U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

Characterization of Nano Octol Formulation

Presenter: Daniel Iwaniuk (daniel.p.iwaniuk.civ@mail.mil)

Principal Investigator: Philip Samuels (philip.j.samuels2.civ@mail.mil)

Team: Dr. Hongwei Qiu (Leidos), Mr. Erik Wrobel, Dr. Henry Grau, Dr. Victor Stepanov, Dr. Rajen Patel, Dr. Reddy Damavarapu, Dr. Kelley Caflin, Mr. Joshua Felts (Indian Head)

DEVCOM AC; Picatinny Arsenal, NJ

BACKGROUND

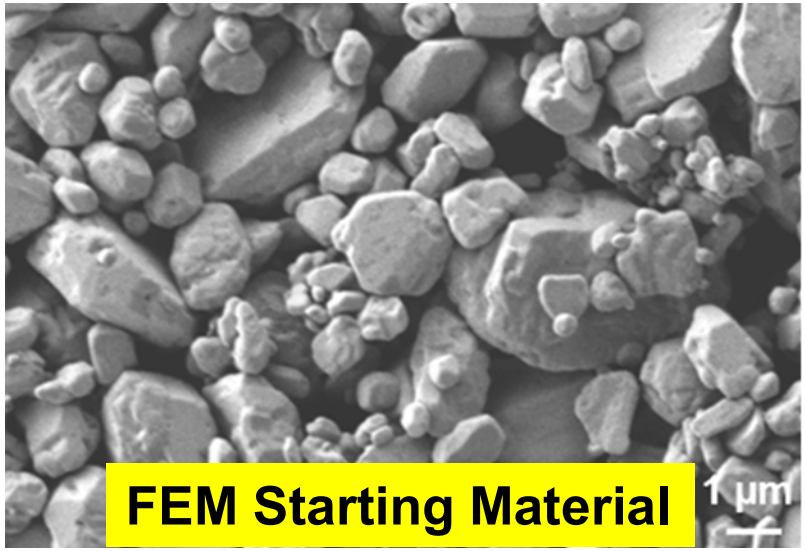
- Over the last several years, DEVCOM AC engineers have demonstrated the manufacturing capability of producing and uniformly coating nano-energetics

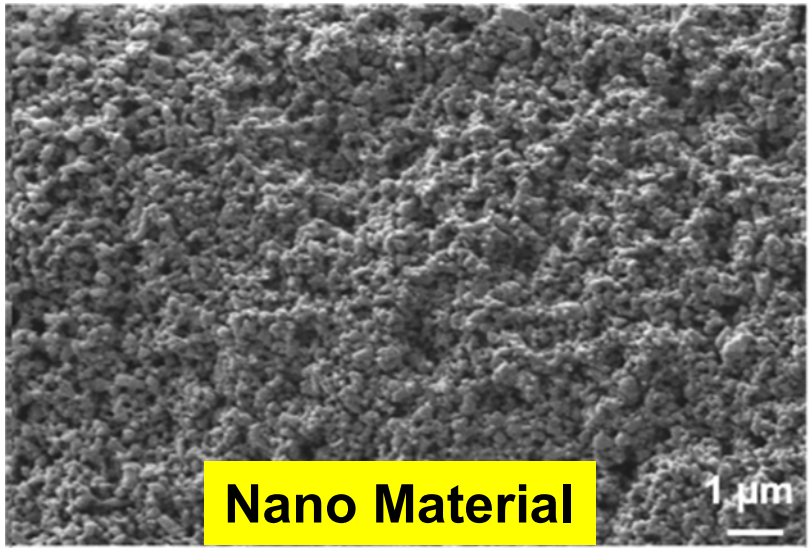
- The use of nanoscale high explosives (HEs) along with a uniform polymeric coating effectively eliminates large voids that are commonly regarded as the main locations for the formation of hot-spots and detonation initiation upon unplanned external stimuli.

- Improved mechanical properties of nano-energetic based explosives may also help with setback survivability.

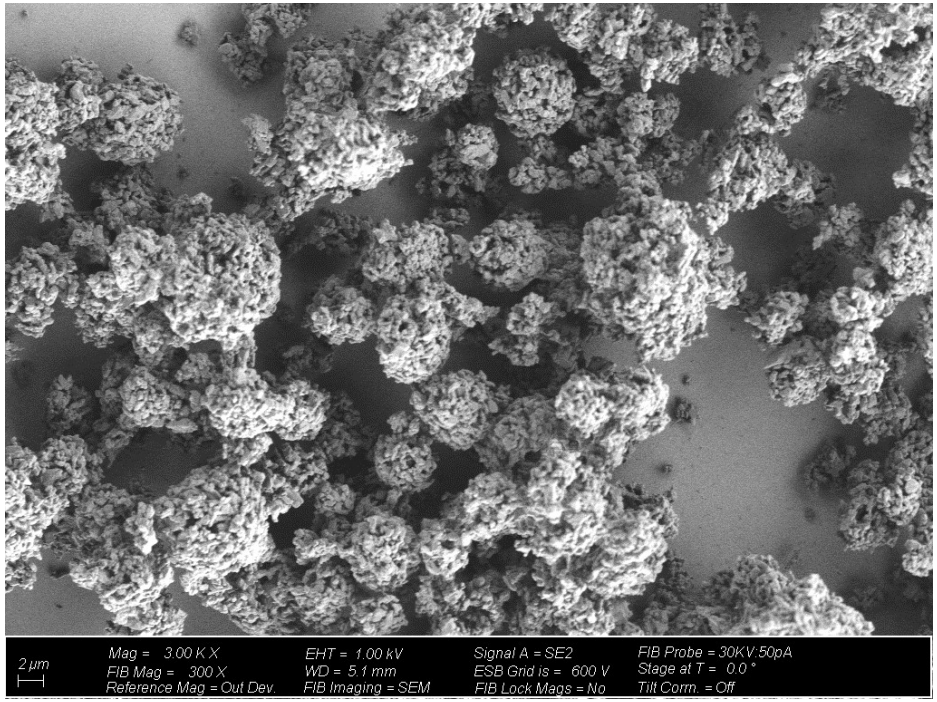
- The majority of the explored formulations utilizing nanoscale HEs were based on polymer-bonded explosives.

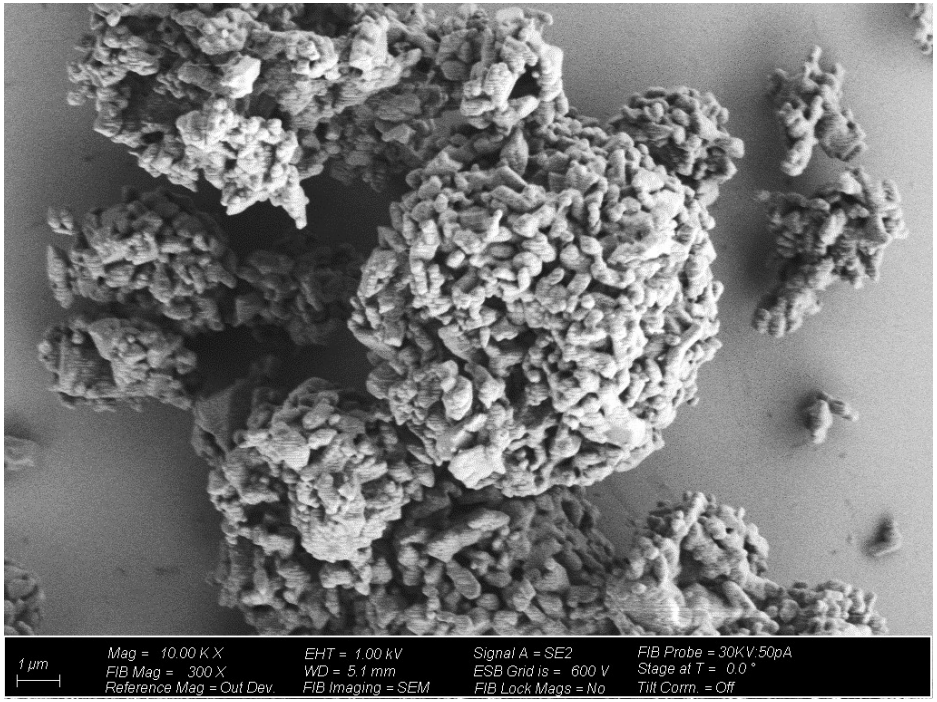
TECHNICAL APPROACH





SEM IMAGES OF NANO OCTOL



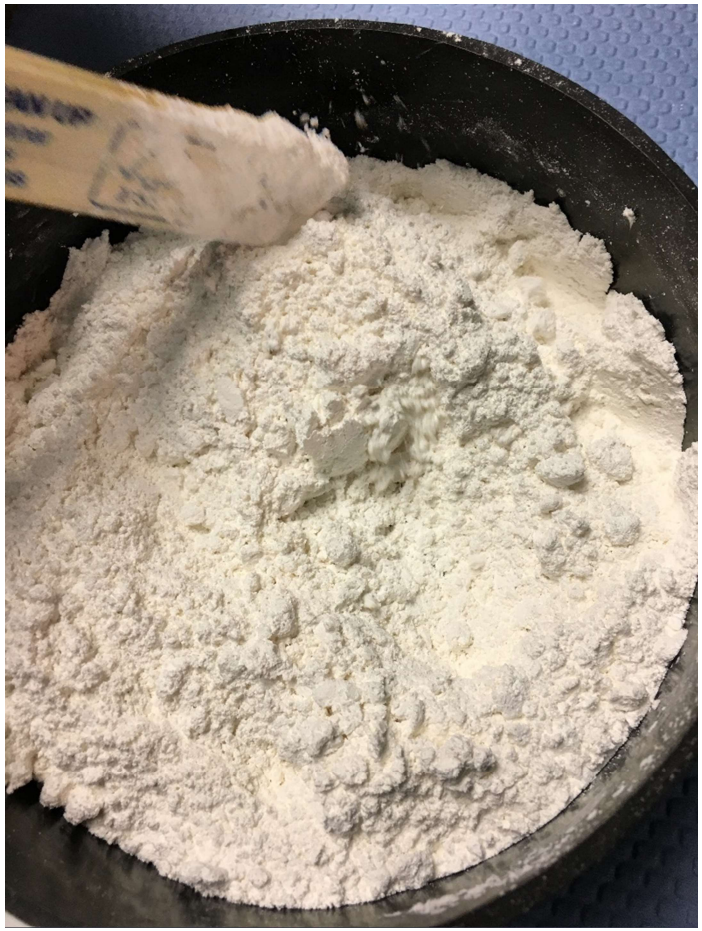


JAGUAR CALCULATIONS

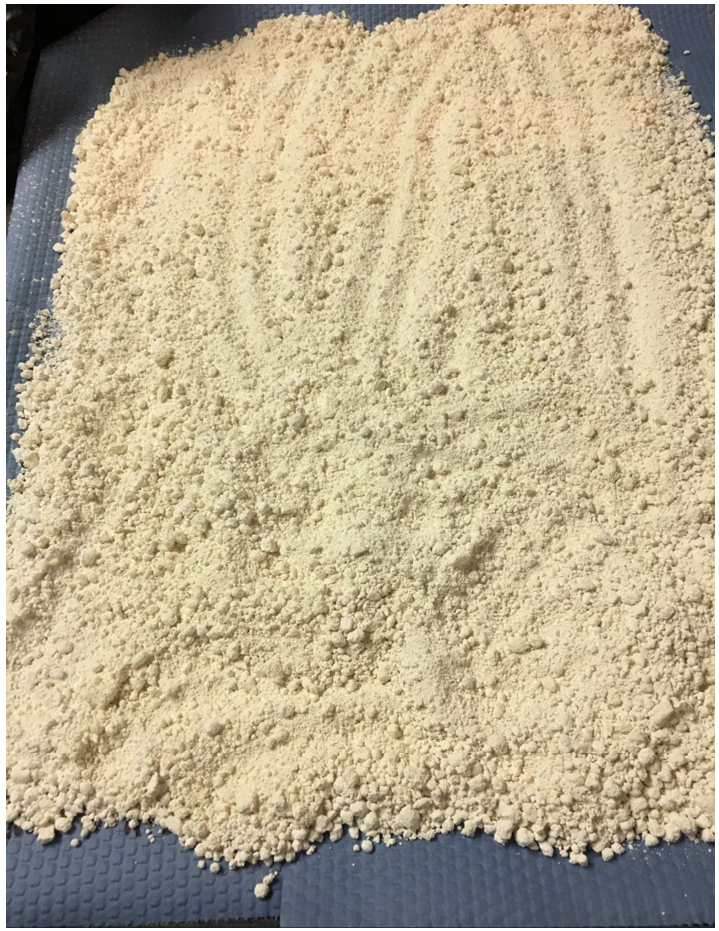
- Jaguar Version 18 Thermo-chemical code was utilized for conducting legacy formulations compared to Nano Octol at 98% TMD
- Nano Octol calculations show equivalent or better and Octol 70:30 and PBXN-9

Formulation	Density (g/cc)	DV (km/s)	CJ Pressure (kbar)	2 Volume Expansions	7 Volume Expansions
Octol (70:30)	1.786	8.24	30.3	2.64	2.87
Octol (75:25)	1.799	8.36	31.2	2.66	2.90
PBXN-9	1.749	8.28	29.6	2.64	2.87
PBXN-5	1.864	8.73	34.7	2.74	2.97
LX-14	1.817	8.62	33.4	2.7	2.94
Nano Octol	1.781	8.32	30.6	2.68	2.88

GRANULATION OF NANO MOLDING POWDER



Nano Octol granulated with Water



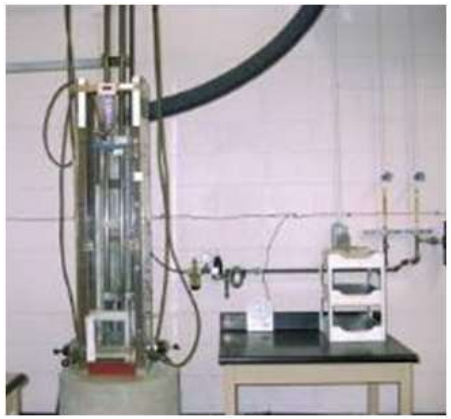
Nano Octol granulation

Increasing the bulk density of the powder, not increasing the PSD of the crystals since they are already coated

Bulk Density: ~ 0.8 g/cc

SAFETY TEST RESULTS

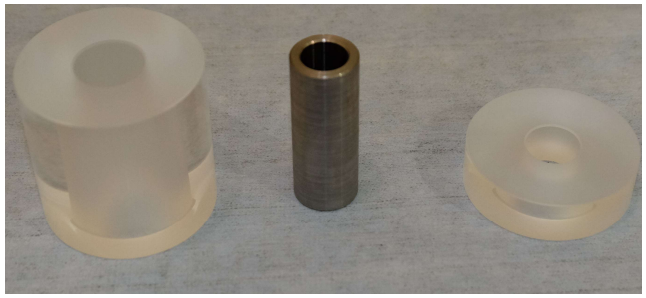
Formulation	ERL Impact (cm)	BAM Friction (N)	ABL ESD (J)
FEM HMX	56.2	0/10 Rxn @ 144	0/20 Rxn @ 0.063
Octol (70:30)	39	0/10 Rxn @ 252	0/20 Rxn @ 0.020
Nano Octol	No Rxn in 10 trials @ 100	0/10 Rxn @ 288	0/20 Rxn @ 0.016
RDX Class I	26.1	0/10 Rxn @ 160	0/20 Rxn @ 0.031
HMX Class I	32.8	0/10 Rxn @ 108	0/20 Rxn @ 0.031

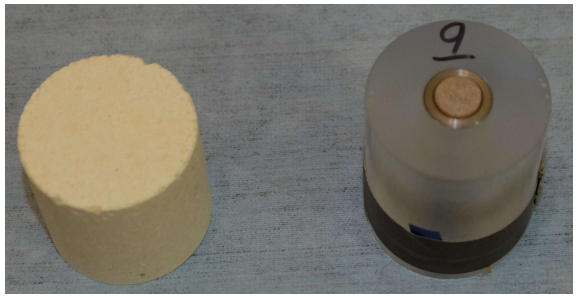


IHE GAP TEST RESULTS SUMMARY

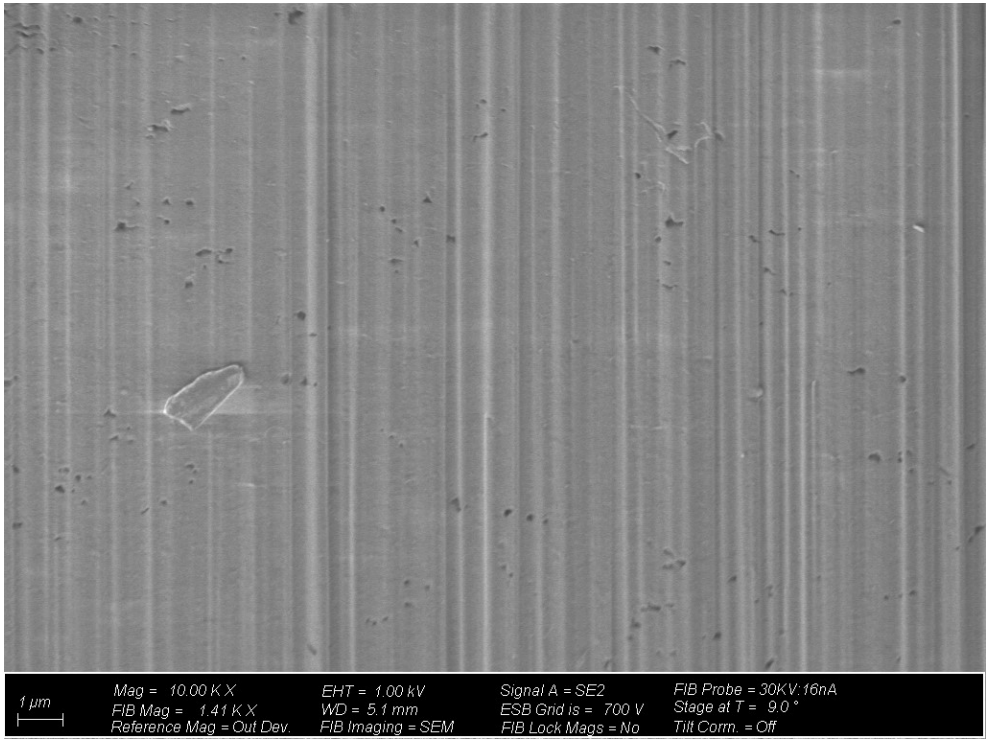
- The IHE Gap test was executed per US National Section of AOP-7 (Draft SRD-AOP-7.2) which uses a pressed pentolite explosive (density of 1.56 g/cm^3) donor system
- This consists of either two stacked pellets or one pellet (2.0 inches thick and 2.0 inches in diameter), each 1.0-inch thick and 2.0 inches in diameter
- Polymethylmethacrylate (PMMA) spacers are used as the attenuator material between the donor and acceptor charges.
- Utilized MSIAC Newgates for IHE Card Gap pressure conversion

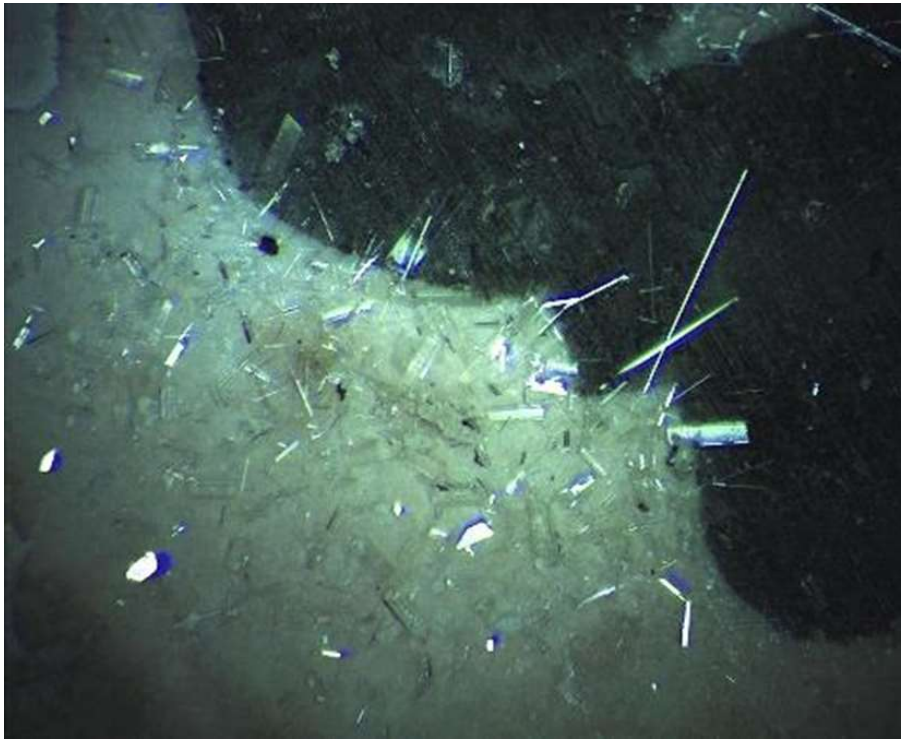
Formulation	Density (g/cc)	Cards
Comp B (Melt Pour)	1.7	175.5
Nano Comp B	1.71	Noted Improvement
Octol 70:30 (Melt Pour)	1.77	172-180
Nano Octol	**1.76**	**Noted Improvement**





FOCUSED ION BEAM-SEM IHE GAP PELLET





- **No large internal voids observed**
- **However, TNT crystal growth was observed from the top of the Nano Octol IHE Gap test pellets**
- **Crystal growth might lead to the consolidation of voids, resulted in the increase of shock sensitivity**

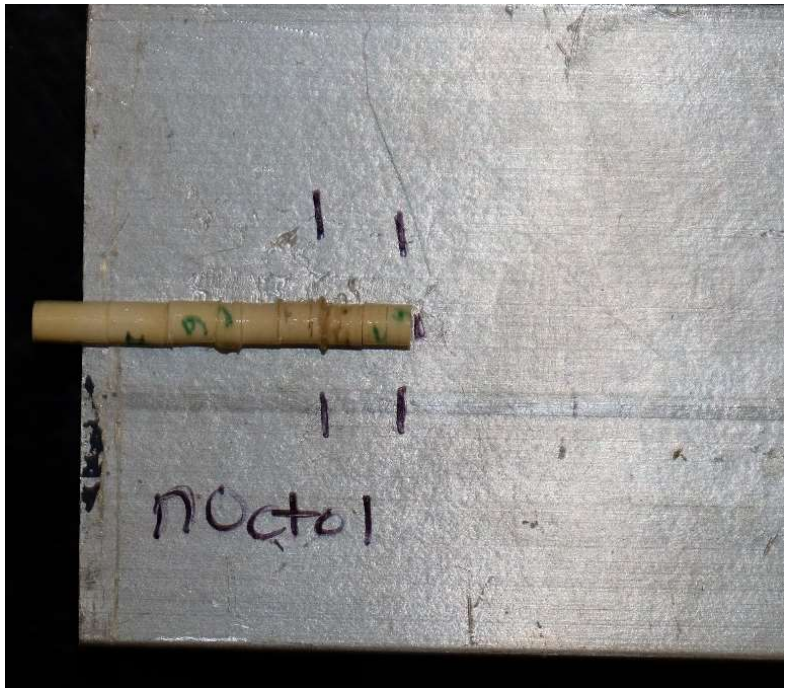
DETONATION VELOCITY / CJ PRESSURE

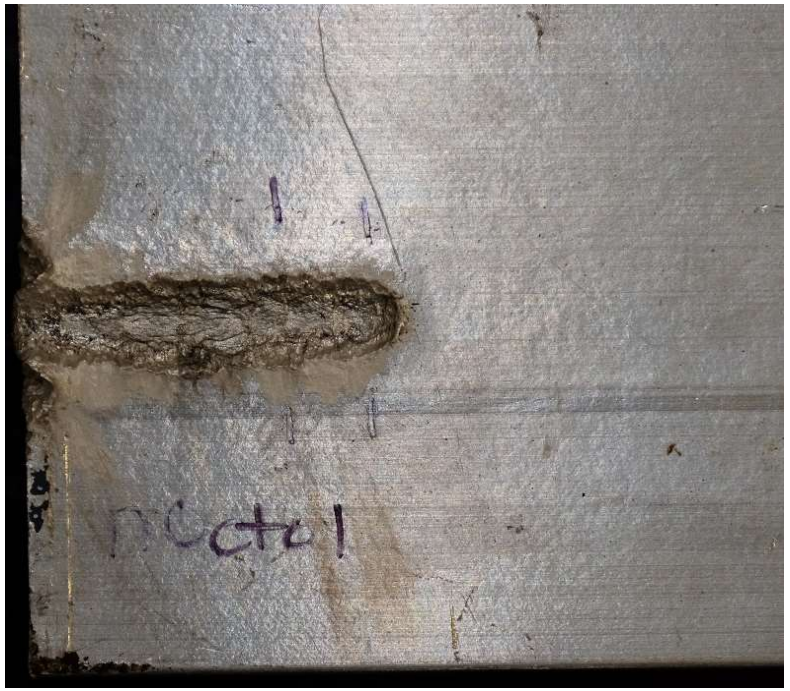
Explosive	Density (g/cc)	DV (km/s)	CJ Pressure (kbars)
LX-14	1.801	8.74	337.6
PBXN-9	1.740	8.52	297 - 318
Octol 70:30	1.795	8.35	303
Nano Octol	**1.765**	**8.42**	**304**

- Nano Octol were tested in 0.5” Diameter Detonation Velocity with calibrated witness plates
  - Used 0.5” x 0.5” Comp A-3 Type II booster initiated by RP-502 EBW
- LX-14 and PBXN-9 CJ Pressures measured by aquarium test
- Octol 70:30 CJ Pressure measured by PDV

CRITICAL DIAMETER

- Nano Octol pressed to 1.72 g/cc detonated at 0.125” diameter
- Smaller pellets were not tested due to not being able to stack the pellets (too small and brittle)
- Pellets were placed on their side on an aluminum plate, greased, and aligned
- Full stack detonated





TECHNICAL CONCLUSIONS

- Nano Octol maintained performance level of PBXN-9 and Octol 70:30
  - DV/CJ Pressure: 8.42 km/s / 304 kbar

- Nano Octol demonstrated small critical diameter
  - Detonated at 0.125” diameter (density: 1.72 g/cc)

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Rob Decker
Dr. Rajen Patel
Dr. Victor Stepanov
Dr. Kelley Caflin
Dr. Reddy Damavarapu

Indian Head

Joshua Felts

Leidos

Dr. Hongwei Qiu
Dr. Raja Duddu

QUESTIONS?