



QUALIFICATION TESTING FOR PBXN-113 CONTAINING RECLAIMED HMX

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Outline

- Background
- Specification Testing
- Formulation & Processing
- Qualification Testing
- Extremely Insensitive Detonating Substance (EIDS) Testing
- Summary
- Future Plans

Program Background

Problem:

- The use of insensitive explosive formulations in munitions reduces the risk of their accidental initiation due to external stimuli. Many munitions continue to rely on TNT-based formulations due to their lower costs.
- The U.S. Department of Defense has several thousand kilograms of HMX in military munitions scheduled for demilitarization. Currently, the accepted method to demilitarize the HMX-based explosives is by open burning / open detonation. This method results in the loss of valuable HMX.

Solution:

- Naval Surface Warfare Center Crane Division has been collaborating with TPL, Inc., Naval Surface Warfare Center Indian Head Division (NSWC-IH), Los Alamos National Laboratory (LANL), and ATK Thiokol to develop a technology to recover HMX from various explosives and propellants with the intention to requalify the reclaimed HMX (R-HMX) for use in new weapons systems
 - The use of R-HMX offers the opportunity for substantial savings in loading costs compared to that of loading with virgin HMX

Program Background Continued

Phase I:

- Defined the technical and programmatic issues concerning the HMX recycling effort by TPL, Inc.
- TPL, Inc., has developed an acid digestion process in which a high purity HMX can be recovered with the by-products being utilized in commercial blasting agents
 - Class 1 and Class 5 materials were obtained by sieving
 - Class 2 and 3 were eliminated because the average particle size of Class 3 was too large for efficient recovery and the quantity of Class 2 was insufficient for testing

Phases II through IV:

- Focused on the chemical analysis of the HMX recovered from LX-14, PBX-9501, PBXN-110 and a Hazard Class 1.1 rocket motor propellant (ATK Thiokol samples)

Phase V (Focus of this presentation):

- Qualification, EIDS and material property testing was performed on the PBXN-113 with R-HMX
- The results of these tests are then compared to data from PBXN-113

Specification Testing: Phases II-IV

MIL-DTL-45444C, HMX Grade B, Requirement	MIL-DTL-45444C, HMX Grade B, Test Method
3.2 Purity HMX β -polymorph, 98% by weight, min HMX α -polymorph, 0.01% by weight, max RDX Content, 2.0% by weight, max	4.7.1 X-ray Diffraction HPLC for HMX Purity & RDX Content
3.2 Melting Point, °C, 277 min	4.7.2 Fisher-Johns or Equivalent
3.2 Number of Insoluble Particles On a USS #40 Sieve-0 max On a USS #60 Sieve-5 max	4.7.3 Per Specification
3.2 Total Acetone Insolubles, 0.05% max	4.7.4 Per Specification
3.2 Inorganic Insolubles, 0.05% max	4.7.5 Per Specification
3.2 Acidity, 0.02% by weight, max	4.7.6 Per Specification
3.2 Impact Sensitivity 17 cm min ERL, Type 12 Tools, 2.5 kg weight	4.7.7.3 Per Specification
3.2/3.2.1 Granulation by Class	4.7.8 Per Specification
3.2/3.4 Workmanship	4.7.9 Per Specification

Specification Testing: Phases II-IV

HMX Spec. Testing	Tests Performed	Units	PBXN-110 Class 1	PBXN-110 Class 3	Thiokol VTQ/UTQ	Thiokol WAKII	Thiokol DEMNI/WAY	LX-14 Class 1	LX-14 Class 5	PBX 9501 Class 1	PBX 9501 Class 2	Mil-Spec
Acetone Insoluble	Average	wt %	0.03	0.04	0.09	0.1	0.06	0.013	0.006	0.024	0.023	0.05
Insoluble Particles	Retained on USSS #40 Average	number	0	2	1	0	2	0	0	1	1	0
	Retained on USSS #60 Average	number	0	2	1	0	2	0	0			5
Inorganic Insoluble	Average	wt %	0	0.02	0	0	0	0	0	0	0.007	0.03
Sieve Analysis	Thru USSS #12 Average	wt %	NA	100	NA	NA	NA	NA	NA	95	100	NA
	Thru USSS #50 Average	wt %	96	46	NA	NA	100	95	NA			90 +/- 6
	Thru USSS #100 Average	wt %	57	17	NA	NA	NA	59	NA			50 +/- 10
	Thru USSS #120 Average	wt %	NA	NA	NA	NA	99	NA	NA			NA
	Thru USSS #200 Average	wt %	21	7	NA	NA	NA	21	NA			20 +/- 6
	Thru USSS #325 Average	wt %	7	NA	75	100	97	7	95			8 +/- 5
Acidity	Average	wt %	0	0	0.01	0.02	0.03	0.014	0.009	0.014	0.011	0.02
Microtrac	FRA10 Average	microns	58.6	49.4	8.5	3.1	7	60	15.6	102	39	NA
	FRA50 Average	microns	149.9	268.8	28.8	11.7	20.8	134.9	32			NA
	FRA90 Average	microns	343.3	552.7	91	27.4	52.1	276.9	53.6			NA
	FRAMV Average	microns	179.6	285.7	42.7	14	27.5	156.9	33.7			NA
Melting Point	Average	degrees C	269	271	271	271	271	278	279	269	266	277
Purity %RDX in HMX	Average	wt %	0	0	0	0.69	0	0.7	0.5	0	0	2
DSC Onset Degree C	Average	degrees C	276.73	275.55				282.38	282	282.82	284.27	
DSC Peak Degree C	Average	degrees C	277.7	276.83				284.07	283.66	284.2	285.66	

Other tests: Crystal morphology by SEM, TGA, GC/MS, VTS

Specification Testing: Phases II-IV

Tests Performed	Sensitivity Testing				
Sample	NOS	ERL	ABL	BAM	ABL
	Impact 50% hgt. (mm)	Impact 50% hgt. (cm)	Friction 20 TIL (psig)	Friction 10 TIL (newtons)	ESD 20 TIL (joules)
PBXN-110 Class 1	169 M	18 M	180 M	84 M	0.326 M
PBXN-110 Class 3	209 M	19 M	100 M	72 M	0.165 M
Thiokol VTQ/UTQ	139 M	21 M	100 M	108 M	0.0326 M
Thiokol WAKII	146 M	25 M	75 M	108 M	0.165 M
Thiokol DEMNI/WAY	139 M	17 M	100 M	84 M	0.095 M
LX-14 Class 1	178 M	24 M	<30 H	96 M	0.095 M
LX-14 Class 5	132 M	24 M	<30 H	108 M	0.037 M
RDX 'A' Standard	277 M	17 M	235 M	120 M	0.326 M
Medium Sensitivity = M					

Formulation & Processing: Phase V

➤ Composition

- 45% Class 5 HMX
- 20% Binder Material
- 35% Aluminum

➤ HMX was recovered from LX-14

- Indian Head ground the Class 1 using a fluid energy mill into Class 5
- Two 5-gallon batches were formulated and cast into test charges
- No processing changes were needed, process was identical for PBXN-113 made with virgin HMX
- X-Rays of the charges revealed no anomalies

Sensitivity Testing

- In accordance with MIL-STD-1751A
- Slight increase in sensitivity due to reclaimed HMX processing

Test	PBXN-113	PBXN-113	Units
	R-HMX	Virgin HMX	
Impact	83	98	cm
Friction	560	>980	psig
ESD	0.853	0.326	joules
Vacuum			
Thermal Stability	0.146	0.09	ml/g/48hrs

Hazard Classification Testing

➤ Cap Test

- Number 8 Cap Test

➤ Gap Test

- Ten Large-Scale Gap Tests (LSGT) were performed

➤ Small Scale Burning

- Four tests performed, two 10 gram and two 100 gram cylindrical samples

➤ Thermal Stability

- A 50 gram sample conditioned at 75 °C for 48 hours

Test	PBXN-113 R-HMX	PBXN-113 Virgin HMX
Cap	No	No
Gap	Detonation 105 cards	Detonation 112 cards
Small Scale	Burned	Burned
Thermal Stability	No Reaction or Changes	No Reaction or Changes

Performance Testing

➤ Detonation Velocity

- Two 2" X 2" X 12.5" long samples were tested
- Calculated from time-of-arrival data

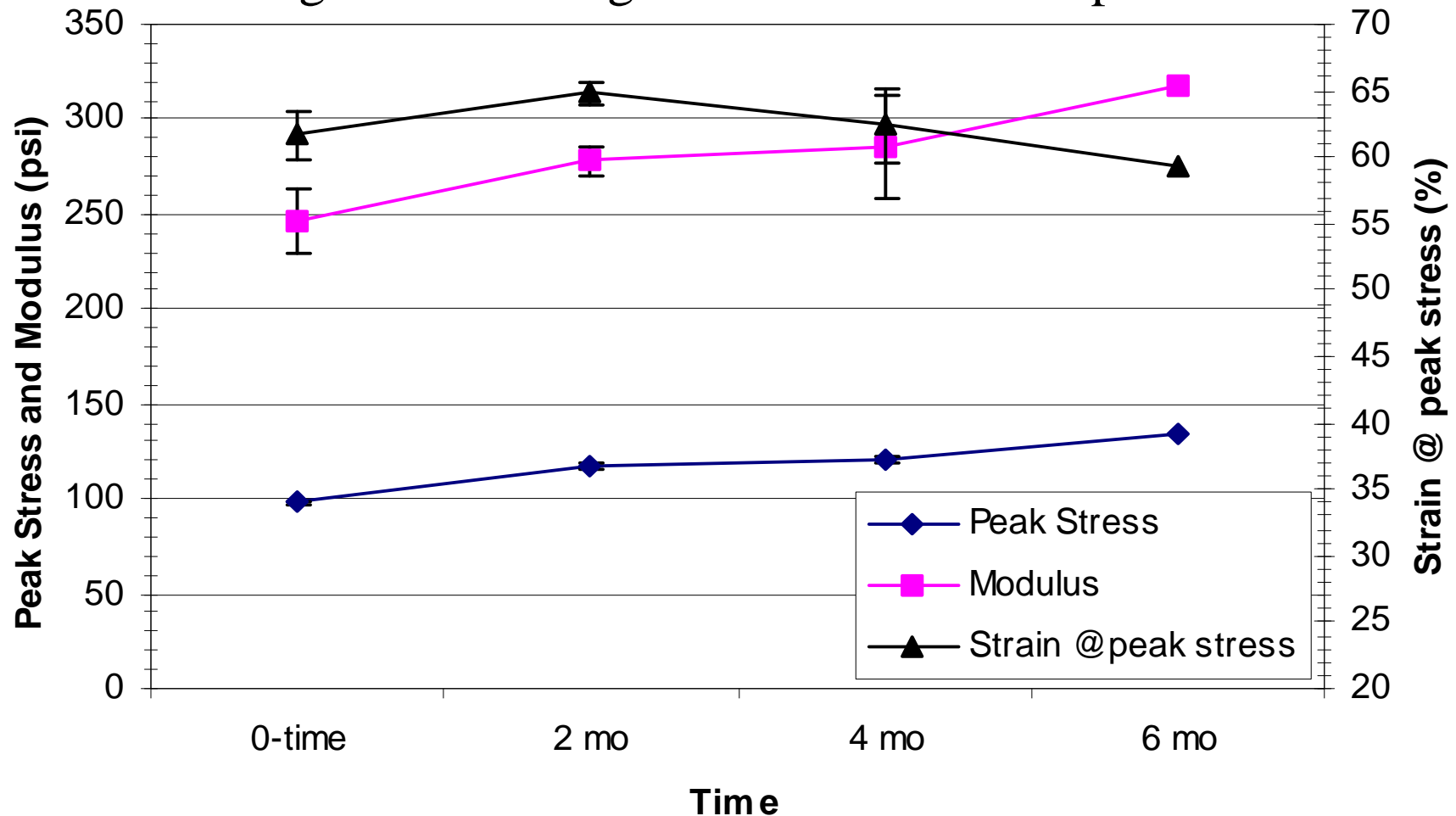
➤ Critical Diameter

- Two test samples of each size were tested at 0.75", 0.625", 0.5", 0.375", and 0.25"

	PBXN-113	PBXN-113	
Test	R-	Virgin	Units
Detonation	HMX	HMX	mm/ μ
Velocity	6.98	6.97	s
Critical Diameter	<0.375	<0.25	inches

Specification Aging Study

- Samples aged at 70°C for 6 months
- No Significant changes in Mechanical Properties



EIDS Testing

- PBXN-113 with virgin HMX has been through the NAVSEAINST 8020.8B UN Test Series 7
- PBXN-113 with virgin HMX was qualified as an Extremely Insensitive Detonating Substance (EIDS)
- PBXN-113 formulated with R-HMX was also put through these tests

EIDS Friability - Passed

- Bare samples were projected against a steel plate
 - 9 grams
 - 18 mm in diameter
- Three low pressure closed bombs were performed
 - 0.5 grams of black powder and a M100 electric match
 - Maximum measured 0.05 MPa/ms

EIDS Testing Continued

EIDS Gap - Passed

- Three gap test units were tested
 - No detonations or explosions
 - Recovery of most of the unreacted explosives
 - No damage to witness plates

EIDS Cap - Passed

- Three tests
 - 5lb sample placed on lead cylinder on witness plate.
 - RP-502 detonator perpendicular to sample and initiated
- No detonation



EIDS Testing Continued

EIDS External Fire - Passed

- Three sets of five samples, banded together
 - 1.78" X 7.875" steel pipes
- No fragments found beyond 15 meters weighing more than 1 gram
 - No overpressure for any of the 15 reactions
 - No significant heat flux output
 - No damage to witness screens



EIDS Slow Cook-off - Passed

- Three tests were performed
 - Oven controlled thermal environment, 40°C to 365°C @ 3.3°C/hr
 - Reaction temperatures at 187°C, 193°C, and 191°C. Pressure ruptures and reactions were burning

Summary

- Comparison of the results from the characterization and specification testing of recycled HMX to that of virgin HMX manufactured by Holsten show few qualitative differences
- The replacement of R-HMX for virgin HMX did not cause any significant changes in the explosive's sensitivity, performance, or aging characteristics in PBXN-113

Future Plans

- Expeditionary Fire Support System (EFSS) 120 mm rifled mortar has been identified as a potential customer
 - Holds 9 lbs of PBXW-128 containing 77% Class 5 HMX
 - Currently going through Hazard Assessment / Classification testing required to meet MIL-STD-2105C, Hazard Assessment Testing for Non-Nuclear Munitions and Final Type Qualification in accordance with NAVSEAINST 8020.8C using virgin HMX
- If R-HMX can be used in the EFSS rifled mortar, the Marine Corps Systems Command would be able to purchase more of the EFSS units
- Process for Qualifying
 - Verify the quality of the R-HMX through specification testing
 - Formulate the R-HMX into PBXW-128
 - Perform qualification testing on the formulation
 - Mirror several of the EFSS IM and environmental tests with the PBXW-128 containing recycled HMX

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Questions

