



ACCELERATED AGING STUDY OF PBXN-109 FORMULATED WITH INSENSITIVE RDX

By:

K. A. Clark and B. P. Thomas

Naval Surface Warfare Center, Indian Head Division

Indian Head, Maryland 20640

Presented by:

Ken Tomasello

Naval Ordnance Safety & Security Activity

Approved for public release; distribution is unlimited



Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 01 MAR 2008	2. REPORT TYPE N/A	3. DATES COVERED -	
4. TITLE AND SUBTITLE Accelerated Aging Study Of PBXN-109 Formulated With Insensitive RDX		5a. CONTRACT NUMBER	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)		5d. PROJECT NUMBER	
		5e. TASK NUMBER	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center, Indian Head Division Indian Head, Maryland 20640		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited			
13. SUPPLEMENTARY NOTES See also ADM202567. Technical Cooperation Program. Subcommittee on Non-Atomic Military Research and Development. Conventional Weapons Technology Group. Technical Panel WPN TP-4, Energetic Materials and Propulsion Technology. Proceedings of the 33rd Meeting Held in Edinburgh, Australia on March 3-7, 2008, The original document contains color images.			
14. ABSTRACT			
15. SUBJECT TERMS			
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified	
			18. NUMBER OF PAGES 21
			19a. NAME OF RESPONSIBLE PERSON

Agenda

- Program objective
- RDX source selection
- Preparation of PBXN-109 samples
- Aging Protocol
- Results
- Summary
- Future efforts
- Acknowledgements
- Questions

Program Objective

The objective of this accelerated aging study was to begin addressing the concept of IM persistence through aging.

- Does the RDX formulation remain insensitive through the duration of an aging cycle?
- Can IM-ness be successfully assessed at the laboratory scale?

RDX Source Variants

- **RDX and PBXN-109 provided in collaboration with the Reduced Sensitivity RDX Round Robin (R4) Program**
- Australian Defence Industries (ADI)
- BAE SYSTEMS Ordnance Systems Inc. (OSI). OSI is the operating contractor of the US Holston Army Ammunition Plant.
- BAE SYSTEMS Royal Ordnance Defence (RO)
- DYNOL Nobel ASA, Defence Products (DN). (Two RDX variants)
- European Energetics Cooperation (EURENCO). EURENCO is jointly owned by SME (SNPE Matériaux Energétiques), Saab, and Patria. (Two RDX variants)

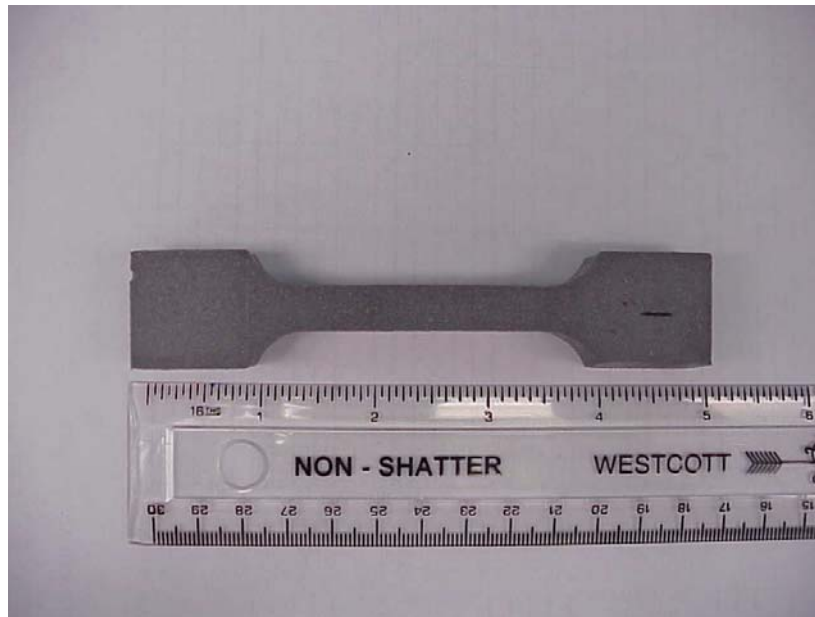
Preparation of PBXN-109 Samples with RDX Source Variants

<u>PBXN-109 Formulation</u>	
	Weight Percent
R45HT NCO/OH: 1.00	7.3460%
DOA	7.3460%
AO 2246	0.1000%
TPB	0.0050%
DHE	0.2600%
AI MDX-81	20.000%
RDX Class 1	64.00%
IPDI	0.9308%

RDX Class 1		
Sample		Manufacturing Process
IH21005GXM109-0300	Royal Ordnance Type 1 Class 1	Woolwich
IH21005GXM109-0301	MI-RDX Conventional Class 1	Woolwich
IH21005GXM109-0302	I-RDX Eurenco Class 1	Woolwich
IH21005GXM109-0303	ADI Class 1 Grade A	Woolwich
IH21005GXM109-0306	OSI Holston Type II Class 1	Bachman
IH21005GXM109-0307	Dyno RS-RDX Class 1	Bachman
IH21005GXM109-0308	Dyno Type II Class 1	Bachman

Preparation of PBXN-109 Samples with RDX Source Variants

During the loading of the baseline IMAD Gap Test hardware, an additional set of gap test hardware was loaded from each mix, along with pan samples which were stored under controlled conditions at 25°C in desiccators under a nitrogen purge to maintain their original integrity.



Aging Protocol

- Two PBXN-109 pan samples were aged for 12 months at 70°C with withdrawals at 3-month time intervals (t-0, t-3, t-6, t-9 and t-12).
 - Hazards Analysis (ESD, Impact, Friction)
 - DMA
 - Plasticizer
 - Mechanical Properties
 - HFC (data not presented here)
 - Antioxidant
 - Rapid Screening Device (RSD)
- Material quantity restraints prevented a diurnal type aging profile.
- Material quantity restraints prevented the introduction of controlled variations in the oxygen and/or humidity conditions of munition storage.

Plasticizer and Antioxidant Analysis

Plasticizer Quantification

- The analysis of the plasticizer content within the aged samples was terminated for the duration of the aging program after the 3-month aging withdrawal.
- The measured plasticizer data may be skewed by the possibility of AO dissolving and migrating within the PBXN-109 binder system during the accelerated aging process.

Antioxidant Quantification

- As expected, the amount of antioxidant decreased over the 12-month aging cycle for each PBXN-109 sample. At the conclusion of the aging program, all antioxidant was measured at or below the level of detection of the analytical instrumentation.

RSD Analysis

Sample	RDX
Lot 300	Royal Ordnance Type 1 Class 1
Lot 301	MI-RDX Conventional Class 1
Lot 302	I-RDX Eurenco Class 1
Lot 303	ADI Class 1 Grade A
Lot 306	OSI Holston Type II Class 1
Lot 307	Dyno RS-RDX Class 1
Lot 308	Dyno Type II Class 1

Maximum Pressure (bar) Zero-time							
LOT #	300	301	302	303	306	307	308
Sample 1	15.6	13.7	19.8	16.1	14.5	14.9	5.9
Sample 2	12.5	13.8	15.4	9.2	4.2	13.9	5.8
Avg.	14	14	18	13	9	14	6
Std. Dev.	2	0.1	3	5	7	0.7	0.1

6 Months Aged							
LOT #	300	301	302	303	306	307	308
Sample 1	6.7	5.4	5.9	6.3	6.8	6.3	15.5
Sample 2	6.0	6.1	6.7	6.0	6.3	6.6	14.6
Avg.	6.4	5.8	6.3	6.2	6.6	6.5	15.1
Std. Dev.	0.5	0.5	0.6	0.2	0.4	0.2	0.6

12 Months Aged							
LOT #	300	301	302	303	306	307	308
Sample 1	11.5	13.7	16.1	11.2	13.9	15.1	15.1
Sample 2	14.4	15.3	Leak	16.5	15.6	16.1	12.2
Avg.	13.0	14.5	16.1	13.9	14.8	15.6	13.7
Std. Dev.	2.1	1.1	#DIV/0!	3.7	1.2	0.7	2.1

RSD Analysis

Sample	RDX
Lot 300	Royal Ordnance Type 1 Class 1
Lot 301	MI-RDX Conventional Class 1
Lot 302	I-RDX Eurenco Class 1
Lot 303	ADI Class 1 Grade A
Lot 306	OSI Holston Type II Class 1
Lot 307	Dyno RS-RDX Class 1
Lot 308	Dyno Type II Class 1

IGNITION TEMPERATURE (DEG C)							
Zero-Time							
LOT #	300	301	302	303	306	307	308
Sample 1	216	225	225	222	221	215	210
Sample 2	226	218	215	220	221	218	223
Avg.	221	222	220	221	221	217	217
Std. Dev.	7	5	7	1	0	2	9

6 Months Age							
LOT #	300	301	302	303	306	307	308
Sample 1	218	216	222	218	220	220	220
Sample 2	216	215	223	216	220	213	220
Avg.	217	216	223	217	220	217	220
Std. Dev.	1	1	1	1	0	5	0

12 Months Age							
LOT #	300	301	302	303	306	307	308
Sample 1	211	226	217	216	229	211	217
Sample 2	225	220	210	222	219	215	221
Avg.	218	223	214	219	224	213	219
Std. Dev.	10	4	5	4	7	3	3

DMA Analysis

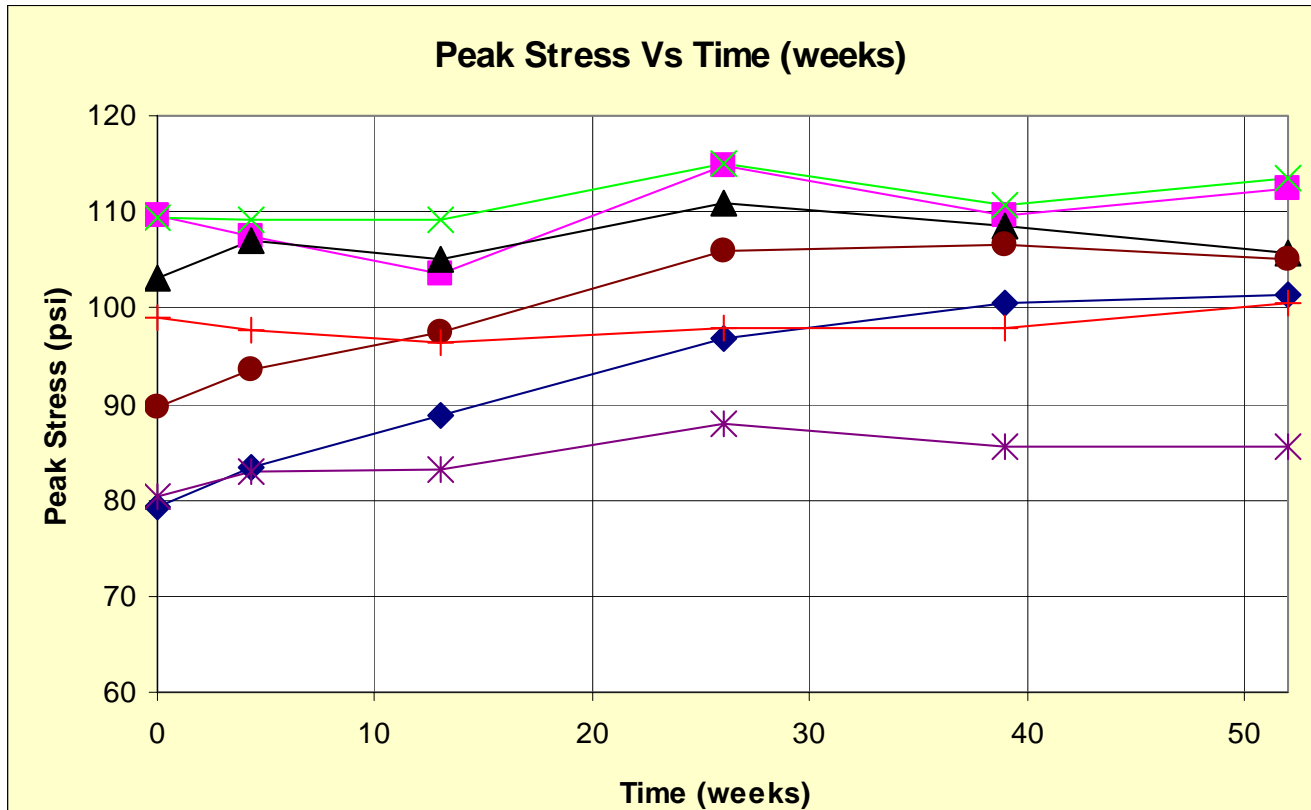
DMA Analysis

All PBXN-109 samples yielded the same glass temperatures (-90°C) within the precision of the instrument over the twelve-month aging period. DMA testing was performed on the TA Instruments Model Q800.

Mechanical Properties

Max Stress

- Baseline max stress values varied across the seven lots from 80psi to 110psi.
- All lots showed an expected increase of 15-20% over the elapsed twelve months of aging.



ADI Class 1 Grade A
MI-RDX Class 1

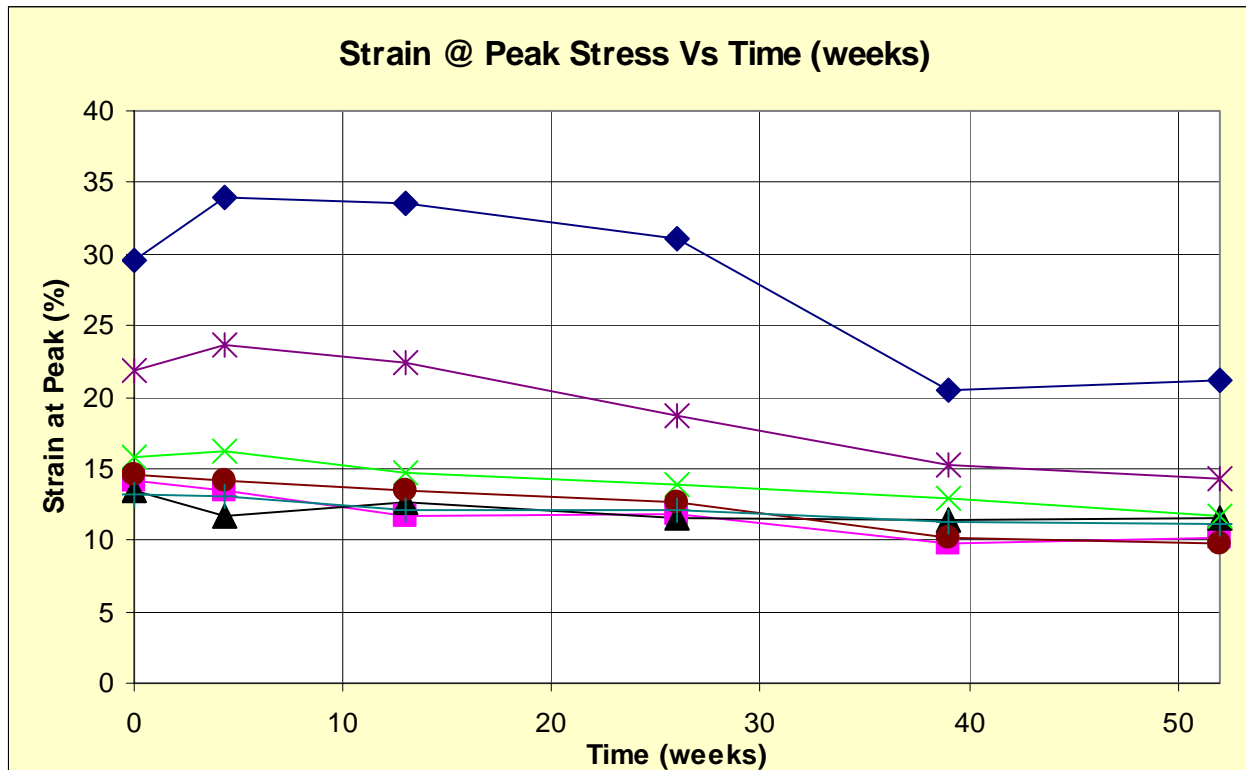
I-RDX Eurenco Class 1
Dyno RS-RDX Class 1
Royal Ordnance Type 1 Class 1
Dyno Type II Class 1

OSI Holston Type II Class 1

Mechanical Properties

Strain at Max Stress

- All lots demonstrated a slight downward trend in the observed strain at max stress.
- Royal Ordnance and OSI Holston exhibited an extended (mesa type) plastic strain region.
- Ensured an increase in the max stress with an increase in max strain over time.
- Result is a strengthening within elongation during aging.

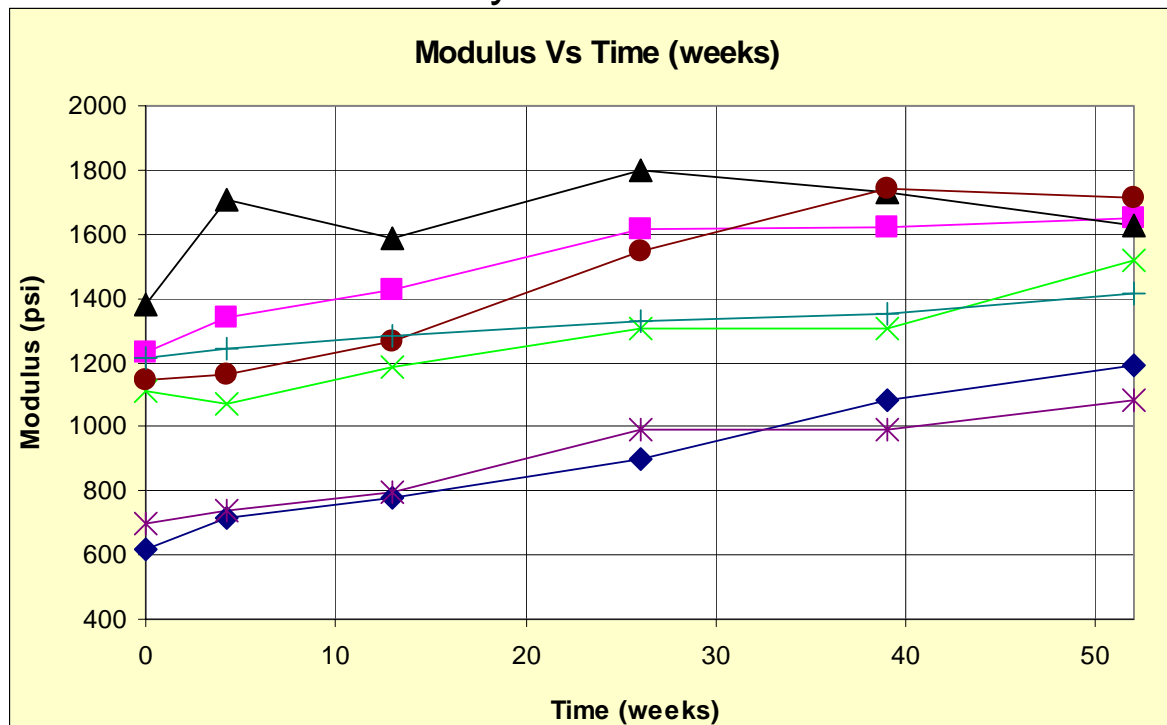


Royal Ordnance Type 1 Class 1
OSI Holston Type II Class 1
ADI Class 1 Grade A
Dyno Type II Class 1
I-RDX Eurenco Class 1
MI-RDX Class 1
Dyno RS-RDX Class 1

Mechanical Properties

Modulus

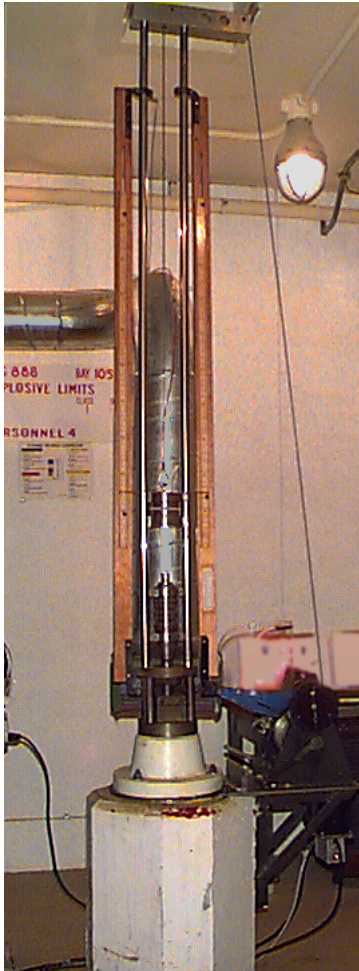
- The baseline modulus varied from 600psi to 1400psi.
- Most lots are showing an as expected increase in modulus with time.
- All lots except Dyno Type II Class 1 are increasing at a rate of 20-30% in the elapsed twelve months.
- Royal Ordnance and OSI Holston have a significantly smaller modulus. This modulus is very characteristic of classic PBX's.



Dyno RS-RDX Class 1
MI-RDX Class 1
I-RDX Eurenco Class 1
ADI Class 1 Grade A

Royal Ordnance Type 1 Class 1
OSI Holston Type II Class 1

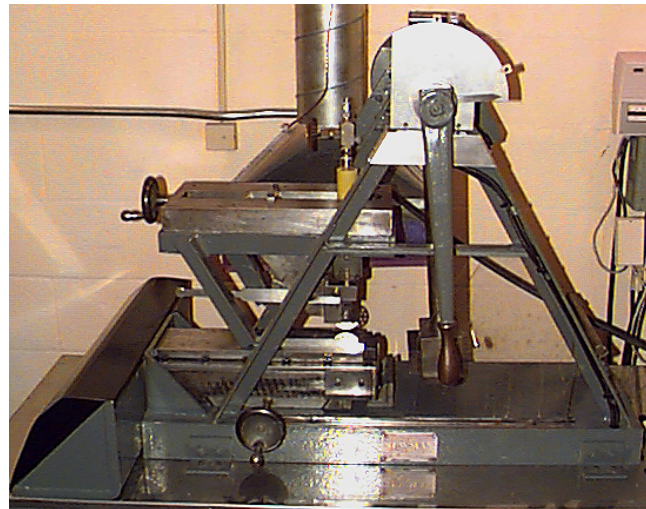
Hazards Characterization



	Baseline NOS Impact (mm)	6-month NOS Impact (mm)	12-month NOS Impact (mm)
Royal Ordnance Type 1 Class 1	447 Low	378 Med	322 Med
MI-RDX Class 1	391 Med	376 Med	287 Med
I-RDX Euroenco Class 1	322 Med	316 Med	391 Med
ADI Class 1 Grade A	333 Med	348 Med	391 Med
OSI Holston Type II Class 1	511 Low	851 Low	492 Low
Dyno RS-RDX Class 1	391 Med	383 Med	299 Med
Dyno Type II Class 1	355 Med	383 Med	293 Med
RDX Standard	261 Med	293 Med	293 Med

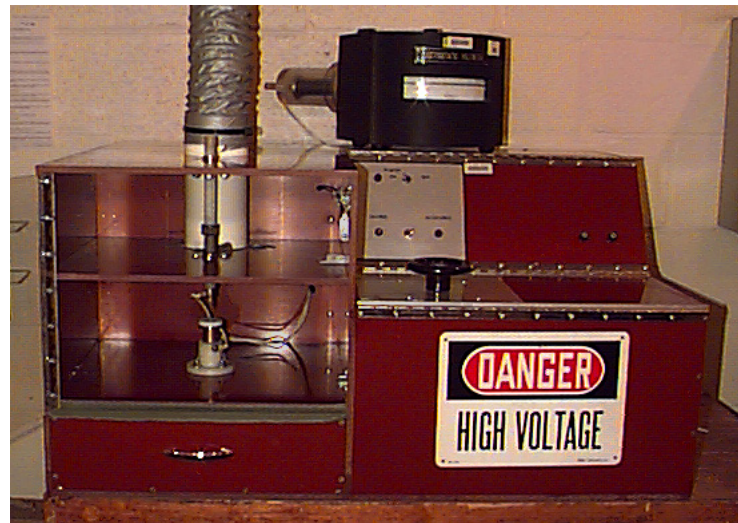
Hazards Characterization

	Baseline ABL Friction (psig)	6-month ABL Friction (psig)	12-month ABL Friction (psig)
Royal Ordnance Type 1 Class 1	560 Low	235 Med	750 Low
MI-RDX Class 1	750 Low	560 Low	420 Med
I-RDX Eurenco Class 1	560 Low	560 Low	235 Med
ADI Class 1 Grade A	235 Med	560 Low	235 Med
OSI Holston Type II Class 1	420 Med	750 Low	560 Low
Dyno RS-RDX Class 1	420 Med	560 Low	560 Low
Dyno Type II Class 1	560 Low	235 Med	5605 Low
RDX Standard	100 Med	180 Med	135 Med



Hazards Characterization

	Baseline ESD (joules)	6-month ESD (joules)	12-month ESD (joules)
Royal Ordnance Type 1 Class 1	0.037 Med	0.015 High	0.010 High
MI-RDX Class 1	0.037 Med	0.015 High	0.010 High
I-RDX Eurenco Class 1	0.037 Med	0.015 High	0.015 High
ADI Class 1 Grade A	0.023 High	0.015 High	0.010 High
OSI Holston Type II Class 1	0.023 High	0.023 High	0.015 High
Dyno RS-RDX Class 1	0.023 High	0.037 Med	0.015 High
Dyno Type II Class 1	0.023 High	0.023 High	0.010 High
RDX Standard	0.095 Med	0.165 Med	0.165 Med



Summary

- Royal Ordnance Type 1 Class 1 RDX and OSI Holston Type II Class 1 RDX demonstrated better mechanical aging characteristics than the rest of the studied population.
- The following material characteristics varied little over the aging cycle for all samples:
 - Plasticizer amount
 - Antioxidant depletion
 - Glass transition temperatures
 - Ignition temperature
 - Off-gassing pressure
- Royal Ordnance Type 1 Class 1 RDX and OSI Holston Type II Class 1 RDX maintained a level of lower hazard sensitivity characteristics throughout the aging study.

Planned Future Efforts

The additional phase of this study will focus on the aging of PBXN-109 formulated with insensitive RDX aged at three different temperatures. This endeavor will provide kinetic data for the aging of the propellant. The attained information will enable a series of calculations to analyze the particle binder interface and the effect that aging has upon this interaction.

Further progression of this study will include the aging of PBXN-109 formulated with insensitive RDX that has been loaded into a relevant warhead and aged. The PBXN-109 propellant would be extracted and analyzed with an emphasis on the chemical, physical, mechanical properties and performance changes of PBXN-109 from the aging of the warhead.

Acknowledgments

The authors wish to thank the analysts within the Applied Analytical Laboratory at NSWC-IHDIV, especially Wes Shaw, Dr. Bill Bryant, Dr. Daniel Sorensen, Dan Remmers and James Thomasson for their contributions to this paper. We also wish to thank our NOSSA sponsor, Roger Swanson, for funding this accelerated aging program and Dr. Ruth Doherty for supplying the formulated PBXN-109.

Questions

