BAE Systems Energetics Pilot Plant

Insensitive Munitions & Energetic Material Technology Symposium 2015

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Holston Army Ammunition Plant, Kingsport TN, USA



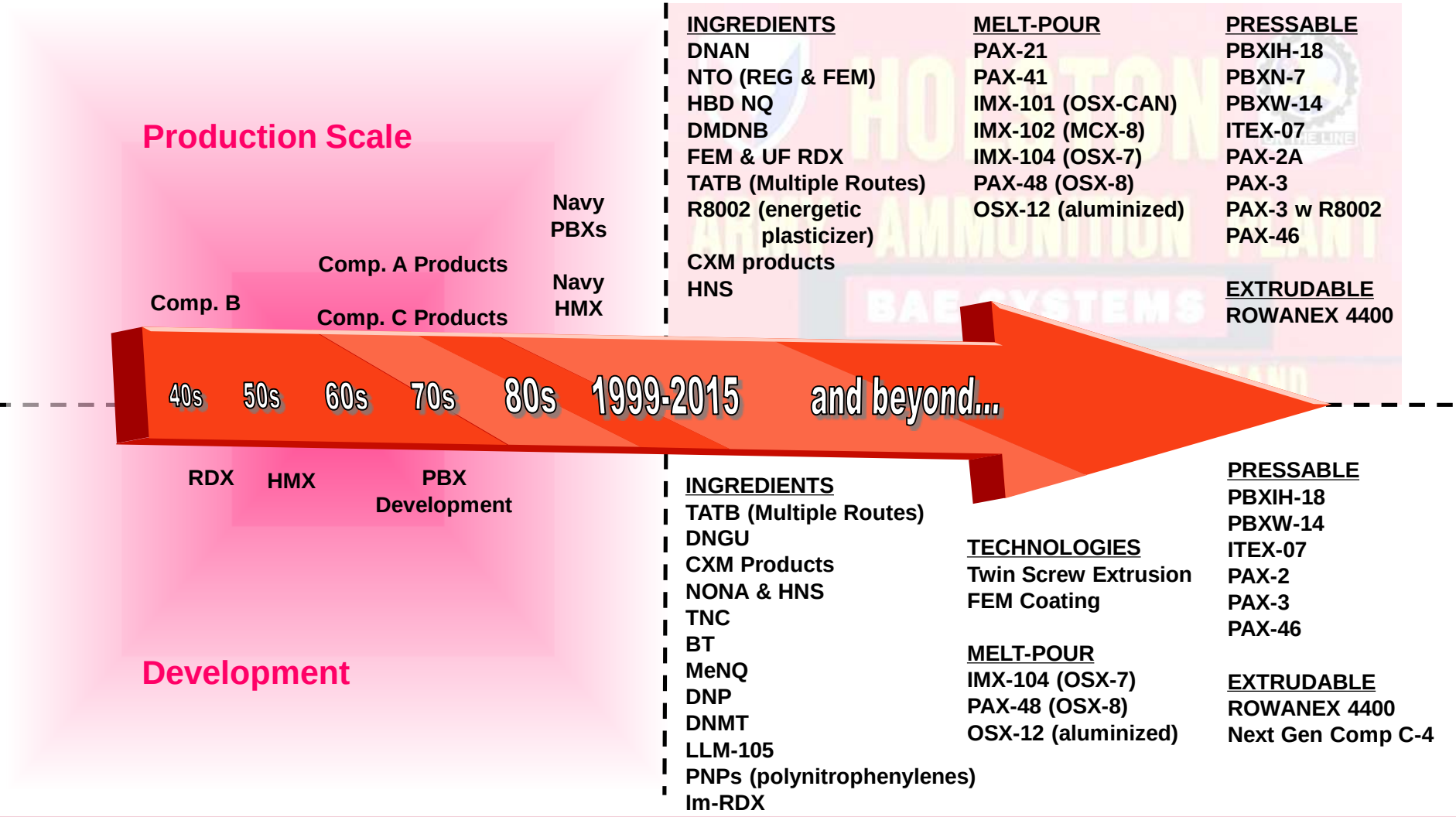



Holston Army Ammunition Plant (HSAAP) Overview

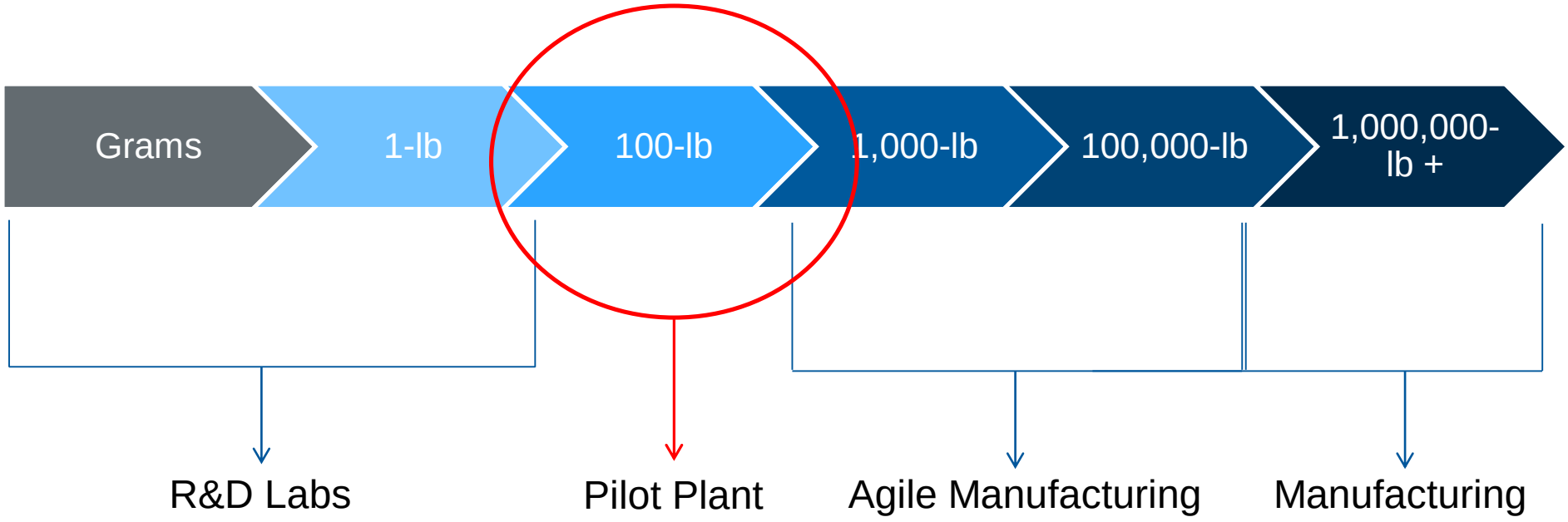
- A 6,000-acre Chemical Plant, located in Kingsport, Tennessee
- U.S. Government-Owned, Contractor-Operated (GOCO) Facility for the manufacture of High Explosive Ingredients and Formulations
- The largest and most capable explosives production facility, produces explosive fills for multiple ordnance used by the US DoD
  - e.g. Cruise Missiles, artillery, mortars, grenades, bombs, demolition charges, etc.
- BAE Systems won the operating contract for HSAAP in 1999
  - 25 Year Facilities Use Contract
  - 5 Year Peacetime Supply Contract (renegotiated every 5 years)
  - Commercial Explosives Sales / Site Commercialization
  - Establishment of Research & Development Capability
  - Executing >$500M in Army Modernization projects
- Current Operating Capacity:
  - 2,400,000 LB/yr. HMX
  - 11,000,000 LB/yr. RDX
  - Additional RDX Nitration Facility ~ 35,000,000 LB/yr. RDX
  - New IM explosive ingredients


HSAAP, Kingsport, TN
EXPLOSIVE R&D and MANUFACTURING

Today's R&D … is Tomorrow's Production
R&D Historic to Present at Holston AAP



Holston Capabilities - Ingredients



Advantages:

- Better transition from lab to production facilities
- Ability to quickly produce large quantity of explosives (10-1,000+ lbs)
- Production of specialized ingredients and formulations

BAE Systems Energetics Pilot Plant

- 50-, 100-, 200-Gallon glass-lined reactors
- Facility also includes a 4-inch Fluid Energy Mill
- Commissioning completed Fall 2013
- Multiple ingredients successfully produced for both military and commercial applications
- Over 8,000-lbs of explosives produced in the pilot plant (2014-2015)
- Ongoing upgrades to capabilities:
  - Sub-ambient chiller system (2014)
  - Stainless-steel filter press (2014)
  - Vacuum system (2015)
  - 100- and 400-gallon formulation stills (2015)

Pilot Plant Products (2014-2015)

Crystalline Ingredients

- NTO Class 1
- WA-TATB
- LLM-105
- Recrystallized HNS
- NONA

Melt-Pour Ingredients

- DNMT
- PrNQ

Formulations

- Granular IMX-104

R&D Fluid Energy Mill

- RDX (coated)
- HMX (coated)

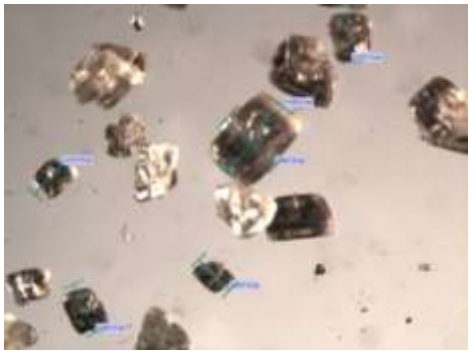
Planned Future Ingredients

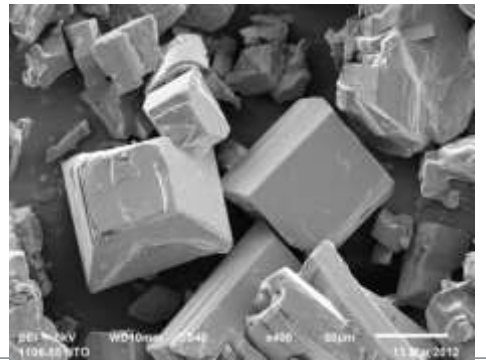
- HNS
- DNP
- PYX
- DNGU
- TNC

NTO Class 1

Program Overview

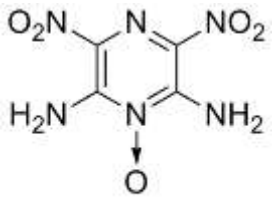
- Two Classes of NTO currently manufactured at HSAAP:
  - Course (300-400 µm)
  - Fluid-Energy Milled (~5 µm)
- Legacy products (RDX, HMX) have >7 Classes
- Smaller classes of NTO help maximize formulation solid loading and may result in improvement in shock sensitivity
- BAE has developed a process to make an intermediate Class of NTO (Class 1) with average particle size of ~150 µm
- **Over 700-lbs of NTO Class 1** produced in pilot plant
- Material is currently in evaluation for new explosive and propellant formulations





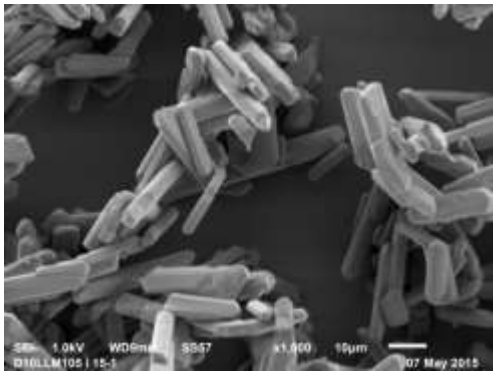
LLM-105 (*2,6-Diamino-3,5-dinitropyrazine-1-oxide*)

Program Overview

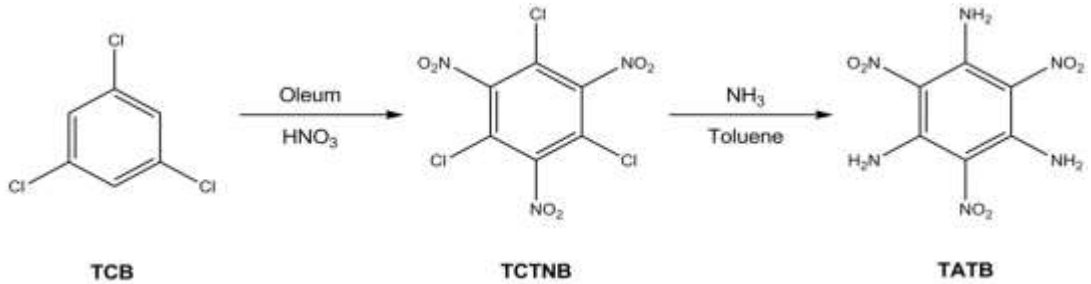


LLM-105

- LLM-105 is a thermal stable explosive with ~RDX performance
- Goal (DoD): Development of PBXN-9/PBXN-5 booster formulations with PBXN-7 sensitivity
- Goal (DoE):LLM-105 formulations as a replacement for UF-TATB and LX-07 formulations.
- ARLX-4201 (HMX, LLM-105, Viton), is currently being developed as the next-generation XM1156 PGK fuze
- LLM-105 synthesis developed on the lab- and 5-gallon scale
- Process successfully transitioned to pilot scale with **>100-lbs of LLM-105 produced** (May 2015)



Wet-Aminated TATB

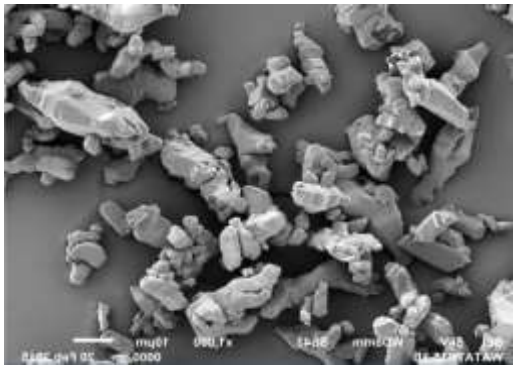


TCB TCTNB TATB

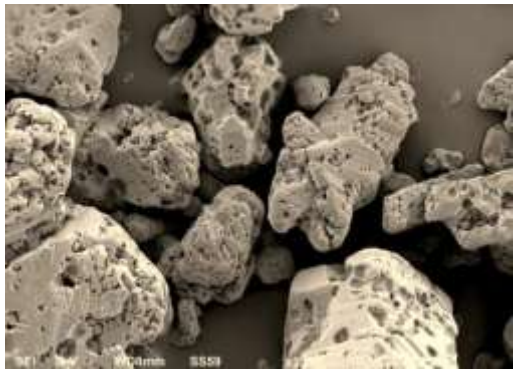
- Program Goal: Reestablishment of Wet-Aminated TATB (WA-TATB) manufacturing capability in the U.S:
  - Like Dry-Aminated TATB, WA-TATB has not been manufactured in over 2 decades and the stockpile is beginning to be depleted.

- Collaborative effort between LLNL and BAE Systems:
  - Initial lab-scale effort to establish a “drop-in” process for Agile Facility at HSAAP (2013-2014)
  - **Process assessment on the pilot scale – 5 batches (2015)**
    - ✓ TATB meets all DoE specifications
  - Qualify TATB and formulations at manufacturing scale (2016)

WA-TATB

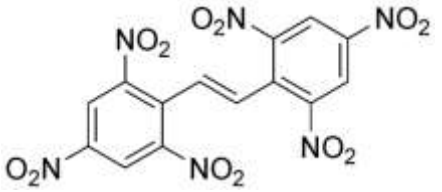


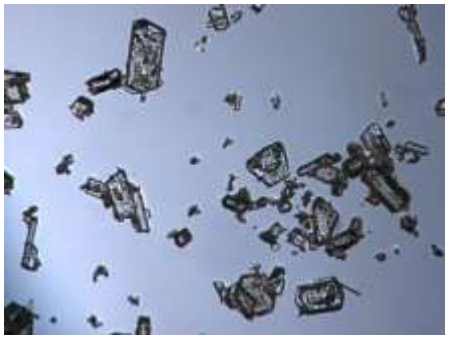
DA-TATB

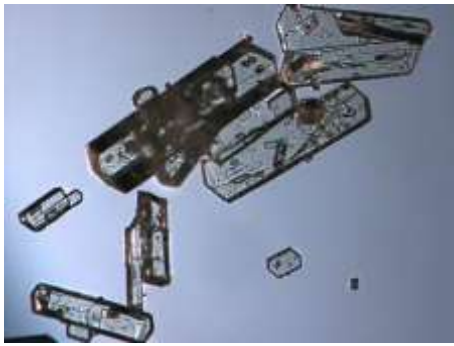


Recrystallized HNS (*Hexanitrostilbene*)

- HNS is a thermally stable explosive (Mp = 316˚C) with moderate sensitivity
- Broad range of uses: military, space, oil and gas, detonating cords, and exploding foil initiators
- HNS synthesis developed on lab-scale with prove-out in the Agile manufacturing facility (2011)
- Pilot plant used to further develop recrystallization process to reliably produce high bulk density HNS (0.9-1 g/cc)
- Material passes all oil & gas specifications for density and thermal stability

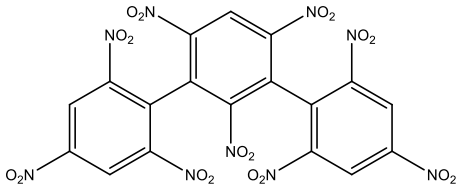


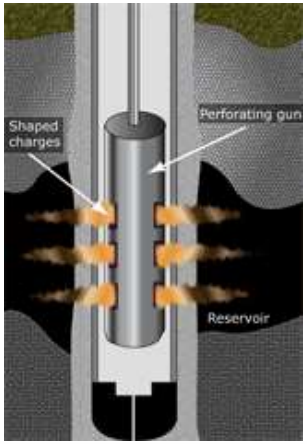




NONA (*Nonanitro-m-terphenyl*)

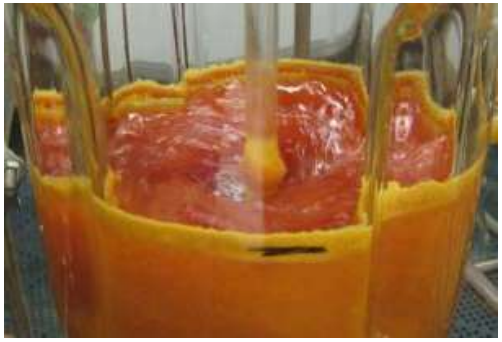
- NONA is a thermally stable explosive (Mp > 400°C)
- Originally developed by Naval Ordnance Lab for space applications in 1960's
- Currently used for down-hole well applications (oil and gas industry) in shaped charges due to its high thermal stability and its ease of initiation.
- NONA synthesized for a number of years on the lab-scale at HSAAP
- NONA synthesis process successfully transitioned to pilot plant (2014)
- Material currently being evaluated for new oil & gas and aerospace applications

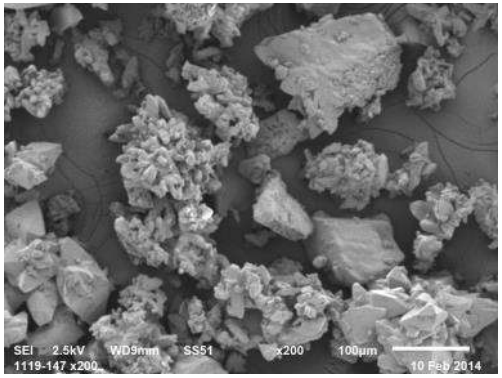


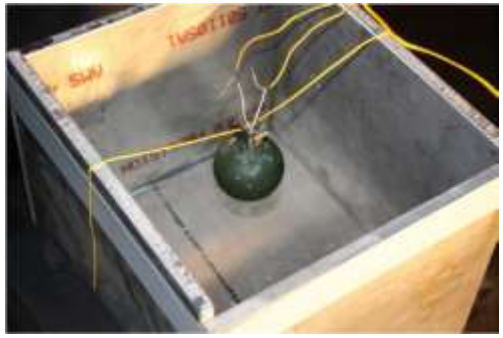


DNMT (*3,5-Dinitro-1-Methyl-Triazole*)

- Goal: Development of a shock-insensitive melt cast HE with Comp. B performance to mitigate FI and SR threats
- Joint effort with ARDEC, Nalas Engineering, and BAE Systems
- Evaluation of DNMT at 5-gallon scale and then 100-gallon scale for future scale-up in our manufacturing facility
- DNMT process successfully proven-out in the pilot plant with >35-lbs of material produced for further evaluation and testing
- DNMT initiated in an M67 grenade with measured Comp B performance
- In initial testing, LSGT for DNMT was a No-Go at 120 cards

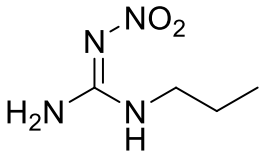






PrNQ (*N-Propyl-Nitroguanidine*)

- Program objective: Development of a scalable process for synthesis of PrNQ
- PrNQ in evaluation as the melt phase in an IM enhanced blast fill for 500- and 1,000-lb GP Bombs
- Joint effort with ARDEC, ARL and BAE Systems
- Process developed and then optimized on the lab-scale before transitioning to the pilot plant.
- Over **5,000 lbs of PrNQ** have been produced on the pilot scale
- Pilot scale synthesis of PrNQ to be used for testing in the 500 and 1000 lb bomb configurations



PrNQ

Granular IMX-104

- IMX-104 is a melt-pour formulation of DNAN, NTO, and RDX and is the qualified replacement of Comp-B in 81, 60, & 120mm Mortars
- Granulation of IMX-104 allows material to be pressed into charges
- Granular IMX-104 is being evaluated for use as the auxiliary charge in the M795 and XM1128 projectiles
- Program objective is to optimize the formulation process for Granular IMX-104 before full-scale manufacturing
- Over **2,100-lbs of Granular IMX-104** have been produced in pilot plant for evaluation and testing
- Currently installing 100- and 400-gallon formulation stills to increase formulation capabilities

Conclusions

- Energetic Pilot Plant has given BAE Systems increased production capabilities as well as a new product portfolio
- Facility also includes a 4-inch Fluid Energy Mill
- Over 8,000-lbs of explosives produced in the pilot plant for both military and commercial applications
- Ongoing upgrades to facility (formulation stills and vacuum system) will further increase capabilities