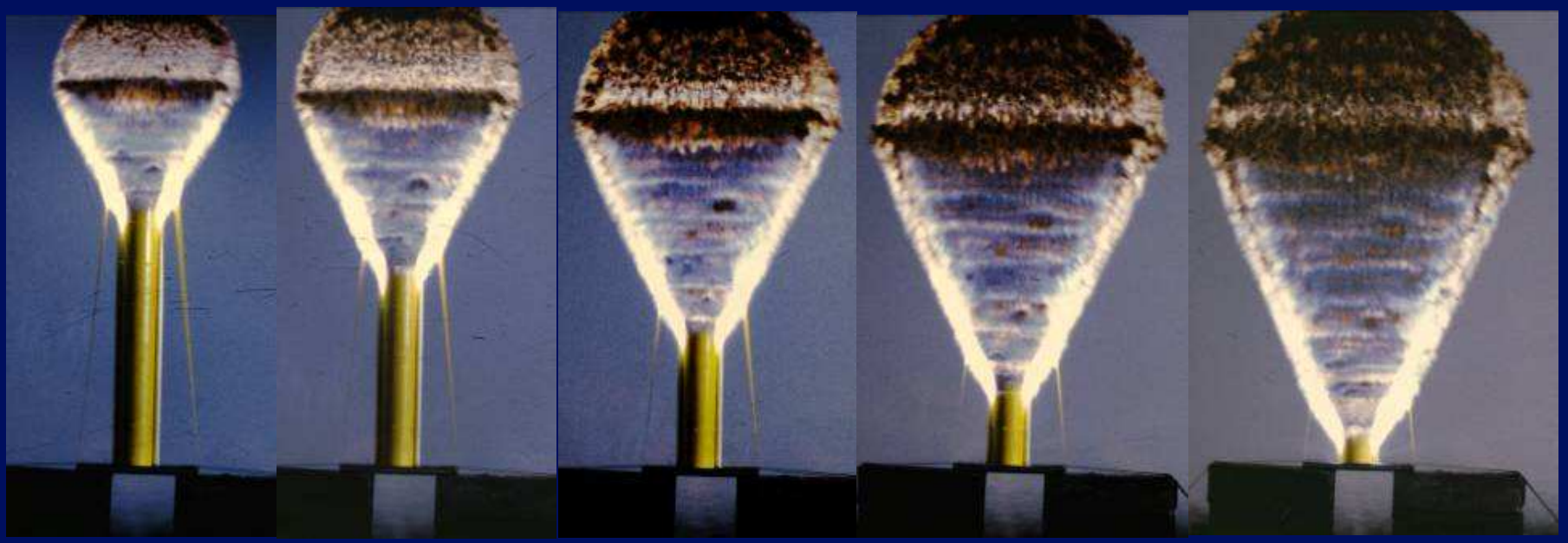
FOX-7 – Charge Scale Testing

- VoD Measurement:



FOX-7 – Cryogenic Processing

- Performed by Nobel Energetics, Ardeer, Scotland.
- FOX-7 and QRX 080 both processed by NE
- Analysis by DSC of processed FOX-7 shows little difference from starting material
- Vacuum stability of processed QRX 080 shows material is stable
- Small scale hazard testing of both materials shows slight decrease in friction sensitiveness, otherwise little change

Conclusions (i)

- **FOX-7 characterised**
  - **Low impact and friction sensitivity confirmed**
  - **Good thermal stability**
- **Moulding powders with FOX-7/HMX & binder successfully produced**
  - **Relatively insensitive to impact/friction**
  - **Suitable for pressing**

Conclusions (ii)

- **95% FOX-7 composition scaled up**
  - **VoD, shock sensitiveness & detonation characteristics measured**
- **VoD 8630 m/s – as expected**
- **Gurney Velocity low – an unexpected result!**

Acknowledgements

MoD Weapon Platforms and Effectors

Nobel Energetics

EURENCO

QinetiQ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