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Navy Qualification Testing of PBXW-14 Explosive

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Qualification Testing of PBXW-14
Outline

- Background
- Composition and Production
- Qualification Testing
- Shock Sensitivity
- Performance Testing
- Stability and Safety Testing
- Compatibility
- Summary

*Scale in mm

Qualification Testing of PBXW-14
Background

- Initial Formulation Work at Naval Ordnance Lab (NOL) White Oak: Early 1990's
  - Booster mat'ls at the time fell short of desired properties
    - PBXN-5 and CH-6 have poor cook-off performance
    - PBXN-7 has good cook-off performance, but lower than desired output for initiating insensitive main charges
- Objectives
  - Develop booster mat'l with IM characteristics at least as good as PBXN-7
  - Must have an output greater than PBXN-7

Qualification Testing of PBXW-14
Composition and Production

- Formulation
  - Down-selection from 3 initial formulations to current formulation in 1999
  - TATB supplied by BAE, Bridgewater UK
  - Either DuPont Viton A or 3M Fluorel binders may be used in W-14

- Production
  - In 2003, 300 lb. full-scale batch produced at OSI-managed Holston Army Ammunition Plant (HSAAP)

Qualification Testing of PBXW-14
Qualification Testing: Aging and Sensitivity

- Aging and Sensitivity Tests
  - Test pellets aged at 70°C for 3 months, 6 months
  - Unaged, 3-month aged, 6-month aged pellets tested
    - ERL Impact
      - Requirement: Greater than RDX (15 cm)
      - W-14 impact results remain fairly consistent, unaged results comparable to N-7, pass
    - ABL Friction
      - Requirement: 20/20 No Fires at 250 lb_f
      - >980 lb_f for W-14 and N-7, pass
    - ABL ESD Tests performed
      - Requirement: 20/20 No Fires at 0.25 J
      - Unaged and 3-month aged pellets at 0.326J, unaged N-7 same
      - 6-month aged pellets at 1.72J
      - All results pass

Qualification Testing of PBXW-14

Qualification Testing: Sensitivity Data

	Explosive	Test Data	Aging Time		
			0 Months	3 Months at 70°C	6 Months at 70°C
ERL Impact	PBXW-14	Height (cm)	38	31	35
	PBXN-7*	Height (cm)	37	--	45
ABL Friction	PBXW-14	20 TIL (lb_f)	>980	>980	>980
	PBXN-7	20 TIL (lb_f)	>980	--	--
ABL ESD	PBXW-14	Joules	0.326	0.326	1.72
	PBXN-7*	Joules	0.326	--	--

* Holston lot HOL88J00E760 qualification data

Qualification Testing of PBXW-14
Shock Sensitivity: Cap Sensitivity and IHE Gap Test

- Cap Sensitivity Test
  - Used RP-502 Detonator
  - PBXW-14 is cap sensitive
- IHE Gap Test and Aging Study
  - Tests performed on unaged, 3-month aged, and 6-month aged samples (aging at 70°C)
  - Unaged 95 and 97%Theoretical Maximum Density (%TMD) pellets tested
  - All aged W-14 pellets were 97%TMD
  - Results comparable between W-14 and N-7

Qualification Testing of PBXW-14
Shock Sensitivity: IHE Gap Test Results

	PBXW-14				PBXN-7			
Aging Time (months)	Avg. %TMD	Avg. Density (g/cc)	50% Initiation Point		Avg. %TMD	Avg. Density (g/cc)	50% Initiation Point	
			Cards	Pressure (kbar)			Cards	Pressure (kbar)
0	95	1.815	210	18.6	95	1.778	196	21.7
	97	1.845	193	22.5	95	1.778	205	19.6
3	97	1.845	204	19.8	--	--	--	--
6	97	1.842	204	19.8	95	1.784	208	19.0

Qualification Testing of PBXW-14
Shock Sensitivity: Small-Scale Gap Test

- Small-Scale Gap Test (SSGT)
  - Requirement: Greater than 3.5 DBg
  - SSGT testing yielded a shock sensitivity of 6.7583 DBg for PBXW-14 at 1.843 g/cc, pass
  - Compared to 5.9-6.1 DBg for PBXN-7 at 1.78 g/cc.
  - W-14 less sensitive in this test than N-7

Qualification Testing of PBXW-14
Performance Testing: Det. Velocity and Critical Diameter

- Detonation Velocity
  - Initiated by PBXN-10 pellet with same dimensions
  - PBXW-14 outperforms PBXN-7's detonation velocity by ~ 10%

- Critical Diameter Tests
  - No data collected for 95% TMD 0.25-inch diameter pellets due to hardware malfunction, however witness block did indicate a detonation
  - Data for 95% TMD 0.125-inch diameter pellets indicate a decay in detonation velocity, although test results still acceptable
  - W-14's estimated critical diameter of 0.125 inches is less than half that of N-7's 0.251-inch critical diameter

Qualification Testing of PBXW-14
Stability and Safety Testing

- Vacuum Thermal Stability

	Unaged	3-Month Aged	6-Month Aged
Weight (g)	1.1103	1.0114	1.1458
Avg. Gas Evolution (ml/g)	0.098	0.150	0.152

  - Required that total gas generation <= 2.0 ml/g, W-14 passes

- Ignition and Unconfined Burning
  - Four tests: 2 tests with 10g of material, 2 tests with 100g
  - All four tests passed by igniting and burning, no detonations

Qualification Testing of PBXW-14

Stability and Safety Testing: VCCT

- PBXW-14 VCCT results milder than for PBXN-7, CH-6, and PBXN-5
- CH-6: Detonation (0.015 inches confinement) @ 1.65 g/cc
- PBXN-5: Deflagration (<0.045 inches confinement) @ 1.79 g/cc

PBXW-14 VCCT Burn Reaction

PBXW-14 VCCT Pressure Rupture

Qualification Testing of PBXW-14

Stability and Safety Testing: VCCT

- Fast Variable Confinement Cook-off Test (VCCT) Results

	PBXW-14				PBXN-7			
Test Number	Steel Confinement (inch)	Computed Burst Pressure (psi)	Reaction Level	Reaction Temperature (°C)	Steel Confinement (inch)	Computed Burst Pressure (psi)	Reaction Level	Reaction Temperature (°C)
1	0.090	15,305	Pressure Rupture	174	0.060	10,000	Pressure Rupture	182
2	0.105	17,634	Pressure Rupture	203	0.075	12,700	Pressure Rupture	183
3	0.105	17,634	Pressure Rupture	176	0.075	12,700	Pressure Rupture	176
4	0.120	19,963	Pressure Rupture	173	0.075	12,700	Deflagration	185
5	0.120	19,963	Pressure Rupture	168	0.090	15,300	Deflagration	181

- Slow VCCT Results

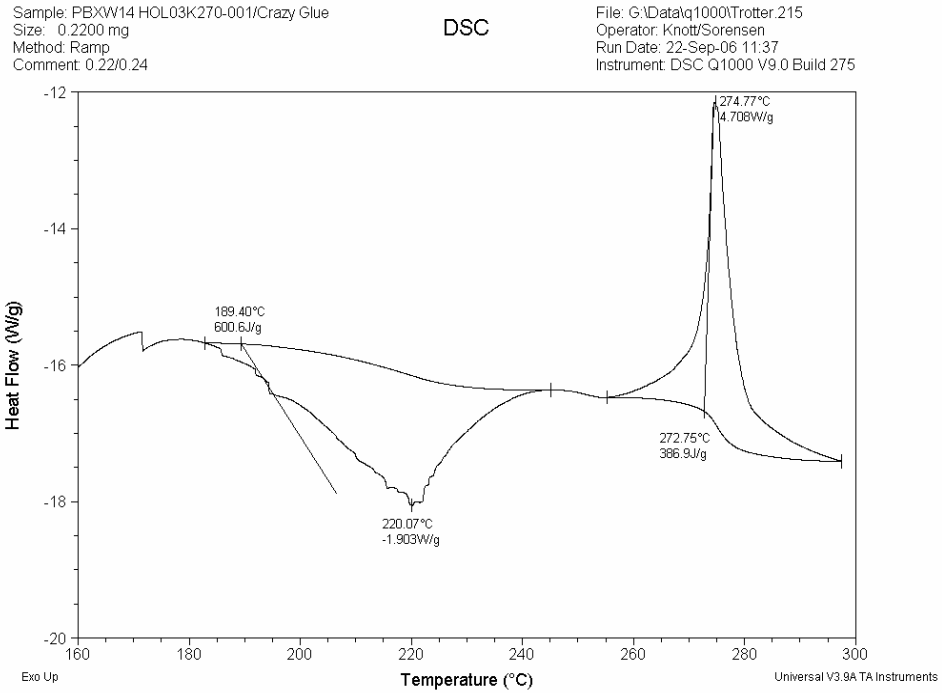
	PBXW-14				PBXN-7			
Test Number	Steel Confinement (inch)	Computed Burst Pressure (psi)	Reaction Level	Reaction Temperature (°C)	Steel Confinement (inch)	Computed Burst Pressure (psi)	Reaction Level	Reaction Temperature (°C)
1	0.090	15,305	Pressure Rupture	280	0.075	12,700	Detonation	315
2	0.105	17,634	Pressure Rupture	320	0.105	17,634	Pressure Rupture	317
3	0.120	19,963	Burn	290	0.120	19,963	Pressure Rupture	296
4	0.120	19,963	Burn	295	--	--	--	--

Qualification Testing of PBXW-14
Compatibility: Differential Scanning Calorimetry

- Differential Scanning Calorimetry (DSC)
  - Materials selected for compatibility testing with PBXW-14:
    - Aluminum (Al), copper (Cu), Krazy Glue, RTV 162, and a mixture of copper (Cu), titanium (Ti), and boron (B)
  - 50 ml/min nitrogen purge while heating at 5°C/min
  - To simulate worst-case scenario, hermetically sealed aluminum pans contained the volatile gases released during heating
  - All materials were determined to be compatible with W-14
    - Krazy Glue showed endothermic behavior (likely mass-dependent melting) during testing, however, the exothermic behavior of the W-14 was unaffected

Qualification Testing of PBXW-14
Compatibility: Differential Scanning Calorimetry

PBXW-14 + Krazy Glue DSC



DSC Data for all Materials

Sample	Exotherm Peak Temp.(°C)	Compatible
PBXW-14	277.7±0.2°	
Krazy Glue	251.6±0.7° (endothermic)	-
PBXW-14 + Krazy Glue	220.8±1.1° (glue) 275.6±1.2° (PBXW-14)	Yes for W14
PBXW-14 + RTV 162	278.1±0.4°	Yes
PBXW-14 + Cu/Ti/B	278.5±0.5°	Yes
PBXW-14 + Al	278.1±0.7°	Yes
PBXW-14 + Cu	278.6±0.4°	Yes

Qualification Testing of PBXW-14
Compatibility: Thermo Gravimetric Analysis

- Thermo Gravimetric Analysis (TGA)
  - Compatibility determined by percent mass change
    - If mass loss < expected mass loss+4%, compatibility is assumed
    - All materials were determined to be compatible with PBXW-14

Sample	Temperature Range	%Mass Loss	Compatible*
PBXW-14	30-191°	-30.1%	
	30-274°	1.17%	
Krazy Glue	30-191°	-60.2%	-
	30-274°	-97.5%	
RTV 162	30-274°	-0.2%	
PBXW-14 + Krazy Glue	30-191°	-23.9%	Cf. -29.7%, yes
	30-274°	-64.3%	Cf. -64.0%, yes
PBXW-14 + RTV 162	30-274°	-18.8%	Cf. -15.3%, yes
PBXW-14 + Cu/Ti/B	30-274°	-16.3%	Cf. W-14 contribution of 15.1%, Yes
PBXW-14 + Al	30-274°	-14.3%	Cf. W-14 contribution of 15.1%, Yes
PBXW-14 + Cu	30-274°	-14.2%	Cf. W-14 contribution of 15.1%, Yes

* Cf. is shorthand for "compared with." The value following Cf. is the expected result of the TGA.

Qualification Testing of PBXW-14
Summary

- Objective: Formulate a booster material with improved IM characteristics over PBXN-5 and CH-6, while increasing performance over PBXN-7
  - Full-scale IM tests have not been completed yet, but VCCT results for W-14 are better than for other booster materials, including PBXN-7
  - PBXW-14 has demonstrated improvements over PBXN-7 in detonation velocity, critical diameter, small-scale gap, vacuum thermal stability, and VCCT
  - PBXW-14 has been shown to perform comparably to PBXN-7 in friction sensitivity, ESD sensitivity, impact sensitivity, and the IHE gap test.

- Based on this data, PBXW-14 will be forwarded to the IM office at the Naval Ordnance Safety and Security Activity requesting explosives qualification

Qualification Testing of PBXW-14
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