



Uniaxial Compression of GEM Reprocessed Experimental Gun Propellant

by Michael G. Leadore

ARL-TR-2620

December 2001

Approved for public release; distribution is unlimited.

20011231 121

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of manufacturer's or trade names does not constitute an official endorsement or approval of the use thereof.

Destroy this report when it is no longer needed. Do not return it to the originator.

Army Research Laboratory

Aberdeen Proving Ground, MD 21005-5069

ARL-TR-2620

December 2001

Uniaxial Compression of GEM Reprocessed Experimental Gun Propellant

Michael G. Leadore

Weapons and Materials Research Directorate, ARL

Approved for public release; distribution is unlimited.

Abstract

The U.S. Army Research Laboratory (ARL) conducted the material test systems (MTS) servo-hydraulic tester (SHT) high-rate mechanical response of one lot of Naval Surface Warfare Center (NSWC)-manufactured high-energy gun propellant. The material was designated as GEM Reprocessed by the NSWC and given a lot number of IH94000WPB26-0116. The lot was a candidate propellant for the Navy 5-in/62 gun round (test sets 17-19/Fiscal 01).

Contents

List of Figures	v
List of Tables	vii
1. Background	1
2. Approach and Results	2
3. Conclusions	2
4. References	7
Appendix. The Mechanical Response of EX99 Gun Propellant	9
Distribution List	11
Report Documentation Page	27

INTENTIONALLY LEFT BLANK.

List of Figures

Figure 1. Navy cruiser with 5-in/62 gun.	1
Figure 2. Prepared test specimens.....	2
Figure 3. Energetic material prepared for testing on the MTS load frame.....	3
Figure 4. Tested specimens at 21°, 50°, and -20 °C.....	4
Figure 5. Stress vs. strain plot at 21°, 50°, and -20 °C.	5
Figure A-1. Stress vs. strain plot of EX99 gun propellants at 21°, 50°, and -20 °C.....	9

INTENTIONALLY LEFT BLANK.

List of Tables

Table 1. Mechanical properties of GEM reprocessed gun propellant at 21°, -20°, and 50 °C.....	3
Table A-1. Mechanical properties of EX99 gun propellant at 21°, -20°, and 50 °C.....	9

INTENTIONALLY LEFT BLANK.

1. Background

The U.S. Army Research Laboratory (ARL) received one lot of Naval Surface Warfare Center (NSWC)-manufactured gun propellant and testing instructions from Wayne Thomas of the NSWC. The lot was a candidate propellant for the Navy 5-in/62 gun round (Figure 1). The gun propellant was manufactured as 7-perforated granular propellants with a diameter of ~ 15.5 mm. The perforation diameter for the lot measured ~ 0.47 mm. Several grains from the lot of experimental gun propellant were shipped to Dr. Robert Lieb of ARL. Also, several lots of similar materials tested in October 2000 are included in the Appendix and the mechanical properties (Table A-1) and stress vs. strain plot (Figure A-1) of the tested material may be used for comparative purposes as the test conditions were similar. The lot of subject material was last tested for high-rate compressive mechanical response evaluation during February/March 2001.

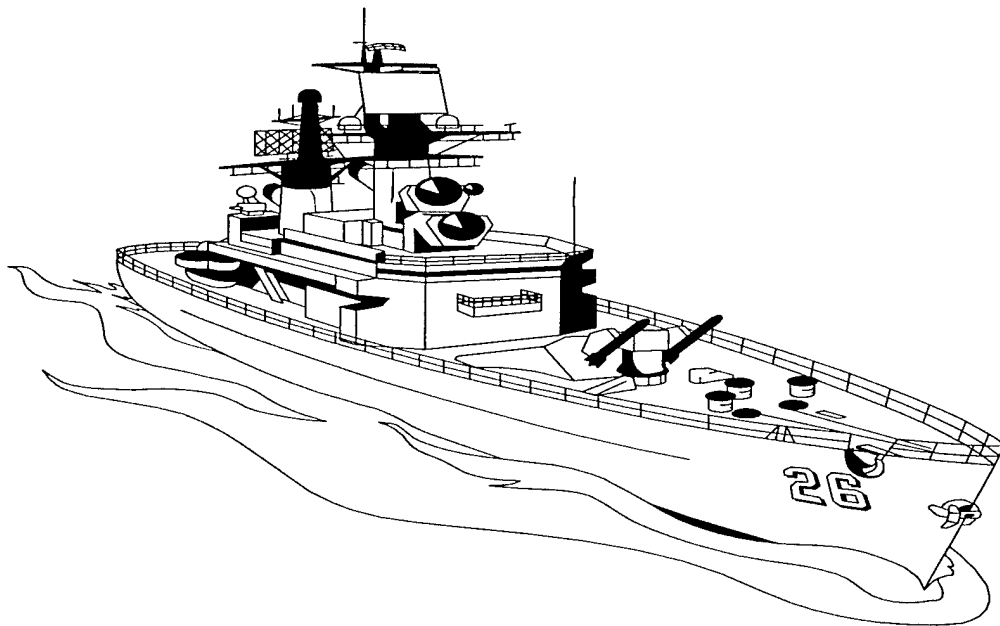


Figure 1. Navy cruiser with 5-in/62 gun.

2. Approach and Results

The GEM Reprocessed propellant lot number IH94000WPB26-0116 was received in granular form with 7-perforations. The material was prepared into test specimens using an Isomet double-bladed diamond saw and the sample ends were cut flat and square. The prepared test specimens (Figure 2) had an average length-to-diameter ratio (L/D) of 1.21.

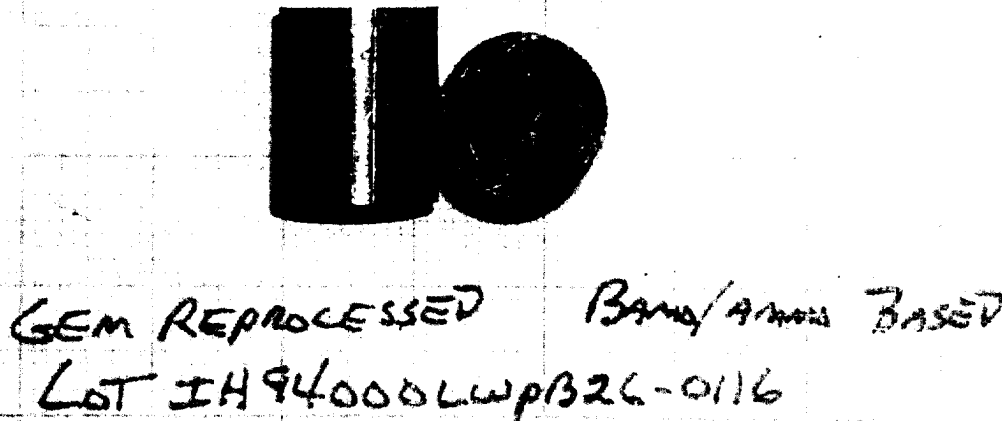


Figure 2. Prepared test specimens.

Material test systems (MTS) servo-hydraulic tester (SHT) mechanical properties tests [1-7] were conducted on several specimens under each test condition (Figure 3). Strain rates of 108.3 s^{-1} were achieved. The specimens were taken to failure at ambient pressure to ~60% end strain while conditioned at 21°, 50°, and -20 °C. The stress at failure, strain at failure, modulus, failure modulus, incremental energy density, and fracture assessment value were recorded for each test. The average values achieved from the tests are listed in Table 1.

3. Conclusions

One lot of NSWC-manufactured GEM Reprocessed Bamo/Ammo-based 7-perforated gun propellant, lot number IH94000WPB26-0116 was tested in uniaxial compression at an average 1.33 m/s deformation rate. The material was taken to ~50% end strain while conditioned at 21°, 50°, and -20 °C. Two lots of



Figure 3. Energetic material prepared for testing on the MTS load frame.

Table 1. Mechanical properties of GEM reprocessed gun propellant at 21°, -20°, and 50 °C.

Lot	Stress at Failure (MPa)	Strain at Failure (%)	Modulus (GPa)	Failure Modulus ^a (GPa)	IED ^b (MPa)	FAV ^c (MPa)
at 21 °C						
IH94000WPB260116	33.5	6.03	0.801	0.0510	8.95	2ABR
at -20 °C						
IH94000WPB260116	100.3	5.56	2.33	-0.55	15.02	7AS
at 50 °C						
IH94000WPB260116	16.6	6.25	0.342	0.275	4.05	0B

^a The failure modulus (slope of the curve after failure) has been added. Generally, the lower the value, the worse the material (i.e., a negative value indicates the material is unable to sustain load). A positive value indicates a positive failure slope (i.e., the material is better able to support load after failure).

^b The incremental energy density (IED) value reported is the amount of energy per unit volume absorbed at 25% strain; this includes a portion of the area located beneath the stress/strain curve.

^c The tested specimens were assigned a fracture assessment value (FAV). The values range from 0 (no observed fracturing) through 9 (severe fracturing observed). The type of fracture was also characterized using the following methodology: A = axial fracture, S = shear fracture, B = barreling/deformation, and R = radial splitting (i.e., 9A indicates the tested specimens showed a severe amount of axial fracture).

similar materials tested using like conditions are included in the Appendix (Table A-1 and Figure A-1) and this information may be used for comparative purposes as similar test conditions were used.

At 21 °C, the mechanical properties of the GEM Reprocessed propellant was very good. Note the compressive and failure modulus values, which indicate the material provided plastic response and was able to sustain loads beyond 40% strain, thus workhardening. When comparing these values with the propellant lots contained in the Appendix, the large difference in compressive and failure modulus values becomes clearer. The tested specimens at 21 °C (Figure 4) showed permanent deformation and only minimal axial fracture/splitting.

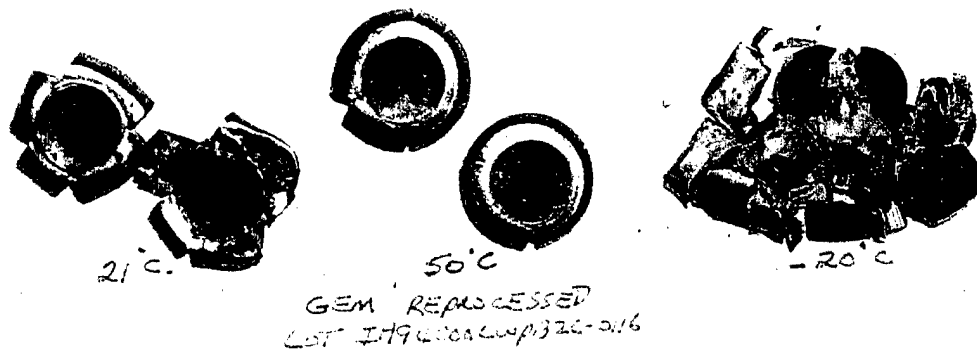


Figure 4. Tested specimens at 21°, 50°, and -20 °C.

At 50 °C, the stress at failure and compressive modulus values showed some softening of the material, as would be expected from the higher testing temperature. The tested specimens at 50 °C showed only deformation of the material, without apparent fracture or splitting.

At -20 °C, the tested specimens (Figure 4) suffered moderate to severe axial and shear fracture damage that would likely cause significant increases in the surface area of this material, thus, likely increasing the burning rate. The stress/strain plots (Figure 5) for the materials also correlate with the physical damage observed. Note the negative failure slope for the lot that indicates the material had likely glass transitioned as a result of the -20 °C exposure. The negative failure modulus values also indicated the material's inability to sustain load at -20 °C beyond 6% strain.

Overall, the GEM Reprocessed 7-perforated gun propellant showed very good mechanical properties at 21° and 50 °C when compared with the Appendix lots. The -20 °C mechanical response of the reprocessed material was poor; however, the mechanical properties were better than the lots contained in the Appendix. Note the factor of 5 improvement in the failure modulus values when comparing the subject and Appendix lots at -20 °C.

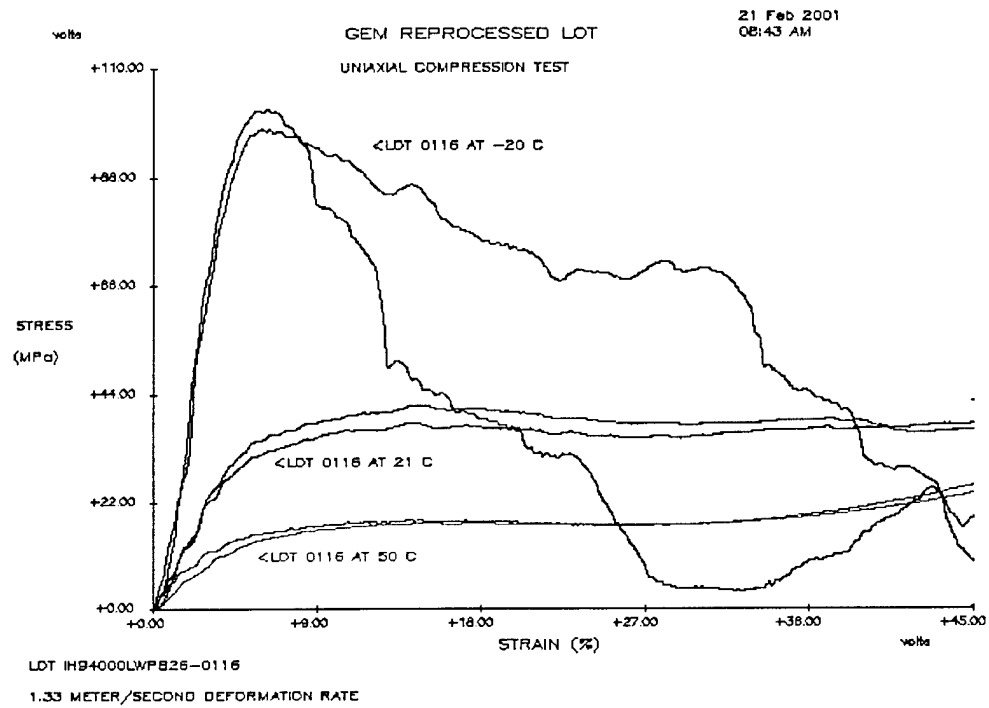


Figure 5. Stress vs. strain plot at 21°, 50°, and -20 °C.

INTENTIONALLY LEFT BLANK.

4. References

1. Gazonas, G. A. "The Mechanical Response of M30, XM39, and JA2 Propellants at Strain Rates From 10⁻² to 250 Sec⁻¹." BRL-TR-3181, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, January 1991.
2. Lieb, R. J. "Impact-Generated Surface Area in Gun Propellant." BRL-TR-2946, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, November 1988.
3. Lieb, R. J., and J. J. Rocchio. "High Strain Rate Mechanical Properties Testing on Lots of Solid Gun Propellant With Deviant Interior Ballistic Performance." 1982 *JANNAF Structures and Mechanical Behavior Subcommittee Meeting*, CPIA Publication 368, pp. 23-38, October 1982.
4. Leadore, M. G. "MTS Servo-Hydraulic Tester (SHT) Mechanical Properties Evaluation of M43 Propellants." ARL-TN-5, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, March 1993.
5. Leadore, M. G., and C. J. Gillich. "Material Testing System (MTS) Servo-Hydraulic Tester (SHT) Mechanical Response of Energetic Thermal Plastic Elastomer (ETPE) RDX Based Propellants." ARL-TN-28, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, April 1994.
6. Leadore, M. G. "Mechanical Response of Energetic Thermoplastic Elastomer Low-Vulnerability Ammunition (ETPE-LOVA) RDX-Based, TNAZ-Based, and CL-20-Based Gun Propellants." ARL-TN-64, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, March 1996.
7. Lieb, R. J. Personal communication. U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, February/March 2000.

INTENTIONALLY LEFT BLANK.

Appendix. The Mechanical Response of EX99 Gun Propellant

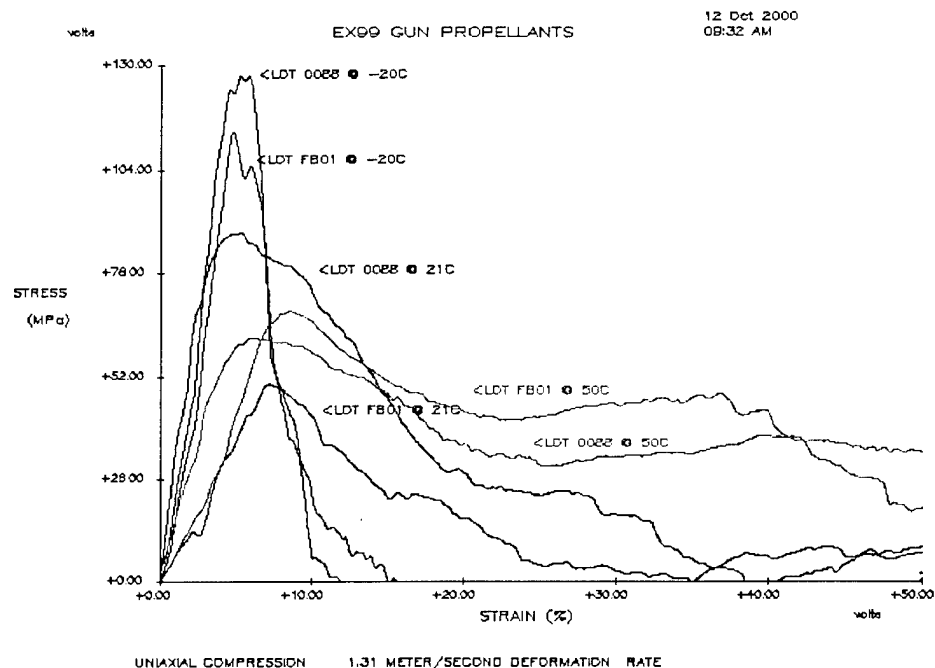


Figure A-1. Stress vs. strain plot of EX99 gun propellants at 21°, 50°, and -20 °C.

Table A-1. Mechanical properties of EX99 gun propellant at 21°, -20°, and 50 °C.

Lot	Stress at Failure (MPa)	Strain at Failure (%)	Modulus (GPa)	Failure Modulus (GPa)	IED (MPa)	FAV (MPa)
at 21 °C						
IH94X990088	98.1	4.40	1.940	-0.320	16.60	8A
Lot IH23X99FB01	56.10	7.20	0.590	-0.310	8.30	8A
at -20 °C						
IH94X990088	128.0	5.40	2.54	-2.85	7.13	9A
Lot IH23X99FB01	108.1	5.25	2.30	-1.90	5.56	9A
at 50 °C						
IH94X990088	59.19	5.10	1.19	-0.120	11.9	7A
Lot IH23X99FB01	67.33	8.40	0.700	-0.230	11.8	7A

INTENTIONALLY LEFT BLANK.

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>	<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
2	DEFENSE TECHNICAL INFORMATION CENTER DTIC OCA 8725 JOHN J KINGMAN RD STE 0944 FT BELVOIR VA 22060-6218	3	DIRECTOR US ARMY RESEARCH LAB AMSRL CI LL 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	HQDA DAMO FDT 400 ARMY PENTAGON WASHINGTON DC 20310-0460	3	DIRECTOR US ARMY RESEARCH LAB AMSRL CI IS T 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	OSD OUSD(A&T)/ODDR&E(R) DR R J TREW 3800 DEFENSE PENTAGON WASHINGTON DC 20301-3800		<u>ABERDEEN PROVING GROUND</u>
1	COMMANDING GENERAL US ARMY MATERIEL CMD AMCRDA TF 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001	2	DIR USARL AMSRL CI LP (BLDG 305)
1	INST FOR ADVNCD TCHNLGY THE UNIV OF TEXAS AT AUSTIN 3925 W BRAKER LN STE 400 AUSTIN TX 78759-5316		
1	US MILITARY ACADEMY MATH SCI CTR EXCELLENCE MADN MATH THAYER HALL WEST POINT NY 10996-1786		
1	DIRECTOR US ARMY RESEARCH LAB AMSRL D DR D SMITH 2800 POWDER MILL RD ADELPHI MD 20783-1197		
1	DIRECTOR US ARMY RESEARCH LAB AMSRL CI AI R 2800 POWDER MILL RD ADELPHI MD 20783-1197		

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	DIRECTOR US ARMY RESEARCH LAB AMSRL CP CA D SNIDER 2800 POWDER MILL RD ADELPHI MD 20783-1145
1	DIRECTOR US ARMY RESEARCH LAB AMSRL CI IS R 2800 POWDER MILL RD ADELPHI MD 20783-1145
3	DIRECTOR US ARMY RESEARCH LAB AMSRL OP SD TL 2800 POWDER MILL RD ADELPHI MD 20783-1145
1	DPTY ASST SECY FOR R&T SARD TT THE PENTAGON RM 3EA79 WASHINGTON DC 20301-7100
1	COMMANDER US ARMY MATERIEL CMD AMXMI INT 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001
4	COMMANDER US ARMY ARDEC AMSTA AR CC G PAYNE J GEHBAUER C BAULIEU H OPAT PICATINNY ARSENAL NJ 07806-5000
2	COMMANDER US ARMY ARDEC AMSTA AR AE WW E BAKER J PEARSON PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR FSE PICATINNY ARSENAL NJ 07806-5000

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	COMMANDER US ARMY ARDEC AMSTA AR TD C SPINELLI PICATINNY ARSENAL NJ 07806-5000
6	COMMANDER US ARMY ARDEC AMSTA AR CCH A W ANDREWS S MUSALLI R CARR M LUCIANO E LOGSDEN T LOUZEIRO PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR CCH P J LUTZ PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR FSF T C LIVECCHIA PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA ASF PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR QAC T C C PATEL PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR M D DEMELLA PICATINNY ARSENAL NJ 07806-5000

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
3	COMMANDER US ARMY ARDEC AMSTA AR FSA A WARNASH B MACHAK M CHIEFA PICATINNY ARSENAL NJ 07806-5000
2	COMMANDER US ARMY ARDEC AMSTA AR FSP G M SCHIKSNIS D CARLUCCI PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR FSP A P KISATSKY PICATINNY ARSENAL NJ 07806-5000
2	COMMANDER US ARMY ARDEC AMSTA AR CCH C H CHANIN S CHICO PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR QAC T D RIGOGLIOSO PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR WET T SACHAR BLDG 172 PICATINNY ARSENAL NJ 07806-5000
1	US ARMY ARDEC INTELLIGENCE SPECIALIST AMSTA AR WEL F M GUERRIERE PICATINNY ARSENAL NJ 07806-5000

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
9	COMMANDER US ARMY ARDEC AMSTA AR CCH B P DONADIA F DONLON P VALENTI C KNUTSON G EUSTICE S PATEL G WAGNECZ R SAYER F CHANG PICATINNY ARSENAL NJ 07806-5000
6	COMMANDER US ARMY ARDEC AMSTA AR CCL F PUZYCKI R MCHUGH D CONWAY E JAROSZEWSKI R SCHLENNER M CLUNE PICATINNY ARSENAL NJ 07806-5000
5	PM SADARM SFAE GCSS SD COL B ELLIS M DEVINE W DEMASSI J PRITCHARD S HROWNAK PICATINNY ARSENAL NJ 07806-5000
2	PEO FIELD ARTILLERY SYS SFAE FAS PM H GOLDMAN T MCWILLIAMS PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC AMSTA AR WEA J BRESCIA PICATINNY ARSENAL NJ 07806-5000

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
12	PM TMAS SFAE GSSC TMA R MORRIS C KIMKER D GUZIEWICZ E KOPACZ R ROESER R DARCY R KOWALSKI R MCDANOLDS L D ULISSE C ROLLER J MCGREEN B PATTEN PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY ARDEC PRODUCTION BASE MODERN ACTY AMSMC PBM K PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY TACOM PM ABRAMS SFAE ASM AB 6501 ELEVEN MILE RD WARREN MI 48397-5000
1	COMMANDER US ARMY TACOM AMSTA SF WARREN MI 48397-5000
1	COMMANDER US ARMY TACOM PM BFVS SFAE GCSS W BV 6501 ELEVEN MILE RD WARREN MI 48397-5000
1	DIRECTOR AIR FORCE RESEARCH LAB MLLMD D MIRACLE 2230 TENTH ST WRIGHT PATTERSON AFB OH 45433-7817

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	OFC OF NAVAL RESEARCH J CHRISTODOULOU ONR CODE 332 800 N QUINCY ST ARLINGTON VA 22217-5600
1	US ARMY CERL R LAMPO 2902 NEWMARK DR CHAMPAIGN IL 61822
1	COMMANDER US ARMY TACOM PM SURVIVABLE SYSTEMS SFAE GCSS W GSI H M RYZYI 6501 ELEVEN MILE RD WARREN MI 48397-5000
1	COMMANDER US ARMY TACOM CHIEF ABRAMS TESTING SFAE GCSS W AB QT T KRASKIEWICZ 6501 ELEVEN MILE RD WARREN MI 48397-5000
1	COMMANDER WATERVLIET ARSENAL SMCWV QAE Q B VANINA BLDG 44 WATERVLIET NY 12189-4050
3	ARMOR SCHOOL ATZK TD R BAUEN J BERG A POMEY FT KNOX KY 40121
2	HQ IOC TANK AMMUNITION TEAM AMSIO SMT R CRAWFORD W HARRIS ROCK ISLAND IL 61299-6000
2	COMMANDER US ARMY AMCOM AVIATION APPLIED TECH DIR J SCHUCK FT EUSTIS VA 23604-5577

NO. OF COPIES	ORGANIZATION
14	COMMANDER US ARMY TACOM AMSTA TR R R MCCLELLAND D THOMAS J BENNETT D HANSEN AMSTA JSK S GOODMAN J FLORENCE K IYER D TEMPLETON A SCHUMACHER AMSTA TR D D OSTBERG L HINOJOSA B RAJU AMSTA CS SF H HUTCHINSON F SCHWARZ WARREN MI 48397-5000
14	BENET LABORATORIES AMSTA AR CCB R FISCELLA M SOJA E KATHE M SCAVULO G SPENCER P WHEELER S KRUPSKI J VASILAKIS G FRIAR R HASENBEIN AMSTA CCB R S SOPOK E HYLAND D CRAYON R DILLON WATERVLIET NY 12189-4050
1	DIRECTOR US ARMY AMCOM SFAE AV RAM TV D CALDWELL BLDG 5300 REDSTONE ARSENAL AL 35898
1	NAVAL SURFACE WARFARE CTR DAHLGREN DIV CODE G06 DAHLGREN VA 22448

NO. OF COPIES	ORGANIZATION
2	US ARMY CORPS OF ENGINEERS CERD C T LIU CEW ET T TAN 20 MASS AVE NW WASHINGTON DC 20314
1	US ARMY COLD REGIONS RSCH & ENGRNG LAB P DUTTA 72 LYME RD HANOVER NH 03755
1	USA SBCCOM PM SOLDIER SPT AMSSB PM RSS A J CONNORS KANSAS ST NATICK MA 01760-5057
2	USA SBCCOM MATERIAL SCIENCE TEAM AMSSB RSS J HERBERT M SENNETT KANSAS ST NATICK MA 01760-5057
2	OFC OF NAVAL RESEARCH D SIEGEL CODE 351 J KELLY 800 N QUINCY ST ARLINGTON VA 22217-5660
1	NAVAL SURFACE WARFARE CTR TECH LIBRARY CODE 323 17320 DAHLGREN RD DAHLGREN VA 22448
1	NAVAL SURFACE WARFARE CTR CRANE DIVISION M JOHNSON CODE 20H4 LOUISVILLE KY 40214-5245
2	NAVAL SURFACE WARFARE CTR U SORATHIA C WILLIAMS CD 6551 9500 MACARTHUR BLVD WEST BETHESDA MD 20817

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>	<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
2	COMMANDER NAVAL SURFACE WARFARE CTR CARDEROCK DIVISION R PETERSON CODE 2020 M CRITCHFIELD CODE 1730 BETHESDA MD 20084	9	US ARMY RESEARCH OFC A CROWSON H EVERETT J PRATER G ANDERSON D STEPP D KISEROW J CHANG PO BOX 12211 RESEARCH TRIANGLE PARK NC 27709-2211
8	DIRECTOR US ARMY NATIONAL GROUND INTELLIGENCE CTR D LEITER MS 404 M HOLTUS MS 301 M WOLFE MS 307 S MINGLEDORF MS 504 J GASTON MS 301 W GSTATTENBAUER MS 304 R WARNER MS 305 J CRIDER MS 306 220 SEVENTH ST NE CHARLOTTESVILLE VA 22091	8	NAVAL SURFACE WARFARE CTR J FRANCIS CODE G30 D WILSON CODE G32 R D COOPER CODE G32 J FRAYSSE CODE G33 E ROWE CODE G33 T DURAN CODE G33 L DE SIMONE CODE G33 R HUBBARD CODE G33 DAHLGREN VA 22448
1	NAVAL SEA SYSTEMS CMD D LIESE 2531 JEFFERSON DAVIS HWY ARLINGTON VA 22242-5160	2	NAVAL SURFACE WARFARE CTR CARDEROCK DIVISION R CRANE CODE 2802 C WILLIAMS CODE 6553 3A LEGGETT CIR BETHESDA MD 20054-5000
1	NAVAL SURFACE WARFARE CTR M LACY CODE B02 17320 DAHLGREN RD DAHLGREN VA 22448	1	AFRL MLBC 2941 P ST RM 136 WRIGHT PATTERSON AFB OH 45433-7750
8	US ARMY SBCCOM SOLDIER SYSTEMS CENTER BALLISTICS TEAM J WARD W ZUKAS P CUNNIFF J SONG MARINE CORPS TEAM J MACKIEWICZ BUS AREA ADVOCACY TEAM W HASKELL AMSSB RCP SS W NYKVIST S BEAUDOIN KANSAS ST NATICK MA 01760-5019	1	AFRL MLSS R THOMSON 2179 12TH ST RM 122 WRIGHT PATTERSON AFB OH 45433-7718
		2	AFRL F ABRAMS J BROWN BLDG 653 2977 P ST STE 6 WRIGHT PATTERSON AFB OH 45433-7739
1	EXPEDITIONARY WARFARE DIV N85 F SHOUP 2000 NAVY PENTAGON WASHINGTON DC 20350-2000	1	WATERWAYS EXPERIMENT D SCOTT 3909 HALLS FERRY RD SC C VICKSBURG MS 39180

NO. OF
COPIES ORGANIZATION

5 DIRECTOR
LLNL
R CHRISTENSEN
S DETERESA
F MAGNESS
M FINGER MS 313
M MURPHY L 282
PO BOX 808
LIVERMORE CA 94550

1 AFRL MLS OL
L COULTER
7278 4TH ST
BLDG 100 BAY D
HILL AFB UT 84056-5205

1 OSD
JOINT CCD TEST FORCE
OSD JCCD
R WILLIAMS
3909 HALLS FERRY RD
VICKSBURG MS 29180-6199

3 DARPA
M VANFOSSEN
S WAX
L CHRISTODOULOU
3701 N FAIRFAX DR
ARLINGTON VA 22203-1714

2 SERDP PROGRAM OFC
PM P2
C PELLERIN
B SMITH
901 N STUART ST STE 303
ARLINGTON VA 22203

1 US DEPT OF ENERGY
OFC OF ENVIRONMENTAL
MANAGEMENT
P RITZCOVAN
19901 GERMANTOWN RD
GERMANTOWN MD 20874-1928

1 DIRECTOR
LOS ALAMOS NATIONAL LAB
F L ADDESSIO T 3 MS 5000
PO BOX 1633
LOS ALAMOS NM 87545

NO. OF
COPIES ORGANIZATION

1 OAK RIDGE NATIONAL
LABORATORY
R M DAVIS
PO BOX 2008
OAK RIDGE TN 37831-6195

1 OAK RIDGE NATIONAL
LABORATORY
C EBERLE MS 8048
PO BOX 2008
OAK RIDGE TN 37831

3 DIRECTOR
SANDIA NATIONAL LABS
APPLIED MECHANICS DEPT
MS 9042
J HANDROCK
Y R KAN
J LAUFFER
PO BOX 969
LIVERMORE CA 94551-0969

1 OAK RIDGE NATIONAL
LABORATORY
C D WARREN MS 8039
PO BOX 2008
OAK RIDGE TN 37831

5 NIST
J DUNKERS
M VANLANDINGHAM MS 8621
J CHIN MS 8621
J MARTIN MS 8621
D DUTHINH MS 8611
100 BUREAU DR
GAITHERSBURG MD 20899

1 HYDROGEOLOGIC INC
SERDP ESTCP SPT OFC
S WALSH
1155 HERNDON PKWY STE 900
HERNDON VA 20170

3 NASA LANGLEY RSCH CTR
AMSRL VS
W ELBER MS 266
F BARTLETT JR MS 266
G FARLEY MS 266
HAMPTON VA 23681-0001

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	NASA LANGLEY RSCH CTR T GATES MS 188E HAMPTON VA 23661-3400
1	FHWA E MUNLEY 6300 GEORGETOWN PIKE MCLEAN VA 22101
1	USDOT FEDERAL RAILRD M FATEH RDV 31 WASHINGTON DC 20590
3	CYTEC FIBERITE R DUNNE D KOHLI R MAYHEW 1300 REVOLUTION ST HAVRE DE GRACE MD 21078
1	MARINE CORPS INTLLGNC ACTVTY D KOSITZKE 3300 RUSSELL RD STE 250 QUANTICO VA 22134-5011
1	DIRECTOR NATIONAL GRND INTLLGNC CTR IANG TMT 220 SEVENTH ST NE CHARLOTTESVILLE VA 22902-5396
1	SIOUX MFG B KRIEL PO BOX 400 FT TOTTEN ND 58335
2	3TEX CORPORATION A BOGDANOVICH J SINGLETARY 109 MACKENAN DR CARY NC 27511
1	3M CORPORATION J SKILDUM 3M CENTER BLDG 60 IN 01 ST PAUL MN 55144-1000

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	DIRECTOR DEFENSE INTLLGNC AGENCY TA 5 K CRELLING WASHINGTON DC 20310
1	ADVANCED GLASS FIBER YARNS T COLLINS 281 SPRING RUN LANE STE A DOWNINGTON PA 19335
1	COMPOSITE MATERIALS INC D SHORTT 19105 63 AVE NE PO BOX 25 ARLINGTON WA 98223
1	JPS GLASS L CARTER PO BOX 260 SLATER RD SLATER SC 29683
1	COMPOSITE MATERIALS INC R HOLLAND 11 JEWEL CT ORINDA CA 94563
1	COMPOSITE MATERIALS INC C RILEY 14530 S ANSON AVE SANTA FE SPRINGS CA 90670
2	SIMULA J COLTMAN R HUYETT 10016 S 51ST ST PHOENIX AZ 85044
2	PROTECTION MATERIALS INC M MILLER F CRILLEY 14000 NW 58 CT MIAMI LAKES FL 33014
2	FOSTER MILLER M ROYLANCE W ZUKAS 195 BEAR HILL RD WALTHAM MA 02354-1196

NO. OF
COPIES ORGANIZATION

1 ROM DEVELOPMENT CORP
R O MEARA
136 SWINEBURNE ROW
BRICK MARKET PLACE
NEWPORT RI 02840

2 TEXTRON SYSTEMS
T FOLTZ
M TREASURE
1449 MIDDLESEX ST
LOWELL MA 01851

1 O GARA HESS & EISENHARDT
M GILLESPIE
9113 LESAINTE DR
FAIRFIELD OH 45014

2 MILLIKEN RSCH CORP
H KUHN
M MACLEOD
PO BOX 1926
SPARTANBURG SC 29303

1 CONNEAUGHT INDUSTRIES INC
J SANTOS
PO BOX 1425
COVENTRY RI 02816

1 BATTELLE NATICK OPNS
B HALPIN
209 W CENTRAL ST STE 302
NATICK MA 01760

1 ARMTEC DEFENSE PRODUCTS
S DYER
85 901 AVE 53
PO BOX 848
COACHELLA CA 92236

1 NATIONAL COMPOSITE CENTER
T CORDELL
2000 COMPOSITE DR
KETTERING OH 45420

3 PACIFIC NORTHWEST LAB
M SMITH
G VAN ARSDALE
R SHIPPELL
PO BOX 999
RICHLAND WA 99352

NO. OF
COPIES ORGANIZATION

2 AMOCO PERFORMANCE
PRODUCTS
M MICHNO JR
J BANISAUKAS
4500 MCGINNIS FERRY RD
ALPHARETTA GA 30202-3944

8 ALLIANT TECHSYSTEMS INC
C CANDLAND MN11 2830
C AAKHUS MN11 2830
B SEE MN11 2439
N VLAHAKUS MN11 2145
R DOHRN MN11 2830
S HAGLUND MN11 2439
M HISSONG MN11 2830
D KAMDAR MN11 2830
600 SECOND ST NE
HOPKINS MN 55343-8367

1 SAIC
M PALMER
1410 SPRING HILL RD STE 400
MS SH4 5
MCLEAN VA 22102

1 SAIC
G CHRYSSOMALLIS
3800 W 80TH ST STE 1090
BLOOMINGTON MN 55431

1 AAI CORPORATION
T G STASTNY
PO BOX 126
HUNT VALLEY MD 21030-0126

1 APPLIED COMPOSITES
W GRISCH
333 NORTH SIXTH ST
ST CHARLES IL 60174

1 CUSTOM ANALYTICAL
ENG SYS INC
A ALEXANDER
13000 TENSOR LANE NE
FLINTSTONE MD 21530

1 OFC DEPUTY UNDER SEC DEFNS
J THOMPSON
1745 JEFFERSON DAVIS HWY
CRYSTAL SQ 4 STE 501
ARLINGTON VA 22202

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
3	ALLIANT TECHSYSTEMS INC J CONDON E LYNAM J GERHARD WV01 16 STATE RT 956 PO BOX 210 ROCKET CENTER WV 26726-0210
1	PROJECTILE TECHNOLOGY INC 515 GILES ST HAVRE DE GRACE MD 21078
3	HEXCEL INC R BOE PO BOX 18748 SALT LAKE CITY UT 84118
5	AEROJET GEN CORP D PILLASCH T COULTER C FLYNN D RUBAREZUL M GREINER 1100 WEST HOLLYVALE ST AZUSA CA 91702-0296
1	HERCULES INC HERCULES PLAZA WILMINGTON DE 19894
1	BRIGS COMPANY J BACKOFEN 2668 PETERBOROUGH ST HERNDON VA 22071-2443
1	ZERNOW TECHNICAL SERVICES L ZERNOW 425 W BONITA AVE STE 208 SAN DIMAS CA 91773
1	GENERAL DYNAMICS OTS L WHITMORE 10101 NINTH ST NORTH ST PETERSBURG FL 33702
3	GENERAL DYNAMICS OTS FLINCHBAUGH DIV E STEINER B STEWART T LYNCH PO BOX 127 RED LION PA 17356

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	GKN AEROSPACE D OLDS 15 STERLING DR WALLINGFORD CT 06492
5	SIKORSKY AIRCRAFT G JACARUSO T CARSTENSAN B KAY S GARBO MS S330A J ADELMANN 6900 MAIN ST PO BOX 9729 STRATFORD CT 06497-9729
1	PRATT & WHITNEY C WATSON 400 MAIN ST MS 114 37 EAST HARTFORD CT 06108
1	AEROSPACE CORP G HAWKINS M4 945 2350 E EL SEGUNDO BLVD EL SEGUNDO CA 90245
2	CYTEC FIBERITE M LIN W WEB 1440 N KRAEMER BLVD ANAHEIM CA 92806
1	UDLP G THOMAS PO BOX 58123 SANTA CLARA CA 95052
2	UDLP R BARRETT MAIL DROP M53 V HORVATICH MAIL DROP M53 328 W BROKAW RD SANTA CLARA CA 95052-0359
3	UDLP GROUND SYSTEMS DIVISION M PEDRAZZI MAIL DROP N09 A LEE MAIL DROP N11 M MACLEAN MAIL DROP N06 1205 COLEMAN AVE SANTA CLARA CA 95052

NO. OF
COPIES ORGANIZATION

4 UDLP
R BRYNSVOLD
P JANKE MS 170
4800 EAST RIVER RD
MINNEAPOLIS MN 55421-1498

2 BOEING ROTORCRAFT
P MINGURT
P HANDEL
800 B PUTNAM BLVD
WALLINGFORD PA 19086

1 BOEING
DOUGLAS PRODUCTS DIV
L J HART SMITH
3855 LAKEWOOD BLVD
D800 0019
LONG BEACH CA 90846-0001

1 LOCKHEED MARTIN
SKUNK WORKS
D FORTNEY
1011 LOCKHEED WAY
PALMDALE CA 93599-2502

1 LOCKHEED MARTIN
R FIELDS
1195 IRWIN CT
WINTER SPRINGS FL 32708

1 MATERIALS SCIENCES CORP
G FLANAGAN
500 OFC CENTER DR STE 250
FT WASHINGTON PA 19034

1 NORTHRUP GRUMMAN CORP
ELECTRONIC SENSORS
& SYSTEMS DIV
E SCHOCH MS V 16
1745A W NURSERY RD
LINTHICUM MD 21090

1 GDLS DIVISION
D BARTLE
PO BOX 1901
WARREN MI 48090

2 GDLS
D REES
M PASIK
PO BOX 2074
WARREN MI 48090-2074

NO. OF
COPIES ORGANIZATION

1 GDLS
MUSKEGON OPERATIONS
W SOMMERS JR
76 GETTY ST
MUSKEGON MI 49442

1 GENERAL DYNAMICS
AMPHIBIOUS SYS
SURVIVABILITY LEAD
G WALKER
991 ANNAPOLIS WAY
WOODBRIDGE VA 22191

6 INST FOR ADVANCED
TECH
H FAIR
I MCNAB
P SULLIVAN
S BLESS
W REINECKE
C PERSAD
3925 W BRAKER LN STE 400
AUSTIN TX 78759-5316

2 CIVIL ENGR RSCH FOUNDATION
PRESIDENT
H BERNSTEIN
R BELLE
1015 15TH ST NW STE 600
WASHINGTON DC 20005

1 ARROW TECH ASSO
1233 SHELBURNE RD STE D8
SOUTH BURLINGTON VT
05403-7700

1 R EICHELBERGER
CONSULTANT
409 W CATHERINE ST
BEL AIR MD 21014-3613

1 UCLA MANE DEPT ENGR IV
H T HAHN
LOS ANGELES CA 90024-1597

2 UNIV OF DAYTON
RESEARCH INST
R Y KIM
A K ROY
300 COLLEGE PARK AVE
DAYTON OH 45469-0168

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	UMASS LOWELL PLASTICS DEPT N SCHOTT 1 UNIVERSITY AVE LOWELL MA 01854
1	IIT RESEARCH CENTER D ROSE 201 MILL ST ROME NY 13440-6916
1	GA TECH RSCH INST GA INST OF TCHNLGY P FRIEDERICH ATLANTA GA 30392
1	MICHIGAN ST UNIV MSM DEPT R AVERILL 3515 EB EAST LANSING MI 48824-1226
1	UNIV OF WYOMING D ADAMS PO BOX 3295 LARAMIE WY 82071
2	PENN STATE UNIV R MCNITT C BAKIS 212 EARTH ENGR SCIENCES BLDG UNIVERSITY PARK PA 16802
1	PENN STATE UNIV R S ENGEL 245 HAMMOND BLDG UNIVERSITY PARK PA 16801
1	PURDUE UNIV SCHOOL OF AERO & ASTRO C T SUN W LAFAYETTE IN 47907-1282
1	STANFORD UNIV DEPT OF AERONAUTICS & AEROBALLISTICS S TSAI DURANT BLDG STANFORD CA 94305

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	UNIV OF MAINE ADV STR & COMP LAB R LOPEZ ANIDO 5793 AEWB BLDG ORONO ME 04469-5793
1	JOHNS HOPKINS UNIV APPLIED PHYSICS LAB P WIENHOLD 11100 JOHNS HOPKINS RD LAUREL MD 20723-6099
1	UNIV OF DAYTON J M WHITNEY COLLEGE PARK AVE DAYTON OH 45469-0240
5	UNIV OF DELAWARE CTR FOR COMPOSITE MTRLS J GILLESPIE M SANTARE S YARLAGADDA S ADVANI D HEIDER 201 SPENCER LABORATORY NEWARK DE 19716
1	DEPT OF MATERIALS SCIENCE & ENGINEERING UNIVERSITY OF ILLINOIS AT URBANA CHAMPAIGN J ECONOMY 1304 WEST GREEN ST 115B URBANA IL 61801
1	NORTH CAROLINA STATE UNIV CIVIL ENGINEERING DEPT W RASDORF PO BOX 7908 RALEIGH NC 27696-7908
1	UNIV OF MARYLAND DEPT OF AEROSPACE ENGNRNG A J VIZZINI COLLEGE PARK MD 20742
1	DREXEL UNIV A S D WANG 32ND & CHESTNUT ST PHILADELPHIA PA 19104

NO. OF
COPIES ORGANIZATION

3 UNIV OF TEXAS AT AUSTIN
CTR FOR ELECTROMECHANICS
J PRICE
A WALLS
J KITZMILLER
10100 BURNET RD
AUSTIN TX 78758-4497

3 VA POLYTECHNICAL
INST & STATE UNIV
DEPT OF ESM
M W HYER
K REIFSNIDER
R JONES
BLACKSBURG VA 24061-0219

1 SOUTHWEST RSCH INST
ENGR & MATL SCIENCES DIV
J RIEGEL
6220 CULEBRA RD
PO DRAWER 28510
SAN ANTONIO TX 78228-0510

ABERDEEN PROVING GROUND

1 US ARMY MATERIEL
SYSTEMS ANALYSIS ACTIVITY
P DIETZ
392 HOPKINS RD
AMXSY TD
APG MD 21005-5071

1 DIRECTOR
US ARMY RESEARCH LAB
AMSRL OP AP L
APG MD 21005-5066

90 DIR USARL
AMSRL CI
AMSRL CI S
A MARK
AMSRL CS IO FI
M ADAMSON
AMSRL SL BA
AMSRL SL BL
D BELY
R HENRY
AMSRL SL BG
AMSRL SL I

NO. OF
COPIES ORGANIZATION

ABERDEEN PROVING GROUND (CONT)

AMSRL WM
J SMITH
AMSRL WM B
A HORST
AMSRL WM BA
D LYON
AMSRL WM BC
P PLOSTINS
J NEWILL
S WILKERSON
A ZIELINSKI
AMSRL WM BD
B FORCH
R FIFER
R PESCE RODRIGUEZ
B RICE
AMSRL WM BE
C LEVERITT
AMSRL WM BF
J LACETERA
AMSRL WM BR
C SHOEMAKER
J BORNSTEIN
AMSRL WM M
D VIECHNICKI
G HAGNAUER
J MCCAULEY
AMSRL WM MA
L GHIORSE
S MCKNIGHT
AMSRL WM MB
B FINK
J BENDER
T BOGETTI
R BOSSOLI
L BURTON
K BOYD
S CORNELISON
P DEHMER
R DOOLEY
W DRYSDALE
G GAZONAS
S GHIORSE
D GRANVILLE
D HOPKINS
C HOPPEL
D HENRY
R KASTE
M KLUSEWITZ
M LEADORE

NO. OF
COPIES ORGANIZATION

ABERDEEN PROVING GROUND (CONT)

R LIEB
E RIGAS
J SANDS
D SPAGNUOLO
W SPURGEON
J TZENG
E WETZEL
A FRYDMAN
AMRSL WM MC
J BEATTY
E CHIN
J MONTGOMERY
A WERECZCAK
J LASALVIA
J WELLS
AMRSL WM MD
W ROY
S WALSH
AMRSL WM T
B BURNS
M ZOLTOSKI
AMRSL WM TA
W GILLICH
T HAVEL
J RUNYEON
M BURKINS
E HORWATH
B GOOCH
W BRUCHEY
M NORMANDIA
AMRSL WM TB
D KOOKER
P BAKER
AMRSL WM TC
R COATES
AMRSL WM TD
A DAS GUPTA
T HADUCH
T MOYNIHAN
F GREGORY
M RAFTENBERG
M BOTELER
T WEERASOORIYA
D DANDEKAR
A DIETRICH
AMRSL WM TE
A NIILER
J POWELL

NO. OF
COPIES ORGANIZATION

ABERDEEN PROVING GROUND (CONT)

AMRSL SS SD
H WALLACE
AMRSL SS SE DS
R REYZER
R ATKINSON

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	LTD R MARTIN MERL TAMWORTH RD HERTFORD SG13 7DG UK
1	SMC SCOTLAND P W LAY DERA ROSYTH ROSYTH ROYAL DOCKYARD DUNFERMLINE FIFE KY 11 2XR UK
1	CIVIL AVIATION ADMINISTRATION T GOTTESMAN PO BOX 8 BEN GURION INTERNL AIRPORT LOD 70150 ISRAEL
1	AEROSPATIALE S ANDRE A BTE CC RTE MD132 316 ROUTE DE BAYONNE TOULOUSE 31060 FRANCE
1	DRA FORT HALSTEAD P N JONES SEVEN OAKS KENT TN 147BP UK
1	DEFENSE RESEARCH ESTAB VALCARTIER F LESAGE COURCELETTE QUEBEC COA IRO CANADA
1	SWISS FEDERAL ARMAMENTS WKS W LANZ ALLMENDSTRASSE 86 3602 THUN SWITZERLAND
1	DYNAMEC RESEARCH AB AKE PERSSON BOX 201 SE 151 23 SODERTALJE SWEDEN

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	ISRAEL INST OF TECHNOLOGY S BODNER FACULTY OF MECHANICAL ENGR HAIFA 3200 ISRAEL
1	DSTO WEAPONS SYSTEMS DIVISION N BURMAN RLLWS SALISBURY SOUTH AUSTRALIA 5108 AUSTRALIA
1	ECOLE ROYAL MILITAIRE E CELENS AVE DE LA RENAISSANCE 30 1040 BRUXELLE BELGIQUE
1	DEF RES ESTABLISHMENT VALCARTIER A DUPUIS 2459 BOULEVARD PIE XI NORTH VALCARTIER QUEBEC CANADA PO BOX 8800 COURCELETTE GOA IRO QUEBEC CANADA
1	INSTITUT FRANCO ALLEMAND DE RECHERCHES DE SAINT LOUIS DE M GIRAUD 5 RUE DU GENERAL CASSAGNOU BOITE POSTALE 34 F 68301 SAINT LOUIS CEDEX FRANCE
1	ECOLE POLYTECH J MANSON DMX LTC CH 1015 LAUSANNE SWITZERLAND

<u>NO. OF COPIES</u>	<u>ORGANIZATION</u>
1	TNO DEFENSE RESEARCH R IJSSELSTEIN ACCOUNT DIRECTOR R&D ARMEE PO BOX 6006 2600 JA DELFT THE NETHERLANDS
2	FOA NATL DEFENSE RESEARCH ESTAB DIR DEPT OF WEAPONS & PROTECTION B JANZON R HOLMLIN S 172 90 STOCKHOLM SWEDEN
2	DEFENSE TECH & PROC AGENCY GROUND I CREWTHERR GENERAL HERZOG HAUS 3602 THUN SWITZERLAND
1	MINISTRY OF DEFENCE RAFAEL ARMAMENT DEVELOPMENT AUTH M MAYSELESS PO BOX 2250 HAIFA 31021 ISRAEL
1	TNO DEFENSE RESEARCH I H PASMAN POSTBUS 6006 2600 JA DELFT THE NETHERLANDS
1	B HIRSCH TACHKEMONY ST 6 NETAMUA 42611 ISRAEL
1	DEUTSCHE AEROSPACE AG DYNAMICS SYSTEMS M HELD PO BOX 1340 D 86523 SCHROBENHAUSEN GERMANY

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this 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, and to the Office of Management and Budget, Paperwork Reduction Project(0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE December 2001	3. REPORT TYPE AND DATES COVERED Final, October 2000-March 2001		
4. TITLE AND SUBTITLE Uniaxial Compression of GEM Reprocessed Experimental Gun Propellant		5. FUNDING NUMBERS 1L161102AH43		
6. AUTHOR(S) Michael G. Leadore				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory ATTN: AMSRL-WM-MB Aberdeen Proving Ground, MD 21005-5069		8. PERFORMING ORGANIZATION REPORT NUMBER ARL-TR-2620		
9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)		10. SPONSORING/MONITORING AGENCY REPORT NUMBER		
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE		
13. ABSTRACT(Maximum 200 words) The U.S. Army Research Laboratory (ARL) conducted the material test systems (MTS) servo-hydraulic tester (SHT) high-rate mechanical response of one lot of Naval Surface Warfare Center (NSWC)-manufactured high-energy gun propellant. The material was designated as GEM Reprocessed by the NSWC and given a lot number of IH94000WPB26-0116. The lot was a candidate propellant for the Navy 5-in/62 gun round (test sets 17-19/Fiscal 01).				
14. SUBJECT TERMS uniaxial compression, mechanical properties, fracture, propellant		15. NUMBER OF PAGES 29		
		16. PRICE CODE		
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

INTENTIONALLY LEFT BLANK.