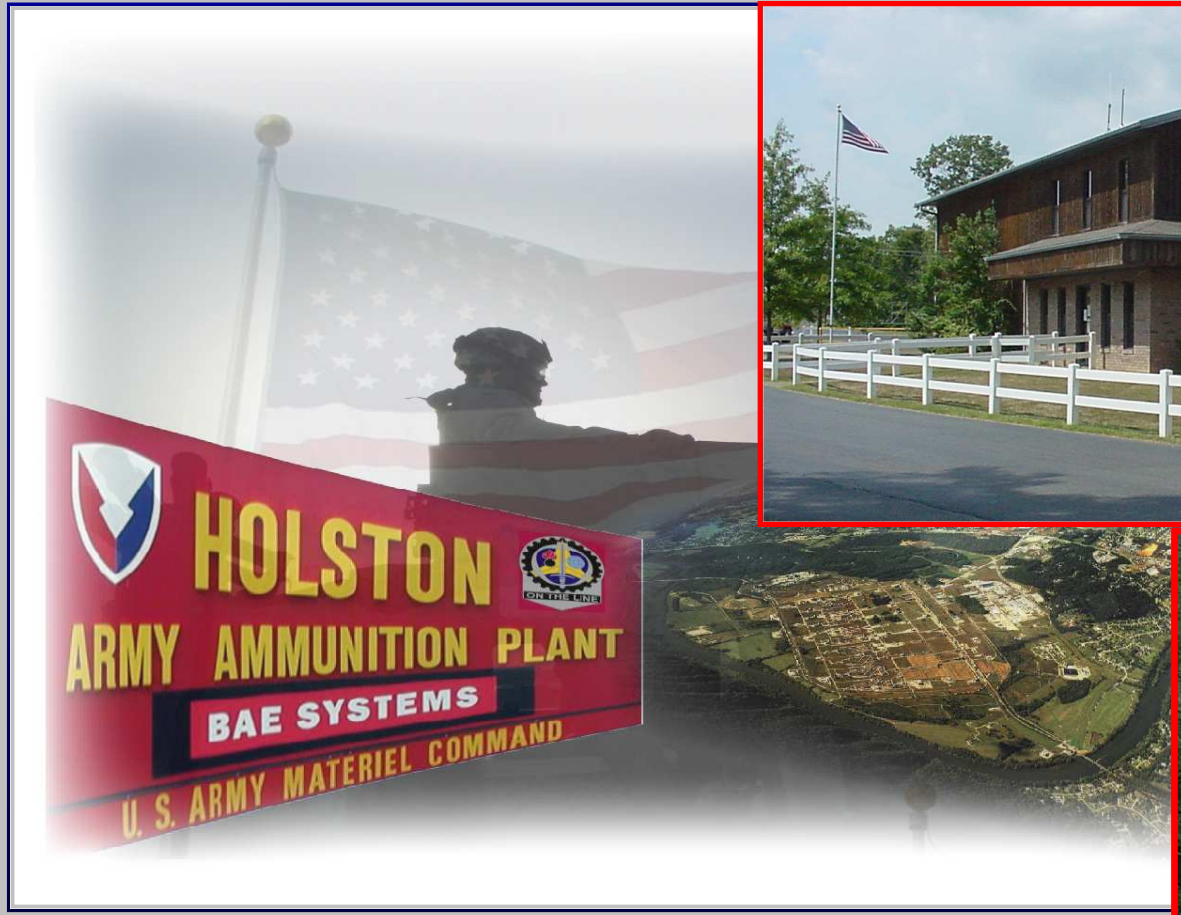
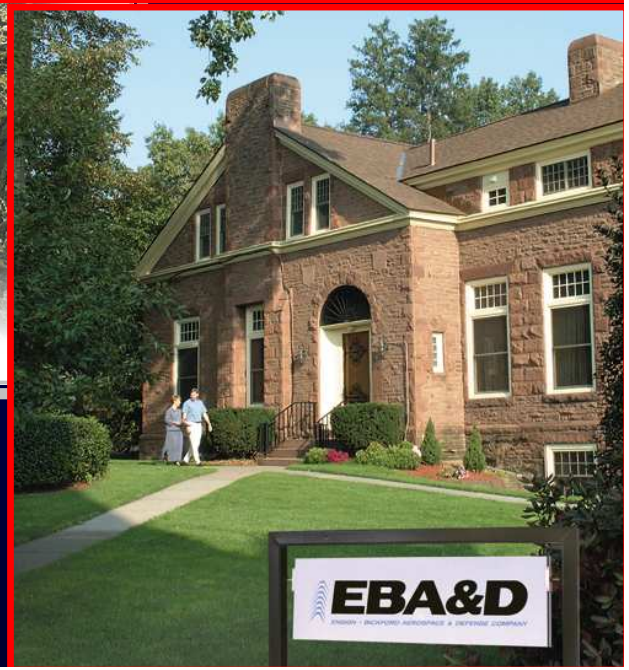
Alan Garvey

IMEMG MURAT
EUROPEAN MANUFACTURERS GROUP

EBA&D
Ensign-Bickford Aerospace & Defense Company
The Global Leader in Reliable Energetic Solutions

Energetic Plasticizer Evaluation in Cast-Cured PBXs





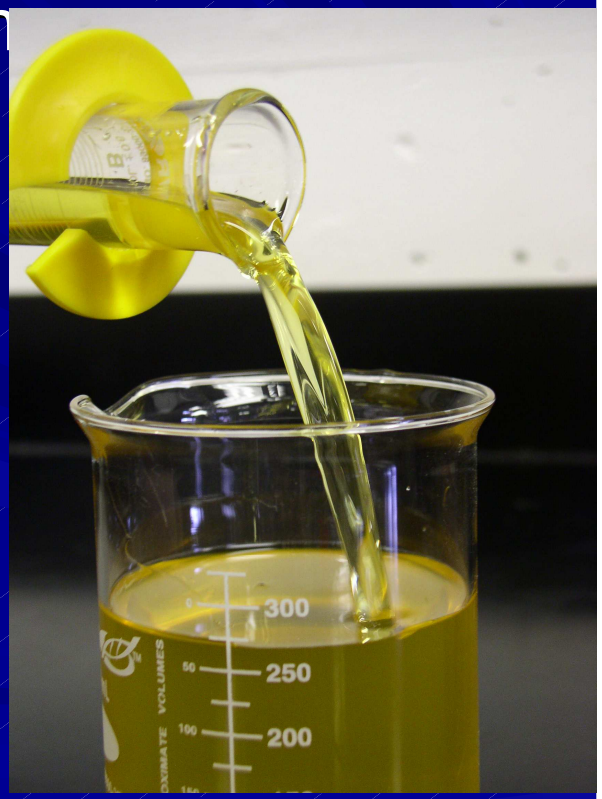
Alan Garvey (EBA&D)
&
David W. Price (BAE)

Acknowledgements

- Mr. Jim Haynes for synthetic and scale-up support.
- Mrs. Lisa Hale, Mr. Harley Dye, Mrs. Roberta Tabor and Mr. Jim Owens for analytical support.
- Ms Brooke Jones for Program Management support.
- Joseph A. Niehay, Mike J. Renshaw, and Brendan M. Walsh for YJ05 casting and evaluation.

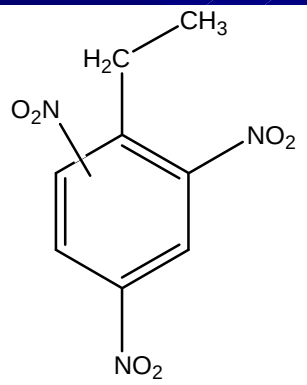
Briefing Outline

- Background
- Synthesis and Scale-up of R8002
- YJ05 Formulations and Evaluation
- Conclusions

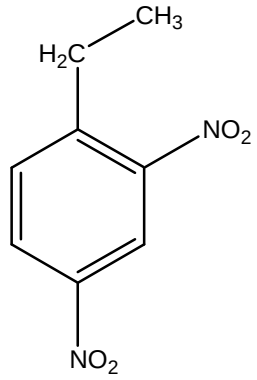


Synthesis Method

- R8002 is a 50:50 Mixture of Dinitroethylbenzene (DNEB) and Trinitroethylbenzene (TNEB)
- Similar to K10 (65:35 DNEB:TNEB)
- R8002 Used in International Formulations Development Efforts
- Synthesis Routes Developed by OSI Scientists Starting from Ethylbenzene



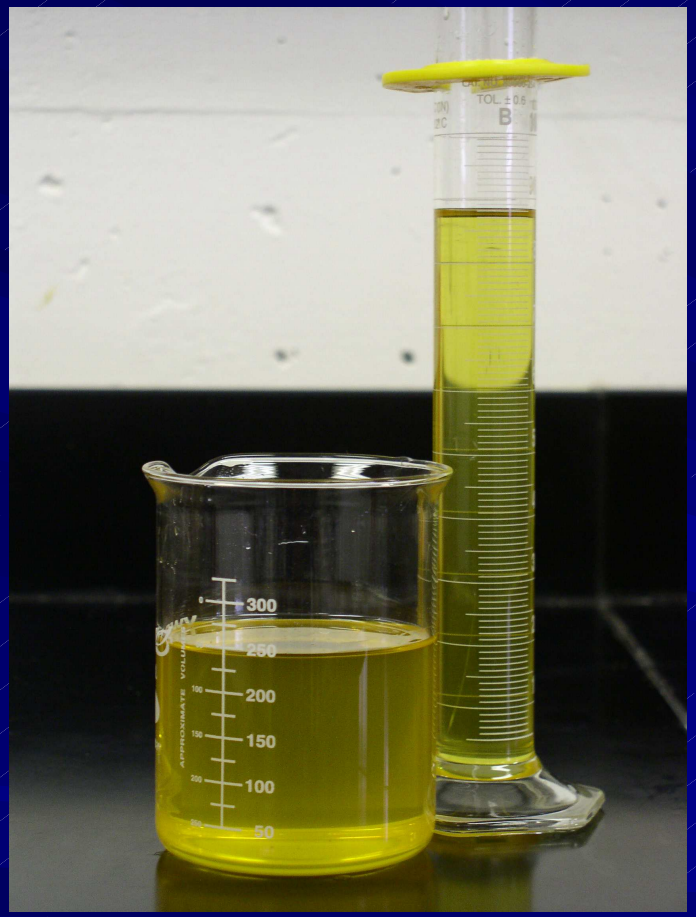
50:50



$C_8H_7N_3O_6$
Mol. Wt.: 241.16
C, 39.84; H, 2.93; N, 17.42; O, 39.81

$C_8H_8N_2O_4$
Mol. Wt.: 196.16
C, 48.98; H, 4.11; N, 14.28; O, 32.63

R8002 Typical Properties



TNEB/DNEB	50/50 +/- 2
Purity	>96%
% Acid (as sulfuric)	<0.005%
% Water	<0.02%
Viscosity	39-47 cps
Density	1.380 +/- 0.002
VTS (40 hrs @ 100˚C)	< 1ml / g

YJ05 Formulation and Experimental Plan

- Developed by Ensign Bickford A&D
  - An Enhanced blast explosive
  - Employs an energetic binder system
- Interest in Evaluating Energetic Plasticizers
  - Including Holston's R8002
- Experimental Mixes Manufactured
  - Cast into cylindrical charges
- Evaluated
  - Processability (cast-cured PBX)
  - Performance (blast overpressure)

Table 3: Comparison of properties of plasticizers (by Specification)

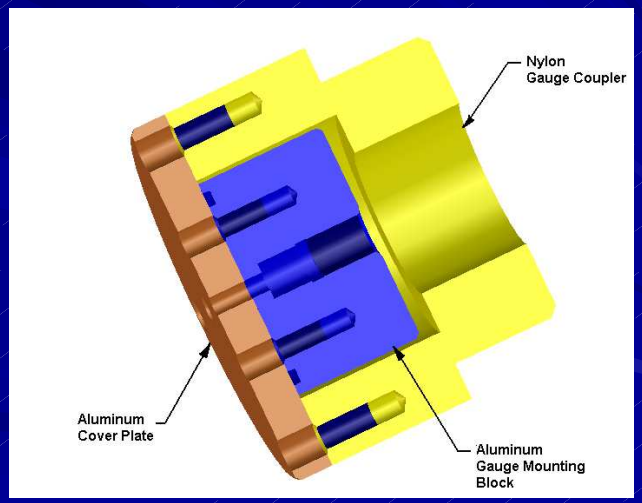
	BDNPA/F	R8002	GAP 0700
MW	**319**	**219**	**700**
Viscosity (cps)	**~350**	**~43**	**140**
DSC:10˚C/min (onset, Celsius)	**235**	**294**	**232**
TGA (onset, Celsius)	**245**	**233**	**240**
% Nitrogen	**17.55**	**15.85**	**42.3**
% Water	**0.05**	**0.02**	**0.05**
Acid number (mg KOH/g)	**<0.5**	**<0.057**	
Stabilizer content	**0.08-0.18%**	**None required**	

EBX Chamber Description

- Enhanced Blast Explosive Chamber
  - 16 inch double reinforced concrete walls
  - 1,000 cubic feet interval volume
  - 160” (L) x 112” (W) x 96” (H)

Pressure Measurement

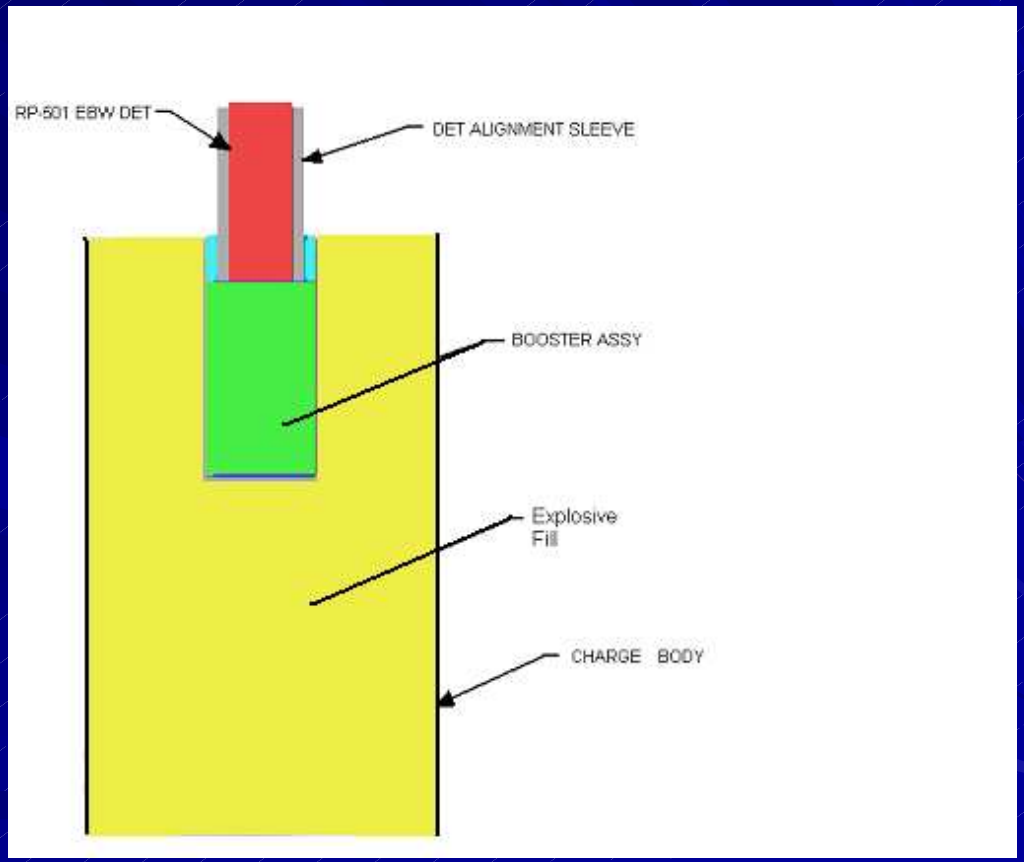
- Set-Up
  - 6 Pressure transducers
  - Connected via low-noise coaxial cable
  - Connected to central data acquisition systems
  - Simultaneously sampled for 100ms @ 104.2 kS/s
  - Data files for pressure vs. time generated for each test
    - Evaluate peak pressure
    - Duration
    - Impulse



Test Description

- Batches Loaded into a 40mm Diameter Plastic Tube
- Booster Assembly, PN D10621-1.
- Test Sample Initiated Using a Reynolds RP-501 Aligned with Det. Alignment Sleeve to the Top End of the Booster Assembly.
- Samples Suspended from Ceiling Located in the Center of the Test Chamber
- Bottom of the Loaded Round Three Feet Above the Ground.

Test Set-Up


RP-501 EBW DET
DET ALIGNMENT SLEEVE
BOOSTER ASSY
Explosive
Fill
CHARGE BODY

Test Measurements

Peak Overpressure (psi)

	S3	S4	S5	S6	R1	R2	R3	R4	R5	NP1	NP2	NP3	NP4	NP5
P1	18.0	17.9	17.6	17.3	23.7	22.4	20.9	20.5	22.8	20.1	22.4	20.7	20.6	18.2
P2	20.1	18.3	15.8	13.5	19.5	12.2	21.1	22.3	16.9	21.2	19.6	20.1	19.8	17.3
P3	28.6	30.2	29.3	36.0	31.0	30.1	22.1	42.1	18.8	40.0	40.2	39.6	37.3	35.1
P4	18.4	18.9	18.9	18.0	22.6	17.6	21.6	19.6	23.2	23.1	20.8	22.1	24.4	19.4
P5	42.4	34.3	47.5	46.5	42.2	51.5	48.0	34.3	39.2	66.6	48.3	47.9	66.2	60.9
P6	21.3	20.9	21.0	20.0	22.8	18.5	27.4	24.0	25.6	22.8	23.9	23.8	23.6	21.3

Impulse at 10ms (psi*sec)

	S3	S4	S5	S6	R1	R2	R3	R4	R5	NP1	NP2	NP3	NP4	NP5
P1	0.017	0.018	0.018	0.017	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.022	0.021
P2	0.018	0.018	0.018	0.017	0.022	0.022	0.023	0.022	0.023	0.023	0.022	0.022	0.022	0.021
P3	0.014	0.014	0.014	0.014	0.017	0.017	0.016	0.019	0.015	0.020	0.028	0.021	0.019	0.014
P4	0.016	0.016	0.016	0.016	0.021	0.020	0.021	0.021	0.021	0.022	0.021	0.020	0.020	0.019
P5	0.013	0.007	0.010	0.009	0.010	0.011	0.012	0.007	0.011	0.015	0.014	0.013	0.014	0.013
P6	0.018	0.019	0.018	0.018	0.024	0.023	0.025	0.024	0.024	0.025	0.024	0.024	0.023	0.022
AVG	0.016	0.015	0.016	0.015	0.020	0.019	0.020	0.019	0.020	0.021	0.022	0.020	0.020	0.018
	0.016				*0.020*					*0.020*				

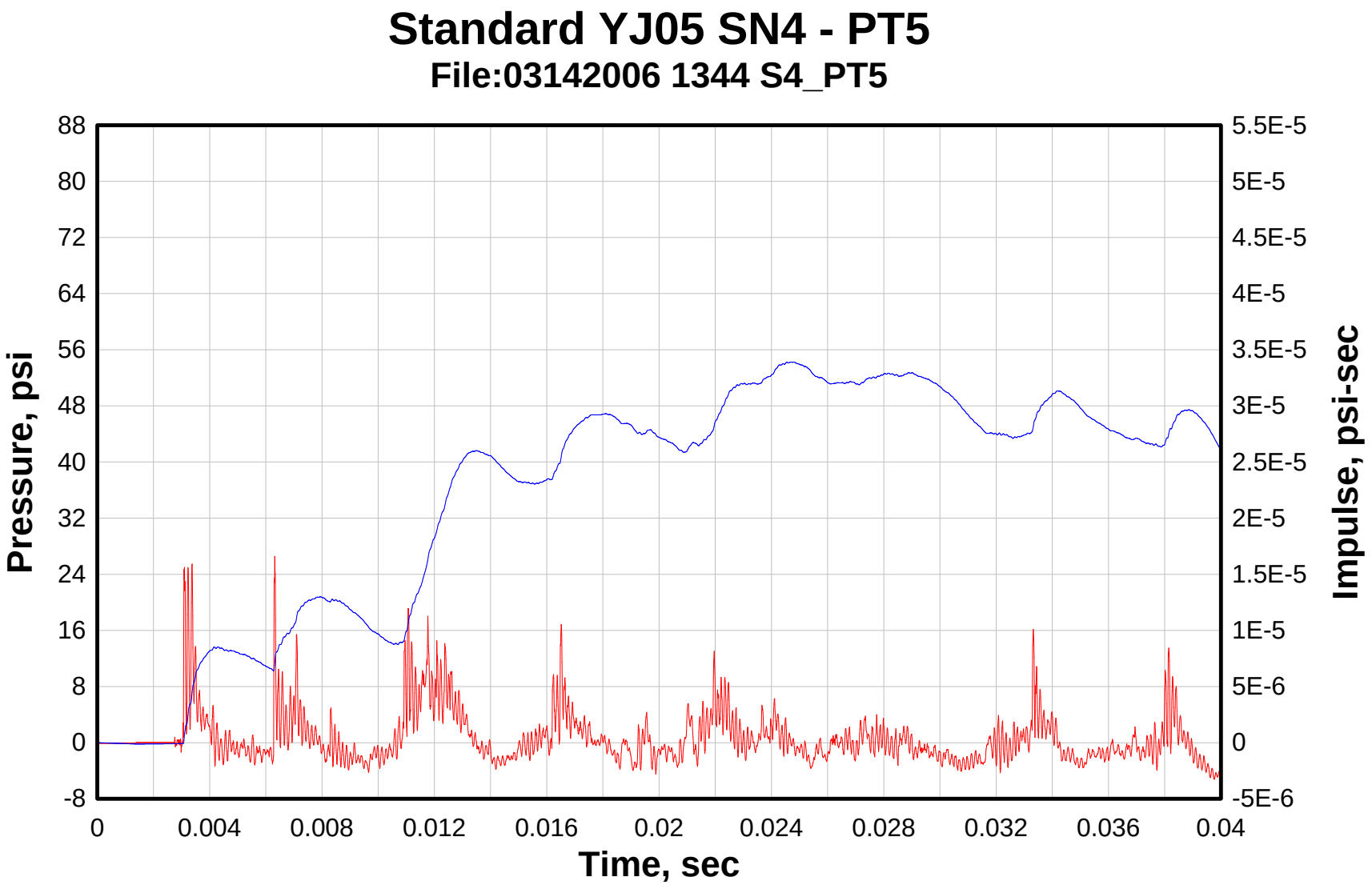
Impulse at 30ms (psi*sec)

	S3	S4	S5	S6	R1	R2	R3	R4	R5	NP1	NP2	NP3	NP4	NP5
P1	0.037	0.043	0.034	0.032	0.042	0.046	0.052	0.051	0.050	0.048	0.046	0.040	0.041	0.037
P2	0.036	0.034	0.033	0.034	0.042	0.043	0.045	0.045	0.044	0.045	0.046	0.044	0.043	0.040
P3	0.034	0.033	0.041	-	-	-	-	-	-	-	-	-	-	-
P4	0.033	0.034	0.034	0.034	0.029	0.040	0.041	0.043	0.039	0.042	0.039	0.040	0.040	0.037
P5	0.052	0.029	0.029	0.029	0.034	0.036	0.039	0.029	0.043	0.040	0.042	0.039	0.043	0.037
P6	0.027	0.040	0.025	0.031	0.042	0.039	0.044	0.040	0.040	0.042	0.046	0.044	0.040	0.039
AVG	0.037	0.036	0.033	0.032	0.038	0.041	0.044	0.042	0.043	0.043	0.044	0.041	0.041	0.038
	0.034				*0.042*					*0.042*				

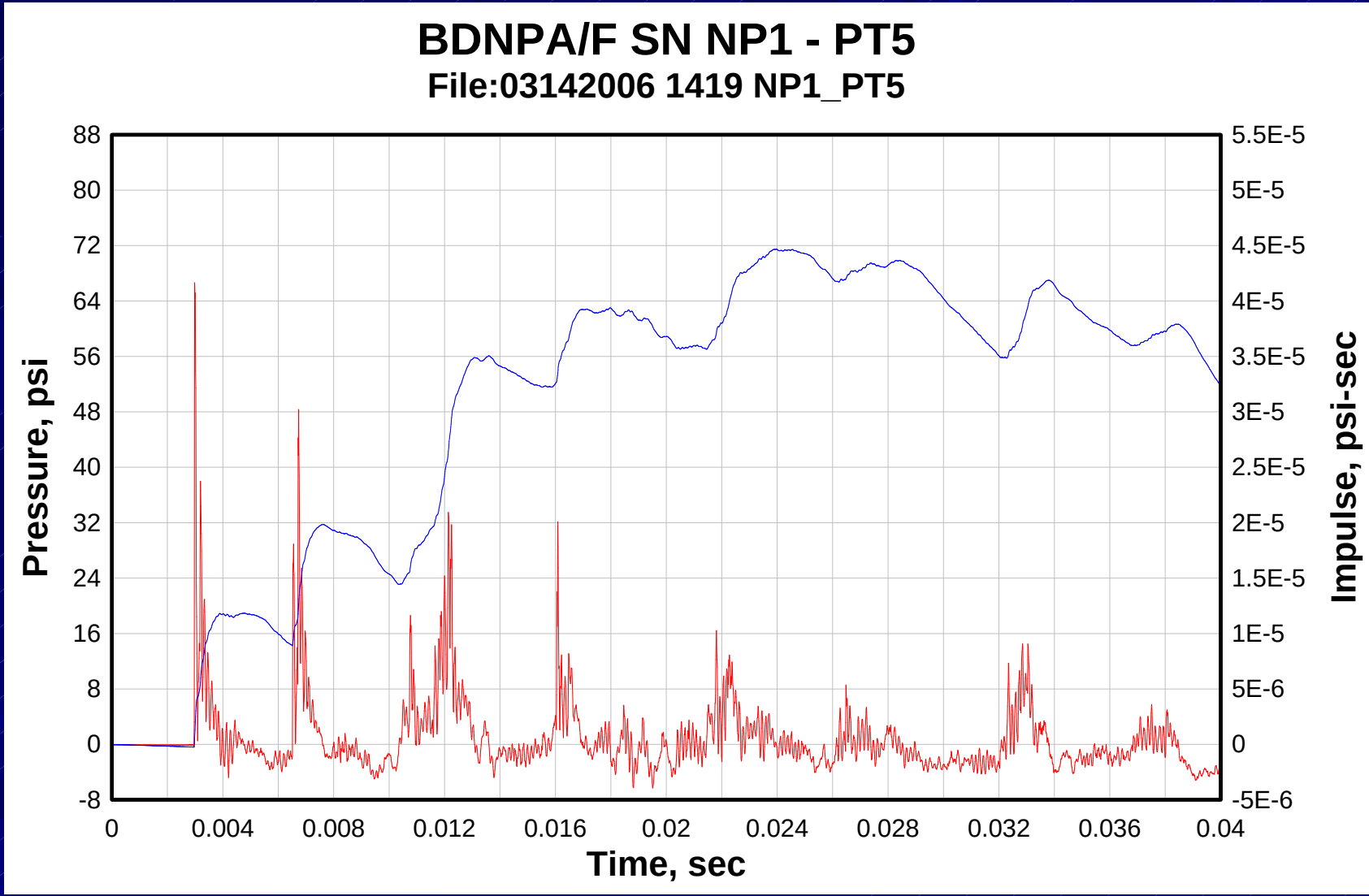
BAE SYSTEMS

EBA&D
Ensign-Bickford Aerospace & Defense Company
The Global Leader in Reliable Energetic Solutions

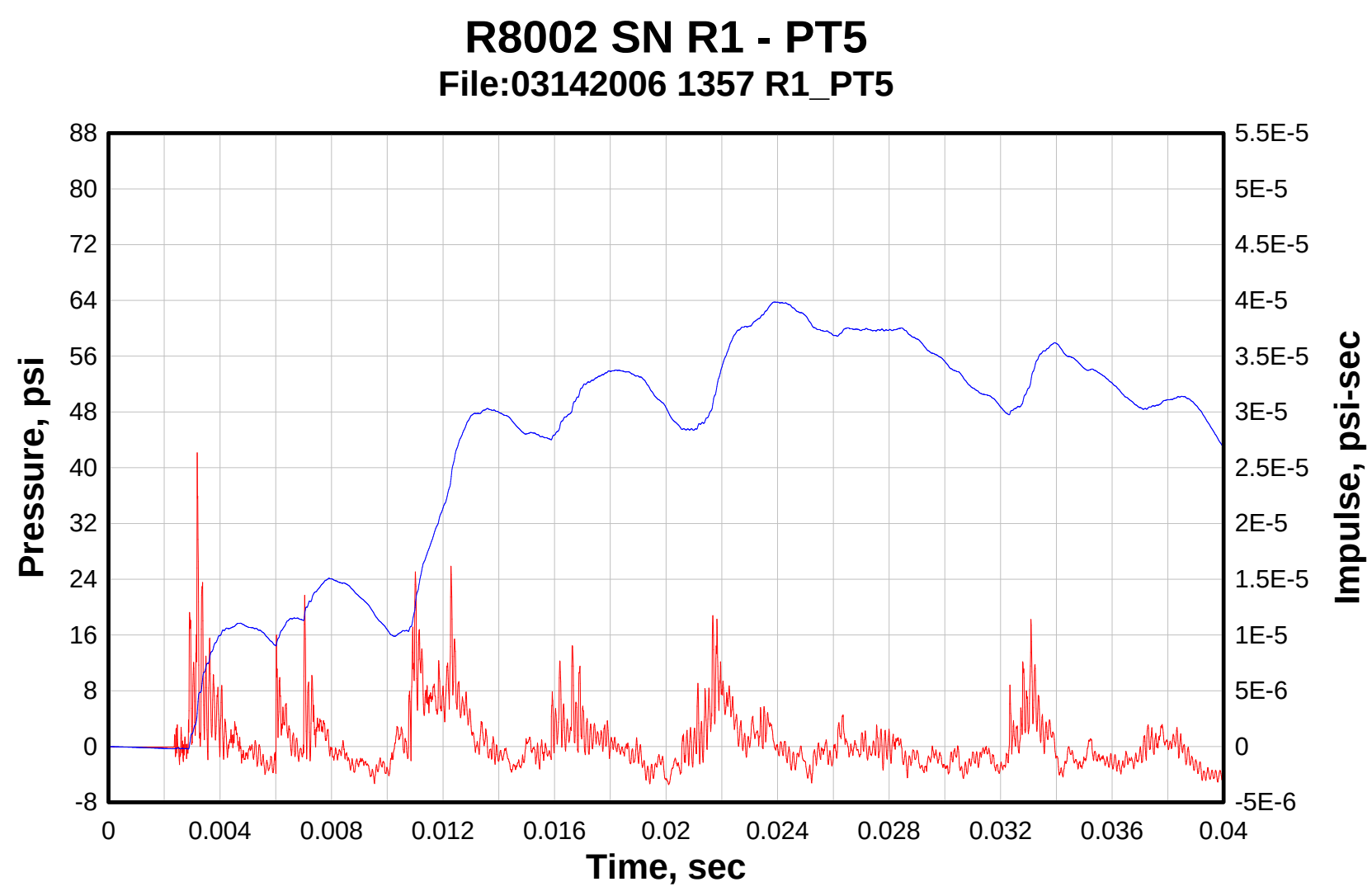
YJ05 Standard Impulse Data



YJ05 (BDNPA/F) Mix Impulse Data



YJ05 (R8002) Mix Impulse Data



Discussion

- Processing
  - All formulations processed well
  - R8002 exhibited minor gassing during cure-cycle
    - Not believed to be a compatibility issue
- Performance
  - All explosives functioned correctly
  - All Plasticizers Contributed to the Blast Overpressure
  - Similar performance achieved by all compositions
- Properties
  - Similar properties, but the lower viscosity of R8002 offers advantages in cast-cured formulations in terms of processability.

YJ05 Mix Data

Entry	GAP Plasticizer	R8002	BDNPA/F
Explosive + Fuel	75%	75%	75%
Binder	17%	17%	17%
Plasticizer	8%	8%	8%

Note:
"Explosive plus fuel" = nitramine and metal-powder mixture total..

Conclusions

- R8002 and A/F Energetic Plasticizers are Comparable in EBX Performance Tests to GAP Plasticizer in YJ05 PBXs
  - Comparable blast performance (overpressure)
  - Similar processing
    - Cast-cured mixes
  - Similar physical properties
    - Cured, rubbery solids