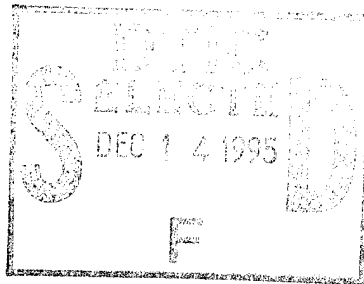


# RECOVERY TECHNIQUE FOR SHOCKED EXPLOSIVE SAMPLES

*T.P. Liddiard, J.W. Forbes, J.W. Watt, R.N. Baker, and J. Sharma*



Approved for public release; distribution is unlimited.



19951212 004



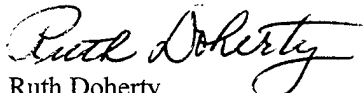
REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestion for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson				
1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE 31 August 1995	3. REPORT TYPE AND DATES COVERED Final Report		
4. TITLE AND SUBTITLE  RECOVERY TECHNIQUE FOR SHOCKED EXPLOSIVE SAMPLES			5. FUNDING NUMBERS	
6. AUTHOR(S)  T.P. Liddiard, J.W. Forbes, J.W. Watt, R.N. Baker, and J. Sharma				
7. PERFORMING ORGANIZATIONS NAME(S) AND ADDRESS(ES)  Indian Head Division Naval Surface Warfare Center Indian Head, MD 20640-5035			8. PERFORMING ORGANIZATION REPORT NUMBER  IHTR 1821	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)  Office of Naval Research Arlington, VA 22217-5000			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)  A technique has been developed to recover explosives that have undergone stresses as high as 26 kilobars. Physical (microscopic) and chemical examination of recovered explosives has led to the discovery of new chemical reactions occurring in these explosives.				
14. SUBJECT TERMS Explosives Recovery of explosives			15. NUMBER OF PAGES 36	
			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  SAR	

## FOREWORD

This work was performed for and funded by the Office of Naval Research as part of the Explosives Project within the Explosives and Undersea Warheads Technology Block Program PE602314N. The results and conclusions in this report will be of interest to those seeking information on (1) shock wave sensitivity of explosives, (2) chemistry of recovered shocked explosive samples, and (3) surface chemistry techniques.

The authors wish to acknowledge Jack Marshall for the design of the aluminum frames which held the donor pentolite sphere and samples in place prior to detonation of the donor. Dr. Harold Sandusky and Carl Groves prepared the recovery capsules containing the RDX and CL-20 crystals for experiment 92-R1. Cynthia Forbes typed this report.

Approved and released by:

  
 Ruth Doherty  
 Head, Detonation Physics Division

Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification .....	
By .....	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

## CONTENTS

Heading	Page
Foreword .....	iii
Introduction .....	1
Experimental Technique for the Recovery System .....	2
Results .....	10
Summary .....	11
References .....	12

## TABLES

I. Calibration of the Underwater Sensitivity Test .....	7
II. Results of Recovery Experiments .....	10

## FIGURES

1. Spherical Donor Charge Assembly .....	2
2. Capsule Placement Around Pentolite Sphere .....	3
3. Placement of Nine Test Samples in Unfilled Tank .....	4
4. Teflon Sample Capsule: Cap (Top) and Threaded Plug .....	5
5. Capsule Holder Arrangement .....	6
6. Method of Determining the Peak Stress Researching to Teflon and TATB .....	8
7. Graphic Method of Determining Pressures Transmitted to the Teflon Capsule and TATB Sample .....	9

## INTRODUCTION

Pre-ignition reactions in explosives subjected to shock compression are of fundamental importance to the study of explosive behavior. Recovery of samples subjected to strong shocks has been a problem. The sample must be contained and remain relatively uncontaminated. Typically, attempts at recovery have resulted in the physical destruction of the explosive test samples due to strong rarefactions and violent collisions with objects such as chamber walls. In addition to the recovery of the explosive sample, some means of determining the shock history in the sample should be available. In most recovery techniques, the impedances of the surrounding materials are quite different from the explosive samples and the confinement is finite in size. Both of these conditions lead to relief waves that significantly affect the strain histories of recovered samples. The use of materials with similar impedances greatly reduces the magnitude of reflected waves within the sample.

In our technique, small (usually 30 mg) explosive samples, encapsulated in Teflon holders, are subjected to strong shock compression. The shock-producing system is the same as that used in the Underwater Sensitivity Test (UST).<sup>1,2</sup> The underwater shock system was carefully calibrated previously.<sup>3</sup> The recovered explosive samples are then removed from the capsules for chemical and physical (microscopic) analysis. Recovery of samples shocked to peak stresses of up to 26 kbar with pulse widths of a few microseconds has been accomplished. The present recovery technique is the result of a number of experiments in which various degrees of success occurred. Modifications after each experiment finally led to a reliable recovery technique.

## EXPERIMENTAL TECHNIQUE FOR THE RECOVERY SYSTEM

### Donor and Detonator:

In the recovery system, the donor is an 82-mm-diameter sphere of cast pentolite (50% TNT/50% PETN) weighing 470 to 480 g. The spherical charge assembly is shown in Figure 1. The detonator, an RP-80, is an exploding bridgewire type manufactured by Reynolds Industries Systems Inc. It is 7.11 mm in diameter and fits into a 46-mm-deep hole cast (not machined) in the sphere. The RP-80 detonator is insensitive to static discharge and requires at least a 1.0- $\mu$ F capacitor charged to 2.5 kV to initiate detonation in the detonator. This makes it quite safe for inserting into the pentolite sphere. A 7.0-mm-diameter by 9.5-mm-long pellet of pressed pentolite (density = 1.6 g/cm<sup>3</sup>) is inserted in the hole ahead of the detonator to ensure a detonation at the center of the cast pentolite sphere. (Pressed pentolite is much more sensitive to shock than is cast pentolite, the run distance to detonation being negligible and the propagation of detonation being essentially isotropic.) The available space around the detonator leads within the hole is filled with C-4 plastic explosive. A sealant (Duxseal) is used to cover the connection of the plastic sheath, containing the detonator leads, to the pentolite sphere.

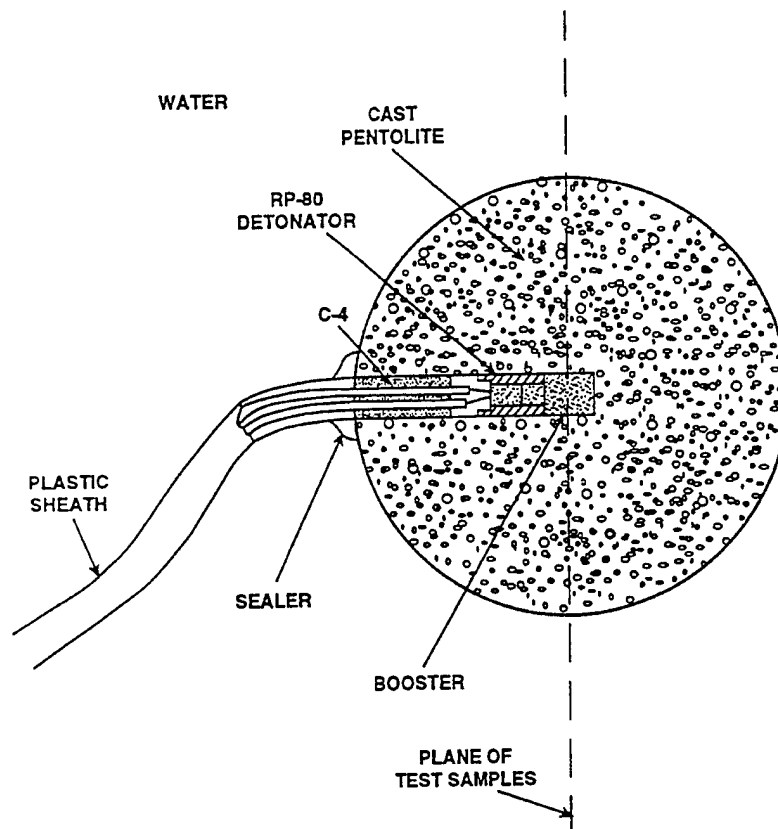


FIGURE 1. SPHERICAL DONOR CHARGE ASSEMBLY

**Placement of Components in Tank:**

The spherical donor is suspended by a nylon cord harness in a cubic tank of water, 60 cm on an edge. The harness is attached to an aluminum supporting frame. The test samples enclosed in Teflon are mounted in thin-walled steel tubes which, in turn, are fastened to the aluminum frame by Plexiglas holders. The donor is positioned in the tank so that the detonator axis is normal to the plane in which the test samples are usually placed. This orientation reduces irregularities in the shock front since the arrival of detonation at the donor surface is observed to be more symmetrical in planes normal to the detonator axis. The Teflon capsules are oriented so as to present the flat ends toward the center of the spherical donor to ensure as close to one-dimensional loading of the sample as possible. The explosive test samples are set at different distances from the donor to obtain various input pressures. The sketch in Figure 2 shows the general arrangement of the donor and four capsule holders within the tank of water. More test specimens can be added to the arrangement as indicated by the photograph in Figure 3. The extra capsule holders are mounted in holes drilled at an angle in the PMMA holder which was placed in front of the donor sphere.

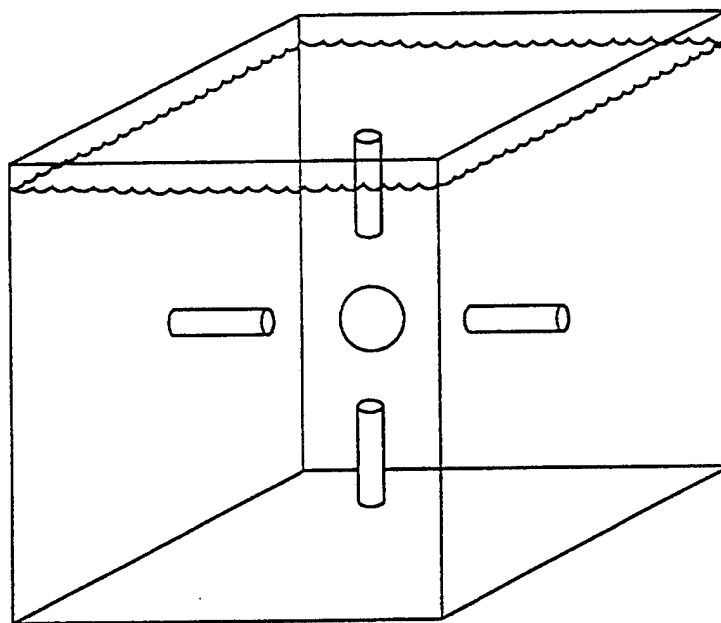


FIGURE 2. CAPSULE PLACEMENT AROUND PENTOLITE SPHERE

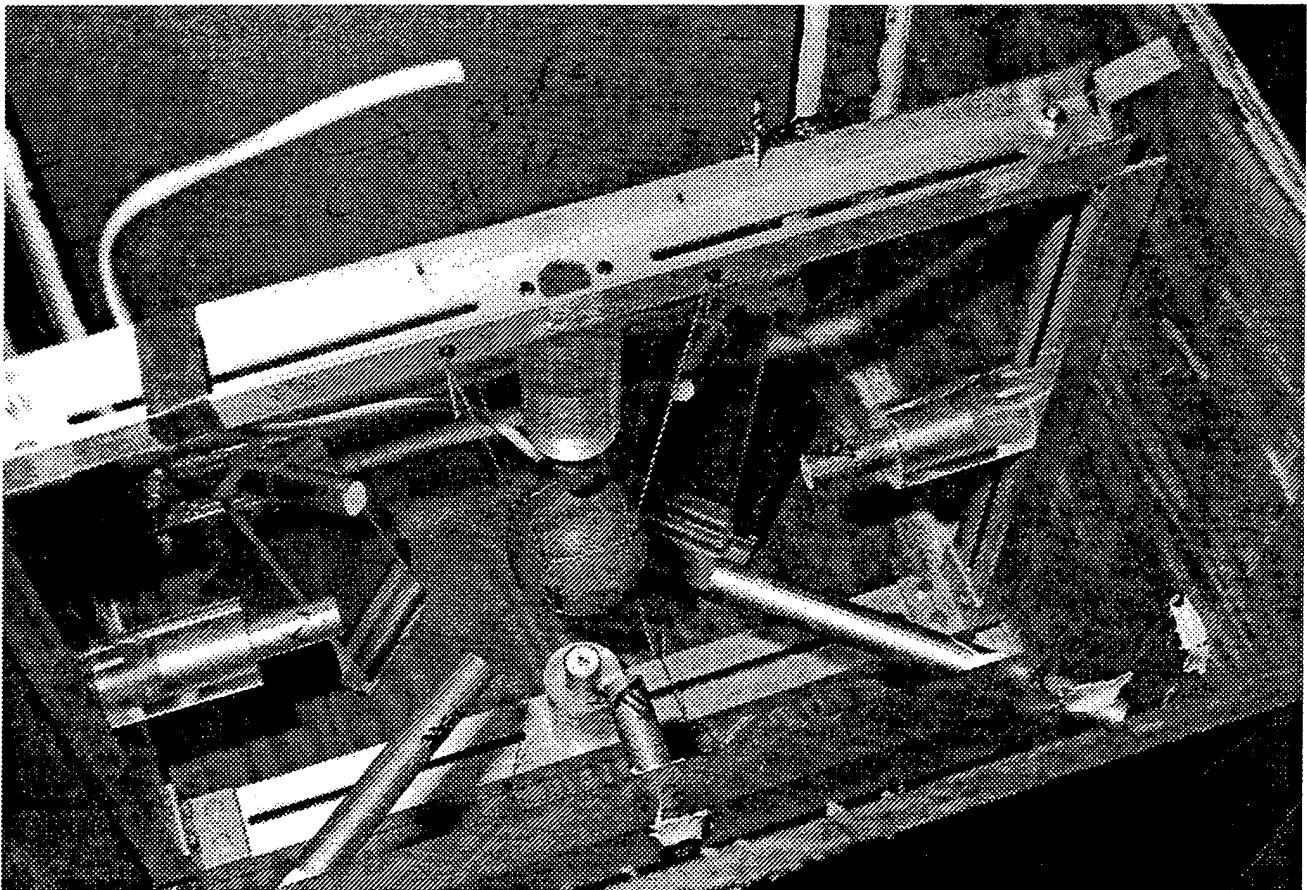
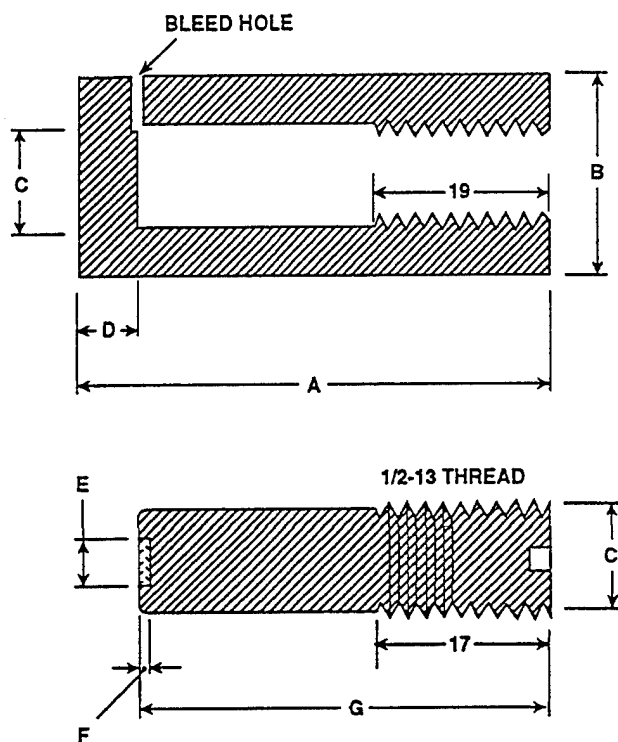


FIGURE 3. PLACEMENT OF NINE TEST SAMPLES IN UNFILLED TANK

**Sample Holder:**

The Teflon sample holder (capsule) is in two parts—a cap and a threaded rod (plug) with a cavity in one end to accommodate the explosive test sample (Figure 4). A 1.6-mm-diameter bleed hole is located at the end of the cavity in the cap to permit air to escape when the threaded plug is inserted into the cap. In early versions of the test capsule, the plug was threaded along its entire length. However, the plug had a tendency to warp, causing it to bind while being screwed into the cap. This made it difficult to know if the explosive specimen was properly confined with the capsule. As a consequence, the threaded length inside the cap was changed to 19 mm (17 mm for the plug). To seal the sample after assembly, the two parts of the capsule originally were etched chemically to permit bonding with special epoxy. Unfortunately, the bonding was so strong that it made it extremely difficult to recover the test sample. The final design uses the 19-mm-long thread without cement. A pipe thread compound containing Teflon is used to seal the threads. After assembly, the bleed hole is plugged with Duxseal.



## DIMENSIONS IN MILLIMETERS

A	50.8	E	5.2 (dia)
B	21.3 (dia)	F	0.89
C	10.71 (dia)	G	44.5
D	6.4		

\*SNUG FIT

FIGURE 4. TEFLON SAMPLE CAPSULE:  
CAP (TOP) AND THREADED PLUG

### Support Tube:

The steel support tube is bored out to a diameter which just allows the sample capsule to slide within the tube. The reamed section is just deep enough to allow the capsule to be pushed in flush with the edge of the steel tube. The capsule is held in place by the close fit. The steel support tube has several 2.4-mm holes drilled in the side along its length to permit water to fill the tube completely. A PMMA collar can be made so that the steel support tube can be positioned at any desired angle. The steel support tube arrangement is shown in Figure 5. The length of the PMMA collar, as well as the length of the steel tube, can be such that considerable flexibility in adjustment is possible.

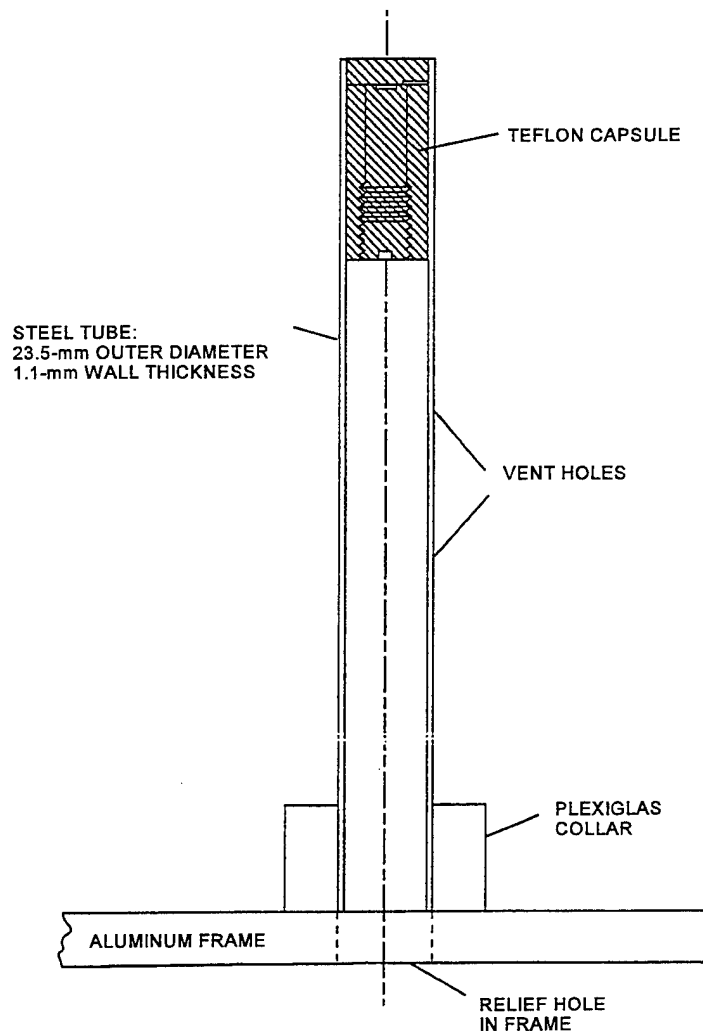


FIGURE 5. CAPSULE HOLDER ARRANGEMENT

**Reduction of Capsule Damage:**

Although a number of improvements in the recovery system were made during the development period, damage to the capsules remained excessive. Toward the end of the investigation, it was suspected that the impact of the tube against the aluminum frame might be the main reason for the excessive damage. Because of this, holes were cut in the aluminum frame to allow the steel tube to slip through the Plexiglas collar when the shock impacted the tube. Relief holes in the aluminum frame can be seen in Figure 3. This apparently solved the problem since all explosive samples were successfully recovered after this alteration was made.

### Shock History of Recovered Sample:

The UST donor used in the recovery system subjects the explosive samples to relatively long low-pressure shocks of spherical geometry. The shock duration is 20 to 40  $\mu$ s in the water, the duration increasing with distance from the donor.<sup>3</sup> The calibration of the UST<sup>1</sup>, i.e., the peak pressure in the water,  $P_w$ , as a function of distance from the donor surface,  $x$ , is given in Table I. The distance is measured along an imaginary straight line extending outward from the center of the spherical donor.

TABLE I. CALIBRATION OF THE UNDERWATER SENSITIVITY TEST

[The water gap,  $x_w$ , is the sum of a number in the first column and a number in the first row. Pressures in kilobars.]

$x_w$ (mm)	0	1	2	3	4	5	6	7	8	9
10	69.48	65.53	61.89	58.53	55.41	52.53	49.86	47.38	45.09	42.95
20	40.96	39.11	37.38	35.76	34.25	32.83	31.51	30.26	29.09	27.99
30	26.95	25.98	25.05	24.18	23.36	22.58	21.84	21.14	20.47	19.84
40	19.24	18.67	18.12	17.60	17.11	16.63	16.18	15.75	15.33	14.94
50	14.56	14.20	13.85	13.51	13.19	12.88	12.59	12.30	12.03	11.76
60	11.51	11.26	11.02	10.79	10.57	10.36	10.15	9.95	9.76	9.58
70	9.40	9.22	9.02	8.89	8.73	8.57	8.42	8.28	8.14	8.00
80	7.87	7.74	7.61	7.49	7.37	7.26	7.15	7.04	6.93	6.83
90	6.73	6.63	6.53	6.44	6.35	6.26	6.17	6.09	6.00	5.92
100	5.84	5.77	5.69	5.62	5.55	5.48	5.41	5.34	5.27	5.21
110	5.15	5.08	5.02	4.96	4.91	4.85	4.79	4.74	4.69	4.63
120	4.58	4.53	4.48	4.43	4.39	4.34	4.29	4.25	4.21	4.16
130	4.12	4.08	4.04	4.00	3.96	3.92	3.88	3.84	3.81	3.77
140	3.73	3.70	3.67	3.63	3.60	3.57	3.53	3.50	3.47	3.44
150	3.41	3.38	3.35	3.32	3.29	3.27	3.24	3.21	3.18	3.16
160	3.13	3.11	3.08	3.06	3.03	3.01	2.98	2.96	2.94	2.91
170	2.89	2.87	2.85	2.83	2.81	2.78	2.76	2.74	2.72	2.70
180	2.68	2.66	2.65	2.63	2.61	2.59	2.57	2.55	2.54	2.52
190	2.50	2.48	2.47	2.45	2.43	2.42	2.40	2.39	2.36	2.35
200	2.34	—	—	—	—	—	—	—	—	—

Highly instrumented experiments would be required to determine the shock pressure-time profile of the small explosive test samples to an uncertainty of  $\pm 5\%$ . A second approach to obtaining the stress-time profiles to uncertainties of  $\pm 10\%$  would be to run two-dimensional hydrocodes. Since neither of the above approaches have been used, all that can reasonably be done is to determine the peak pressure entering the test samples to uncertainties of  $\pm 10\%$  and shock pulse time half-widths to  $\pm 20\%$  (see Appendix G of ref. 1).

An example of how the approximate shock history in an explosive sample is determined is as follows. First, the peak pressure in the water, taken from Table I, is plotted as a function of  $x$ , as in Figure 6. It is seen that the peak pressure of the spherical shockwave in water is 14.2 kbar just before the shock front contacts the center of the flat surface of the Teflon capsule at  $x_1 = 50.8$  mm. This stress is found to be 19.9 kbar by using standard impedance relations and is shown in Figure 7 for a graphical solution. The shock impedance relationships (shock velocity versus particle velocity) for water and Teflon are taken from ref. 5 and 6 respectively. The peak stress entering the Teflon at  $x_1$  is known to an uncertainty of  $\pm 8\%$  according to standard error analysis<sup>4</sup>. Next, the stress in the Teflon capsule at the boundary with a TATB sample prior to the wave entering the TATB,  $x_2 = 57.2$  mm, is 17.0 kbar to within

$\pm 10\%$ . It is assumed that the decay of the peak pressure through 6.4 mm of Teflon is proportional to the decay of pressure through an equivalent distance in water, as demonstrated in Figure 6. Finally, the peak pressure entering the TATB sample,  $19.0 \text{ kbar} \pm 15\%$ , is determined by using the unreacted shock impedance relation for TATB.<sup>7</sup>

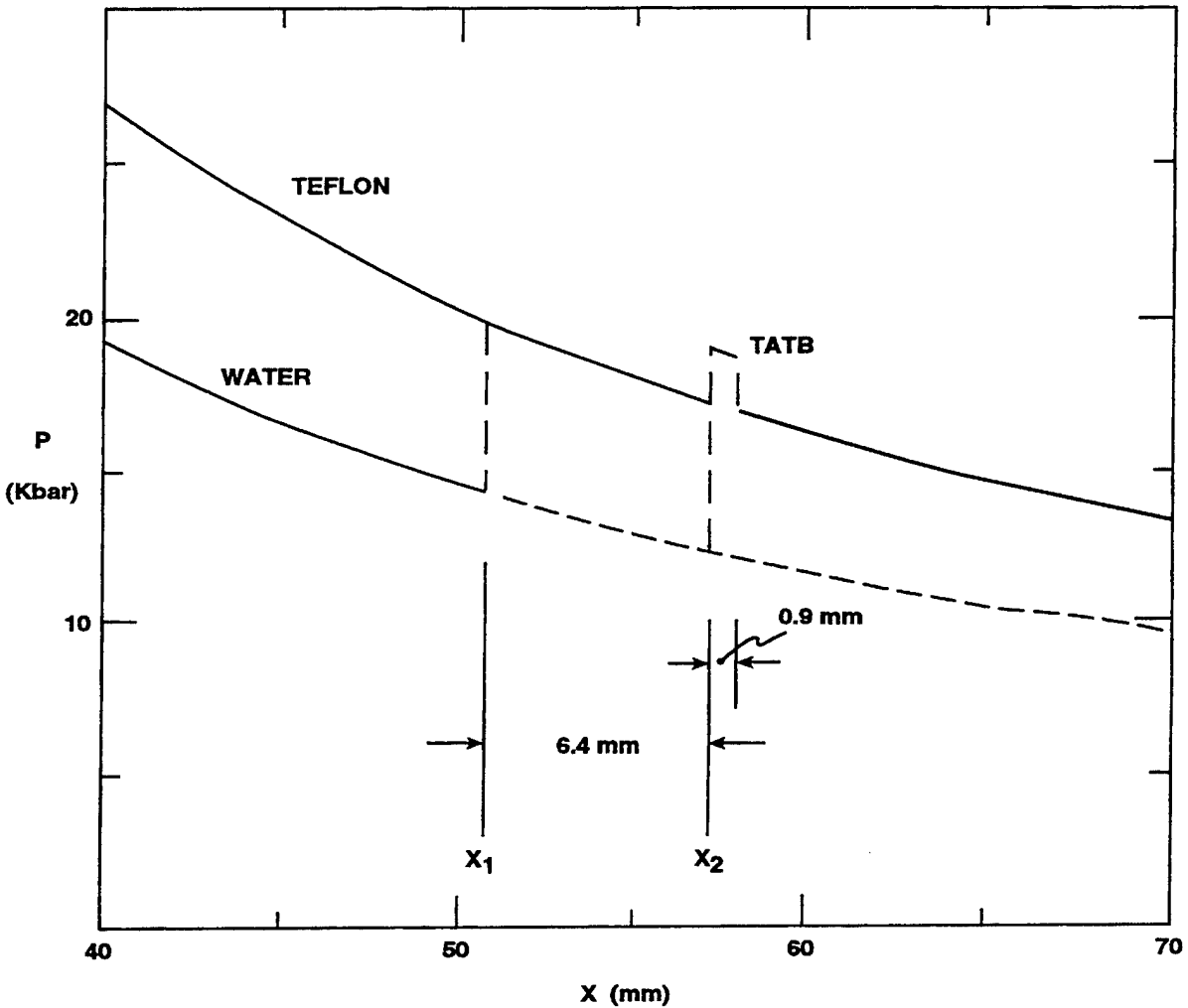


FIGURE 6. METHOD OF DETERMINING THE PEAK STRESS RESEARCHING TO TEFLON AND TATB

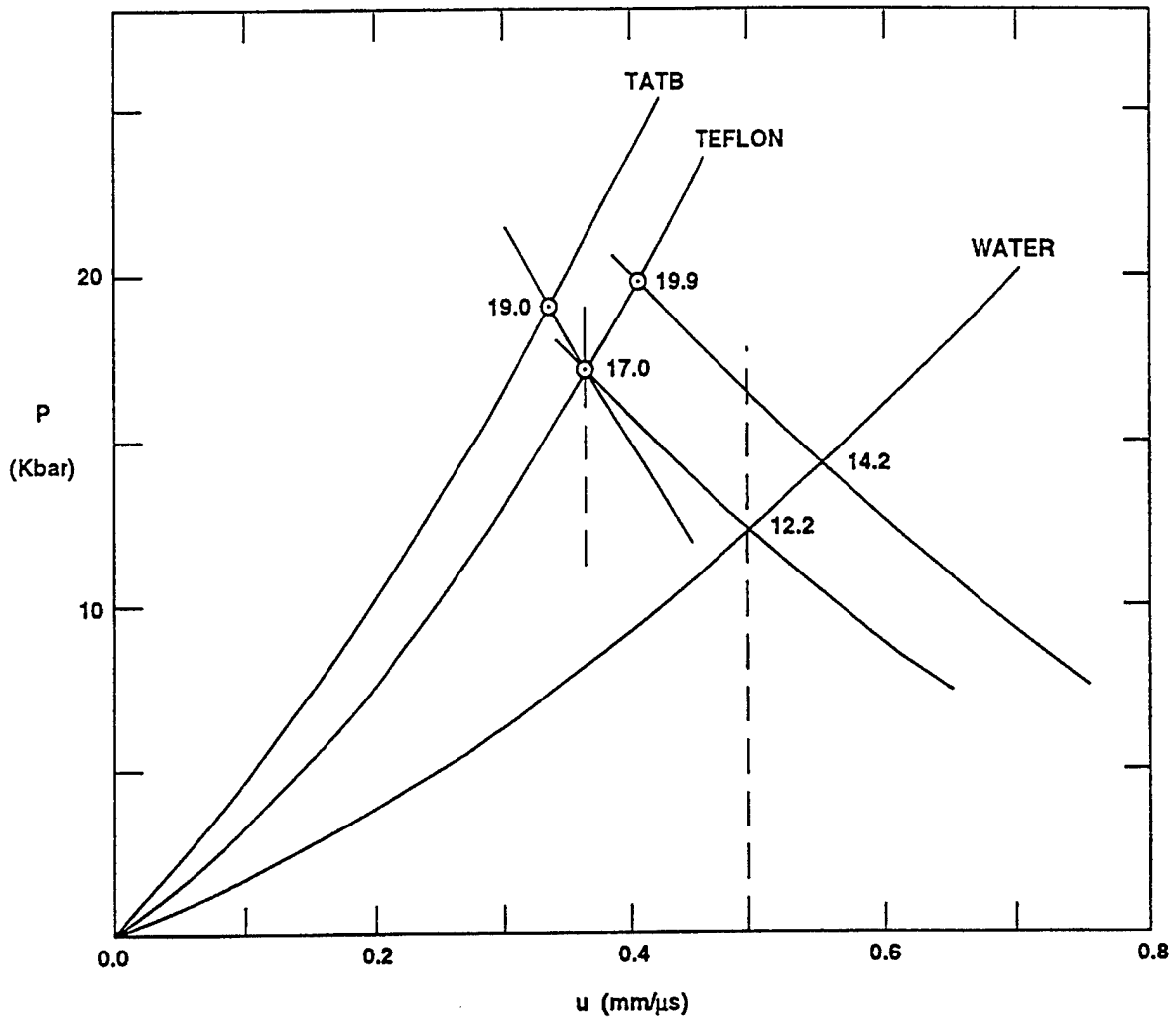


FIGURE 7. GRAPHIC METHOD OF DETERMINING PRESSURES TRANSMITTED TO THE TEFLON CAPSULE AND TATB SAMPLE

Since the Teflon and the explosive have about the same shock impedance, the shape of the stress-time pulse at the center line of the small sample (0.9 mm thick by 5 mm diameter) is primarily limited by the relief waves originating from the Teflon capsules. Assuming the pressure pulse half-width is about equal to the time of travel of the relief wave from the outer radial edge to the center of the Teflon holder gives a pulse half-width of about 5.3  $\mu$ s (i.e.  $\sim 10.6$  mm/[2 mm/ $\mu$ s]).

## RESULTS

In Table II are the results of the recovery experiments done to date. A number of papers reported the chemical and physical changes found in some of the samples in the table that were shocked to threshold pressures.<sup>8,9,10,11</sup> In recovered shocked TATB, sub-micron ragged holes were found, accompanied by a fine deposit of furoxan and furazan derivative of TATB. Since the furoxans are more sensitive than TATB, this alteration of the molecule provides a chemical basis of *hot spot* formation and sensitization of the explosive. The furazans are produced by the formation of a water molecule and identified as the first of the exothermic steps in the decomposition reaction of the molecule. In RDX and HMX, the products generated by shock compression are mostly volatile. Analysis of the recovered nitramine material observed a loss of nitro functional groups. In HMX subjected to an underwater shock, a 16% loss of nitro groups was observed.

TABLE II. RESULTS OF RECOVERY EXPERIMENTS

Experiment No. <sup>a</sup>	Sample	Distance capsule is from sphere (mm)	Pressure in Teflon (Kbar)	Results
83-77A	TATB	135	4.9	Sample reacted, no recovery
83-79	TATB	125	5.5	Sample recovered
83-81	TATB(A)	76	10.3	Sample recovered
	TATB(B)	64	13.1	Sample recovered
	TATB(C)	57	14.9	Sample recovered
	TATB(D)	51	17.3	Sample recovered
88-665	HMX(A)	159	4.2	Sample recovered, three pieces found
	HMX(B)	182	3.5	Sample recovered, three pieces found
	HMX(C)	129	5.1	Sample recovered, three pieces found
	HMX(D)	130	5.1	Two pieces found
	NTO(E)	67	12.4	Sample recovered intact
	NTO(F)	49	18.1	Sample recovered intact
92-R1	TNT(I)	100	7.4	Sample recovered
	TNT(II)	120	5.7	Sample recovered
	TATB(III)	50	17.7	Sample recovered
	TATB(IV)	40	22.8	Sample recovered
	RDX crystals(VI)	50	17.7	End blown off capsule, small parts of crystals found
	RDX crystals(VII)	40	22.8	End blown off capsule, no recovery
	CL20/Oil(VIII)	100	7.4	Capsule recovered, soot around air hole, residue found
	CL20/Oil(IX)	150	4.5	Capsule recovered, soot around air hole, residue found

<sup>a</sup>TATB, TNT, NTO, and HMX samples were pressed to 95% to 97% theoretical maximum density.

### SUMMARY

A technique has been developed to recover explosives undergoing stresses as high as 26 kbar. Physical (microscopic) and chemical examination of recovered explosives has led to the discovery of new chemical reactions occurring in these explosives.

Improved understanding of this recovery technique results requires two-dimensional hydrocode calculations. These calculations will also give guidance for future improvements of this recovery technique. One obvious improvement would be to replace the steel capsule holders with plastic ones to reduce the impedance mismatch between the capsule holders and the Teflon capsules.

## REFERENCES

1. Liddiard, T.P., Forbes, J.W., *A Summary Report of the Modified Gap Test and The Underwater Sensitivity Test*, NSWC TR 86-350, 12 March 1987.
2. Liddiard, T.P., Forbes, J.W., Price, D., "Physical Evidence of Different Chemical Reactions in Explosives as a Function of Stress," Ninth Symposium (International) on Detonation, Portland, OR, 28 Aug-1 Sep 1989, pp. 1235-1242.
3. Liddiard, T.P., Forbes, J.W., *Shockwaves in Fresh Water Generated by the Detonation of Pentolite Spheres*, NSWC TR 82-488, 26 May 1983.
4. Beers, Y., *Introduction to the Theory of Errors* (Addison-Wesley Co., Inc., 1962), 2nd edition.
5. Rice, M.H., Walsh, J.M., "Equation of State of Water to 250 Kilobars," *J. Chem Phys.*, Vol. 26, No. 4, 1957, pp. 824-830.
6. Champion, A.R., "Shock Compression of Teflon from 2.5 to 25 kbar—Evidence for a Shock-Induced Transition," *J. Appl. Phys.*, Vol. 42, No. 13, 1971, pp. 5546-5550.
7. Coleburn, N.L., Liddiard, T.P., "Hugoniot Equations of State for Several Unreacted Explosives," *J. Appl. Phys.*, Vol. 44, 1966, pp. 1929-1936.
8. Sharma, J., Beard, B.C., Forbes, J., Coffey, C.S., "Physical and Chemical Nature of Hot Spots in TATB and HMX," Ninth Symposium (International) on Detonation, Portland, OR, 28 Aug-1 Sep 1989, pp. 897-905.
9. Sharma, J., Forbes, J.W., Coffey, C.S., Liddiard, T.P., "The Physical and Chemical Nature of Sensitization Centers Left from Hot Spots Caused in Triaminotrinitrobenzene by Shock or Impact," *J. Phys. Chem.*, 10, 1987, pp. 5139-5144.
10. Sharma, J., Hoffsommer, J.C., Glover, D.J., Coffey, C.S., Forbes, J.W., Liddiard, T.P., Elban, W.L., Santiago, F., "Sub-Ignition Reactions at Molecular Levels in Explosives Subjected to Impact and Underwater Shock," Eighth Symposium (International) on Detonation, Albuquerque, NM, 15-19 July 1985, pp. 725-733.
11. Sharma, J., Beard, B.C., *Energetic Materials*, (Edited by J. E. Field and P. Gray), The Royal Society, London, (1992), pp. 285-292.

## DISTRIBUTION

SD (A) DDRE (R AT ET) STAFF SPEC FOR WEAPONS TECHNOLOGY ATTN F MENZ THE PENTAGON WASHINGTON DC 20301	1	DEFENSE RESEARCH AND ENGINEERING ATTN TECHNICAL LIBRARY WASHINGTON DC 20305	1
OUSD(A&T) S&TS/M ATTN G KOPCSAK (OM) THE PENTAGON WASHINGTON DC 20301-3080	1	DEFENSE RESEARCH AND ENGINEERING ATTN DIRECTOR WASHINGTON DC 20305	1
OASN RE&S ATTN SURFACE WARFARE THE PENTAGON WASHINGTON DC 20301	1	INSTITUTE FOR DEFENSE ANALYSES ATTN TECHNICAL LIBRARY (FRIES) 1801 N BEAUREGARD ST ALEXANDRIA VA 22311	1
OASN RE&S ATTN AIR WARFARE THE PENTAGON WASHINGTON DC 20301	1	DIRECTOR DEF ADVANCED RESEARCH PROJECTS OFF ATTN LIBRARY 1400 WILSON BOULEVARD ARLINGTON VA 22209	1
OASN RE&S ATTN SUBS ASW THE PENTAGON WASHINGTON DC 20301	1	DIRECTOR DEFENSE NUCLEAR AGENCY ATTN TECHNICAL LIBRARY WASHINGTON DC 20305	1
NAVAL SURFACE WARFARE CENTER ATTN I BLATSTEIN (TD) WASHINGTON DC 20362	1	DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SPSP (P CASTLEBERG) WASHINGTON DC 20305	1
ADMINISTRATOR DEF TECHNICAL INFORMATION CENTER ATTN: DTIC-OCC CAMERON STATION, BLDG. 5 ALEXANDRIA, VA 22304-6145	2	DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SPSP (J CONNELL) WASHINGTON DC 20305	1
COMMANDER CENTER FOR NAVAL ANALYSIS ATTN TECHNICAL LIBRARY 200 N BEAUREGARD ST ALEXANDRIA VA 22311	1	DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SPSP (J DEPLITCH) WASHINGTON DC 20305	1
	1	DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SPSP (K GOERING) WASHINGTON DC 20305	1

IHTR 1821

DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SPSD (K STEIN) WASHINGTON DC 20305	1	COMMANDING OFFICER NAVAL RESEARCH LABORATORY ATTN T RUSSELL WASHINGTON DC 20350-5000	1
DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SPSP (M FRANKEL) WASHINGTON DC 20305	1	OFF OF THE CHIEF OF NAVAL RESEARCH ATTN ONR 333 (R MILLER) 800 N QUINCY ST BCT1 ARLINGTON VA 22217-5000	1
DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SPSP (T FREDRICKSON) WASHINGTON DC 20305	1	OFF OF THE CHIEF OF NAVAL RESEARCH ATTN ONR 351 (D SIEGEL) 800 N QUINCY ST BCT1 ARLINGTON VA 22217-5000	1
DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SPSP (K. KIM) WASHINGTON DC 20305	1	OFF OF THE CHIEF OF NAVAL RESEARCH ATTN ONR 323 (J GOLDWASSER) 800 N QUINCY ST BCT1 ARLINGTON VA 22217-5000	1
DIRECTOR DEFENSE NUCLEAR AGENCY ATTN SP (C MCFARLAND) WASHINGTON DC 20305	1	OFF OF THE CHIEF OF NAVAL RESEARCH ATTN ONR 35 (E ZIMET) 800 N QUINCY ST BCT1 ARLINGTON VA 22217-5000	1
DEPT OF DEF EXPLOSIVE SAFETY BOARD HOFFMAN BUILDING 1 ATTN DDESB KT 2461 EISENHOWER AVENUE ALEXANDRIA VA 22331-0600	1	OFF OF THE CHIEF OF NAVAL RESEARCH ATTN ONR 911 800 N QUINCY ST BCT1 ARLINGTON VA 22217-5000	1
DEPT OF DEF EXPLOSIVE SAFETY BOARD HOFFMAN BUILDING 1 ATTN DDESB KT1 (J WARD) 2461 EISENHOWER AVENUE ALEXANDRIA VA 22331-0600	1	OFF OF THE CHIEF OF NAVAL RESEARCH ATTN ONR 333 (J FEIN) 800 N QUINCY ST BCT1 ARLINGTON VA 22217-5000	1
COMMANDING OFFICER NAVAL RESEARCH LABORATORY ATTN A WILLIAMS WASHINGTON DC 20350-5000	1	OFF OF THE CHIEF OF NAVAL RESEARCH ATTN ONR 333 (D HOUSER) 800 N QUINCY ST BCT1 ARLINGTON VA 22217-5000	1
COMMANDING OFFICER NAVAL RESEARCH LABORATORY ATTN TECHNICAL LIBRARY WASHINGTON DC 20350-5000	1	CHIEF OF NAVAL OPERATIONS ATTN OP 005 WASHINGTON DC 20350	1
		CHIEF OF NAVAL OPERATIONS ATTN OP 02 WASHINGTON DC 20350	1

DISTRIBUTION 2

CHIEF OF NAVAL OPERATIONS ATTN OP 03 WASHINGTON DC 20350	1	COMMANDER SPACE AND NAVAL WARFARE SYSTEMS COMMAND ATTN SPAWAR 05 WASHINGTON DC 20363-5100	1
CHIEF OF NAVAL OPERATIONS ATTN OP 035 WASHINGTON DC 20350	1	COMMANDER DAVID TAYLOR RESEARCH CENTER ATTN CODE 177 UERD PORTSMOUTH VA 23709	1
CHIEF OF NAVAL OPERATIONS ATTN OP 0354 WASHINGTON DC 20350	1	COMMANDER DAVID TAYLOR RESEARCH CENTER ATTN TECHNICAL LIBRARY UERD PORTSMOUTH VA 23709	1
CHIEF OF NAVAL OPERATIONS ATTN OP 070 WASHINGTON DC 20350	1	JHU/CPIA ATTN: SECURITY OFFICER 10630 LITTLE PATUXENT PKWY, STE. 202 COLUMBIA, MD 21044-3200	1
COMMANDER NAVAL AIR SYSTEMS COMMAND ATTN TECHNICAL LIBRARY WASHINGTON DC 20361	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN TECHNICAL LIBRARY CARDEROCK DIVISION BETHESDA MD 20084-5000	1
COMMANDER NAVAL AIR SYSTEMS COMMAND ATTN AIR 540 WASHINGTON DC 20361	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN R GARRISON CARDEROCK DIVISION BETHESDA MD 20084-5000	1
COMMANDER NAVAL AIR SYSTEMS COMMAND ATTN AIR 5404 WASHINGTON DC 20361	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN S WANG CARDEROCK DIVISION BETHESDA MD 20084-5000	1
COMMANDER NAVAL AIR SYSTEMS COMMAND ATTN AIR 54051 WASHINGTON DC 20361	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN R TUSSING CARDEROCK DIVISION BETHESDA MD 20084-5000	1
COMMANDER NAVAL AIR SYSTEMS COMMAND ATTN AIR 54043 WASHINGTON DC 20361	1		

IHTR 1821

COMMANDER  
NAVAL SURFACE WARFARE CENTER  
ATTN W CONLEY  
CARDEROCK DIVISION  
BETHESDA MD 20084-5000 1

COMMANDER  
NAVAL SURFACE WARFARE CENTER  
ATTN F FISCH  
CARDEROCK DIVISION  
BETHESDA MD 20084-5000 1

COMMANDER  
NAVAL SURFACE WARFARE CENTER  
ATTN CODE 17  
CARDEROCK DIVISION  
BETHESDA MD 20084-5000 1

COMMANDER  
NAVAL SURFACE WARFARE CENTER  
ATTN CODE 172  
CARDEROCK DIVISION  
BETHESDA MD 20084-5000 1

COMMANDING OFFICER  
NAVAL SURFACE WARFARE CENTER  
NAVAL COASTAL SYSTEMS STATION  
ATTN TECHNICAL LIBRARY  
PANAMA CITY FL 32407-5000 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 05  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 06APR (MUIR)  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 06  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 62Y  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 06U  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 62  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 62Z  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 91WM  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 91WM1  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN SEA 9961  
WASHINGTON DC 20362-5105 2

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN PMO 422 16 (LUBIN)  
WASHINGTON DC 20362-5105 1

COMMANDER  
NAVAL SEA SYSTEMS COMMAND  
ATTN PMO 422G  
WASHINGTON DC 20362-5105 1

DISTRIBUTION 4

COMMANDER NAVAL SEA SYSTEMS COMMAND ATTN CHENG T1 (RITTER) WASHINGTON DC 20362-5105	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C27 CHINA LAKE CA 93555-6001	1
COMMANDER NAVAL ORDNANCE CENTER ATTN N7 INDIAN HEAD MD 20640	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C27A (C PORTER) CHINA LAKE CA 93555-6001	1
COMMANDER NAVAL ORDNANCE CENTER ATTN N71 INDIAN HEAD MD 20640	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C27A (S DEMAY) CHINA LAKE CA 93555-6001	1
COMMANDER NAVAL ORDNANCE CENTER ATTN N713 INDIAN HEAD MD 20640	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C2773 (D BLUE) CHINA LAKE CA 93555-6001	1
COMMANDING OFFICER NAVAL EXPLOSIVE ORDNANCE DISPOSAL TECHNOLOGY CENTER ATTN TECHNICAL LIBRARY INDIAN HEAD MD 20640	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C2711 (J BALDWIN) CHINA LAKE CA 93555-6001	1
COMMANDER NAVAL UNDERWATER WARFARE CENTER DIVISION ATTN TECHNICAL LIBRARY NEWPORT RI 02841-5047	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C2712 (C HALSEY) CHINA LAKE CA 93555-6001	1
COMMANDER NAVAL UNDERWATER WARFARE CENTER DIVISION ATTN CODE 363 (R NADOLINK) NEWPORT RI 02841-5047	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C2713 (T MOORE) CHINA LAKE CA 93555-6001	1
COMMANDING OFFICER NAVAL INTEL SUPPORT CENTER 4302 SUITLAND ROAD WASHINGTON DC 20390-5140	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C2713 (H JOHN) CHINA LAKE CA 93555-6001	1
COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN TECHNICAL LIBRARY CHINA LAKE CA 93555-6001	1	COMMANDER NAVAL AIR WARFARE WEAPONS DIV ATTN CODE C2714 (M SWETT) CHINA LAKE CA 93555-6001	1

IHTR 1821

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C274 (S FOWLER)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C271 (L JOSEPHSON)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C274 (WEEKS)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C274 (N FASIG)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C274 (BUCKLEY)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C2743 (R COPE)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C2745 (J WALLER)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C2746 (L BRAUER)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C277  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C0235 (J FISCHER)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C0235 (G LINDSAY)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C0235 (R HOLLINS)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C0239 (T BOGGS)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C02931 (M CHAN)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C02394 (J COVINO)  
CHINA LAKE CA 93555-6001 1

COMMANDER  
NAVAL AIR WARFARE WEAPONS DIV  
ATTN CODE C0239 (A LINDFORS)  
CHINA LAKE CA 93555-6001 1

COMMANDING OFFICER  
NAVAL SURFACE WARFARE CENTER  
PORT HUENEME DIVISION  
PORT HUENEME CA 93043 1

COMMANDING OFFICER  
NAVAL UNDERSEA WARFARE DIVISION  
KEWPORT WA 98345-0580 1

DISTRIBUTION 6

COMMANDER NAVAL WEAPONS EVALUATION FAC KIRTLAND AIR FORCE BASE ALBUQUERQUE NM 87117	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 (W MOCK) DAHLGREN VA 22448-5000	1
COMMANDER NAVAL SURFACE WARFARE CENTER ATTN LIBRARY DAHLGREN VA 22448-5000	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 (T SMITH) DAHLGREN VA 22448-5000	1
COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G10 DAHLGREN VA 22448-5000	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 (T SPIVAK) DAHLGREN VA 22448-5000	1
COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G13 (D L DICKINSON) DAHLGREN VA 22448-5000	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 (T SWIERK) DAHLGREN VA 22448-5000	1
COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G13 (T WASMOND) DAHLGREN VA 22448-5000	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 (S WAGGENER) DAHLGREN VA 22448-5000	1
COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G20 DAHLGREN VA 22448-5000	1	COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 (L WILSON) DAHLGREN VA 22448-5000	1
COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 DAHLGREN VA 22448-5000	1	COMMANDING GENERAL MARINE CORPS DEV & EDUCATION COM MARINE CORPS LAND FORCE DEV CEN ATTN LIBRARY QUANTICO VA 22134	1
COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 (C GARNETT) DAHLGREN VA 22448-5000	1	COMMANDING OFFICER NAVAL SURFACE WARFARE CENTER CRANE DIVISION ATTN LIBRARY CRANE IN 47522-5001	1
COMMANDER NAVAL SURFACE WARFARE CENTER ATTN G22 (W HOLT) DAHLGREN VA 22448-5000	1	COMMANDING OFFICER NAVAL SURFACE WARFARE CENTER CRANE DIVISION ATTN CODE 3031 (E NEAL) CRANE IN 47522-5001	1

IHTR 1821

COMMANDING OFFICER NAVAL SURFACE WARFARE CENTER CRANE DIVISION ATTN CODE 50D (A NORRIS) CRANE IN 47522-5001	1	PRESIDENT NAVAL WAR COLLEGE ATTN TECHNICAL LIBRARY NEWPORT RI 02841	1
COMMANDING OFFICER NAVAL SURFACE WARFARE CENTER CRANE DIVISION ATTN CODE 505 (J SHORT) CRANE IN 47522-5001	1	COMMANDING OFFICE SEAL TEAM 2 FPO AE 09510-4633	1
COMMANDING OFFICER NAVAL SURFACE WARFARE CENTER CRANE DIVISION ATTN CODE 90 (A WHITNER) CRANE IN 47522-5001	1	COMMANDER US ARMY MISSILE COMMAND ATTN AMSMI RD ST WF (LOVELACE) REDSTONE ARSENAL AL 35898-5247	1
COMMANDING OFFICER NAVAL SURFACE WARFARE CENTER CRANE DIVISION ATTN CODE PM 412 (M TILL) CRANE IN 47522-5001	1	DIRECTOR ARMY MATERIALS SYSTEMS ANALYSIS AGENCY ATTN DRXSY D ABERDEEN PROVING GROUND MD 21005	1
COMMANDING OFFICER NAVAL SURFACE WARFARE CENTER CRANE DIVISION ATTN CODE PM 413 (L MASSA) CRANE IN 47522-5001	1	DIRECTOR ARMY MATERIALS SYSTEMS ANALYSIS AGENCY ATTN DRXSY J (J MCCARTHY) ABERDEEN PROVING GROUND MD 21005	1
COMMANDER NAVAL COM AND CONTROL OCEAN SURVELLIANCE CENTER ATTN TECHNICAL LIBRARY SAN DIEGO CA 92152-5000	1	DIRECTOR USARL ATTN R FREY ABERDEEN PROVING GROUND MD 21005	1
COMMANDER PACIFIC MISSILE TEST CENTER ATTN CODE 2145 POINT MUGU CA 93042	1	DIRECTOR USARL ATTN W HILLSTROM ABERDEEN PROVING GROUND MD 21005	1
SUPERINTENDENT NAVAL POSTGRADUATE SCHOOL ATTN LIBRARY MONTEREY CA 93940	1	DIRECTOR USARL ATTN R JAMIESON ABERDEEN PROVING GROUND MD 21005	1

DISTRIBUTION 8

DIRECTOR USARL ATTN J STARKENBERG ABERDEEN PROVING GROUND MD 21005	1	COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DRDSMC LCE (E BAKER) DOVER NJ 07806-5000	1
DIRECTOR USARL ATTN L VANDEKIEFT ABERDEEN PROVING GROUND MD 21005	1	COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DRSMC LCE C DOVER NJ 07806-5000	1
DIRECTOR USARL ATTN W WALTERS ABERDEEN PROVING GROUND MD 21005	1	COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DRSMC LCE D DOVER NJ 07806-5000	2
DIRECTOR USARL ATTN TECHNICAL LIBRARY ABERDEEN PROVING GROUND MD 21005	1	COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DRSMC LCM DOVER NJ 07806-5000	2
DIRECTOR USARL ATTN STINFO OFFICE ABERDEEN PROVING GROUND MD 21005	1	COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DRSMC LCM SA (R WESTERDAHL) DOVER NJ 07806-5000	1
US ARMY LABORATORY COMMAND ATTN AMSLC TD 2800 POWDER MILL ROAD ADELPHI MD 20783-1145	1	COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DRSMC LCU DOVER NJ 07806-5000	2
SANDIA NATIONAL LABORATORY ATTN E AUSTIN TECH LIBRARY REPORTS RECEIVING CLERK PO BOX 5800 ALBUQUERQUE NM 87185	1	COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DRSMC LCU E DOVER NJ 07806-5000	1
COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DRSMC TD DOVER NJ 07806-5000	1	COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN AMSTA-AR-QAS DOVER NJ 07806-5000	1
COMMANDER US ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENG CENTER ATTN DDRSMC LCE DOVER NJ 07806-5000	2		

IHTR 1821

COMMANDER  
US ARMY ARMAMENT RESEARCH  
DEVELOPMENT AND ENG CENTER  
ATTN AMSTA-AR-AEE-WE  
DOVER NJ 07806-5000 1

COMMANDER  
US ARMY RESEARCH OFFICE  
ATTN G R HUSK  
PO BOX 12211  
RESEARCH TRIANGLE PARK NC 27709-2211 1

COMMANDER  
AIR FORCE OFF OF SCIENTIFIC RESEARCH  
ATTN T MATUSKO  
BOLLING AIR FORCE BASE  
WASHINGTON DC 20332 1

AIR FORCE INTELLIGENCE SERVICE  
ATTN AFIS INTAW (MAJ R ESAW)  
BOLLING AIR FORCE BASE  
WASHINGTON DC 20332-5000 1

COMMANDER  
AIR FORCE ASTRONAUTICS LABORATORY  
ATAL MKPL  
ATTN C MERRILL  
EDWARDS AFB CA 93521 1

COMMANDER  
AIR FORCE ASTRONAUTICS LABORATORY  
ATAL MKPL  
ATTN F ROBERTO  
EDWARDS AFB CA 93521 1

DEPT OF INTERIOR BUREAU OF MINES  
PITTSBURGH RESEARCH CENTER  
ATTN R WATSON  
COCHRANS MILL ROAD  
PITTSBURGH PA 15236-00700 1

COMMANDER  
AFATL MN  
ATTN WL MNMF (R BOULET)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN MNMF (R ERHART)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN AFDTC/SES (J MITCHELL)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN WL MNMW (E POSTON)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN WL MNME (S AUBERT)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN WL MNME (J CORLEY)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN WL MNME (G GLENN)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN WL MNME (R MCKENNEY)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN WL MNME (S STRUCK)  
EGLIN AFB FL 32542-5434 1

COMMANDER  
AFATL MN  
ATTN WL MNME (G PARSONS)  
EGLIN AFB FL 32542-5434 1

COMMANDER AFATL MN ATTN MSD SES (F WEST) EGLIN AFB FL 32542-5434	1	UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN F FOLTZ PO BOX 808 LIVERMORE CA 94550	1
COMMANDER AFATL MN ATTN MSD XRS (J JENNS JR) EGLIN AFB FL 32542-5434	1	UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN J HUMPHREY PO BOX 808 LIVERMORE CA 94550	1
UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN H JEAN HIGHBY (L53) PO BOX 808 LIVERMORE CA 94550	1	UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN J MAIENSCHIEIN PO BOX 808 LIVERMORE CA 94550	1
UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN R ATKINS (EMC DIRECTOR) PO BOX 808 LIVERMORE CA 94550	1	UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN A NICHOL PO BOX 808 LIVERMORE CA 94550	1
UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN K BAHL PO BOX 808 LIVERMORE CA 94550	1	UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN K SCRIBNER PO BOX 808 LIVERMORE CA 94550	1
UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN P CRAWFORD PO BOX 808 LIVERMORE CA 94550	1	UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN C SOUERS PO BOX 808 LIVERMORE CA 94550	1
UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN L GREEN PO BOX 808 LIVERMORE CA 94550	1	UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN R SIMPSON PO BOX 808 LIVERMORE CA 94550	1
UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB ATTN A FRANCK PO BOX 808 LIVERMORE CA 94550	1		

IHTR 1821

UNIVERSITY OF CALIFORNIA  
LAWRENCE LIVERMORE NATIONAL LAB  
ATTN W TAO  
PO BOX 808  
LIVERMORE CA 94550

1

UNIVERSITY OF CALIFORNIA  
LAWRENCE LIVERMORE NATIONAL LAB  
ATTN C TARVER  
PO BOX 808  
LIVERMORE CA 94550

1

UNIVERSITY OF CALIFORNIA  
LAWRENCE LIVERMORE NATIONAL LAB  
ATTN P URTIEW  
PO BOX 808  
LIVERMORE CA 94550

1

UNIVERSITY OF CALIFORNIA  
LAWRENCE LIVERMORE NATIONAL LAB  
ATTN R WEINGART  
PO BOX 808  
LIVERMORE CA 94550

1

SANDIA NATIONAL LABORATORY  
ATTN TECH LIBRARY (DARLENE M LOLL)  
PO BOX 969  
LIVERMORE CA 94550-0096

1

APPLIED RESEARCH LABORATORY  
PENNSYLVANIA STATE UNIVERSITY  
ATTN LIBRARIAN  
PO BOX 30 UNIVERSITY PARK  
STATE COLLEGE PA 16804

1

APPLIED RESEARCH LABORATORY  
PENNSYLVANIA STATE UNIVERSITY  
ATTN E LISZKA  
PO BOX 30 UNIVERSITY PARK  
STATE COLLEGE PA 16804

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN M 8  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN MST DO MS G 756  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN B ASAY  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN J BDZIL  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN A BOWMAN  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN G BUNTAIN  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN L CHAPMAN  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN M COBURN  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN J DAVIS  
PO BOX 1663  
LOS ALAMOS NM 87545

1

LOS ALAMOS NATIONAL LABORATORY  
ATTN J DICK  
PO BOX 1663  
LOS ALAMOS NM 87545

1

DISTRIBUTION 12

LOS ALAMOS NATIONAL LABORATORY ATTN B DOBRATZ PO BOX 1663 LOS ALAMOS NM 87545	1	LOS ALAMOS NATIONAL LABORATORY ATTN R RABIE PO BOX 1663 LOS ALAMOS NM 87545	1
LOS ALAMOS NATIONAL LABORATORY ATTN C FOREST PO BOX 1663 LOS ALAMOS NM 87545	1	LOS ALAMOS NATIONAL LABORATORY ATTN J REPA PO BOX 1663 LOS ALAMOS NM 87545	1
LOS ALAMOS NATIONAL LABORATORY ATTN J GOFORTH PO BOX 1663 LOS ALAMOS NM 87545	1	LOS ALAMOS NATIONAL LABORATORY ATTN S SHEFFIELD PO BOX 1663 LOS ALAMOS NM 87545	1
LOS ALAMOS NATIONAL LABORATORY ATTN J HOPSON PO BOX 1663 LOS ALAMOS NM 87545	1	LOS ALAMOS NATIONAL LABORATORY ATTN L STRETZ PO BOX 1663 LOS ALAMOS NM 87545	1
LOS ALAMOS NATIONAL LABORATORY ATTN P HOWE PO BOX 1663 LOS ALAMOS NM 87545	1	LOS ALAMOS NATIONAL LABORATORY ATTN P TANG PO BOX 1663 LOS ALAMOS NM 87545	1
LOS ALAMOS NATIONAL LABORATORY ATTN J N JOHNSON PO BOX 1663 LOS ALAMOS NM 87545	1	LOS ALAMOS NATIONAL LABORATORY ATTN D IDAR PO BOX 1663 LOS ALAMOS NM 87545	1
LOS ALAMOS NATIONAL LABORATORY ATTN J KENNEDY PO BOX 1663 LOS ALAMOS NM 87545	1	LOS ALAMOS NATIONAL LABORATORY ATTN E FERM PO BOX 1663 LOS ALAMOS NM 87545	1
LOS ALAMOS NATIONAL LABORATORY ATTN W MAUTZ PO BOX 1663 LOS ALAMOS NM 87545	1	THE JOHNS HOPKINS UNIVERSITY APP PHYSICS LAB PROP INFOR AGCY ATTN T W CHRISTIAN JOHNS HOPKINS ROAD LAUREL MD 20707-6099	1
LOS ALAMOS NATIONAL LABORATORY ATTN S PETERSON PO BOX 1663 LOS ALAMOS NM 87545	1	JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY ATTN TECH LIBRARY (DEANNA JONES) JOHNS HOPKINS ROAD LAUREL MD 20707-6099	1

IHTR 1821

N M INSTITUTE OF MINING TECHNOLOGY ATTN SECURITY ADMINISTRATOR (ELIZABETH A TILL) CAMPUS STATION SOCORRO NM 87801	1	BOEING AEROSPACE COMPANY ATTN E WILHELM PO BOX 3707 SEATTLE WA 98124	1
N M INSTITUTE OF MINING TECHNOLOGY ATTN CODE TERA (M KEMPTON) CAMPUS STATION SOCORRO NM 87801	1	BOEING AEROSPACE COMPANY ATTN R HELZER PO BOX 3707 SEATTLE WA 98124	1
N M INSTITUTE OF MINING TECHNOLOGY ATTN CODE CETR (T JOYNER) CAMPUS STATION SOCORRO NM 87801	1	COMARCO INC WEAPON SUPPORT DIVISION ATTN R SEWELL RIDGECREST CA	1
N M INSTITUTE OF MINING TECHNOLOGY ATTN CODE CETR (P PERSSON) CAMPUS STATION SOCORRO NM 87801	1	CHAMBERLAIN MFG CORP ATTN J MOSCHEL 550 ESTHER STREET WATERLOO IA 50704-2524	1
AEROJET ORDNANCE AND MANUFACTURING COMPANY ATTN G CHIN 9236 EAST HALL ROAD DOWNEY CA 90241	1	CHAMBERLAIN MFG CORP ATTN C STROSBERG 550 ESTHER STREET WATERLOO IA 50704-2524	1
ATLANTIC RESEARCH CORPORATION ATTN KENNETH GRAHAM 5945 WELLINGTON ROAD GAINESVILLE VA 22055-1699	1	CHAMBERLAIN MFG CORP ATTN J MEIER 550 ESTHER STREET WATERLOO IA 50704-2524	1
AVCO TECHTRON SYSTEMS INC ATTN F LASCHER 201 LOWELL STREET WILMINGTON MA 01887	1	CHAMBERLAIN MFG CORP ATTN M BRAMMER 550 ESTHER STREET WATERLOO IA 50704-2524	1
AVCO TECHTRON SYSTEMS INC ATTN E MOULIC 201 LOWELL STREET WILMINGTON MA 01887	1	DYNA EAST CORPORATION ATTN R WEST 320 ARCH STREET PHILADELPHIA PA 19104-2588	1
BATELLE MEMORIAL LABORATORY TACTICAL TECHNOLOGY CENTER ATTN JOSEPHINE HUGGINGS 505 KING AVENUE COLUMBUS OH 43201	1	DYNA EAST CORPORATION ATTN P CHOU 320 ARCH STREET PHILADELPHIA PA 19104-2588	1

DISTRIBUTION 14

FORD AEROSPACE AND COMM CORP AERONAUTRONIC DIVISION ATTN SAM MIGUEL FORD ROAD JAMBOREE NEWPORT BEACH CA 92658-9983	1	D R KENNEDY ASSOCIATES PO BOX 4003 MOUNTAIN VIEW CA 94040	1
HERCULES INCORPORATED ROCKET CEN ATTN G WILLIAMS PO BOX 210 ROCKET CENTER WV 26726	1	RADKOWSKI ASSOCIATES P O BOX 5474 RIVERSIDE CA 92517	1
HERCULES BACCHUS WORKS ATTN M KLAKKEN MAGNA UT 84044	1	KORNHAUSER CONSULTING SERVICES 620 ARGYLE AVENUE WYNNEWOOD PA 19096	1
HERCULES BACCHUS WORKS ATTN M BERGER MAGNA UT 84044	1	LOCKHEED MISSILES & SPACE CO ATTN R HODGES PO BOX 504 SUNNYVALE CA 94086	1
HERCULES BACCHUS WORKS ATTN G BUTCHER MAGNA UT 84044	1	LOCKHEED MISSILES & SPACE CO ATTN J SMITH PO BOX 504 SUNNYVALE CA 94086	1
HERCULES BACCHUS WORKS ATTN L LOSEE MAGNA UT 84044	1	LTV AEROSPACE & DEFENSE CO LTV AEROSPACE PRODUCTS GROUP ATTN J FLOWERS PO BOX 655907 DALLAS TX 95265-5907	1
HERCULES BACCHUS WORKS ATTN T SPEED MAGNA UT 84044	1	MARTIN MARIETTA CORPORATION ORLANDO AEROSPACE MISSILE SYS ATTN H FUEHRER PO BOX 555837 ORLANDO FL 32855	1
HUGHES AIRCRAFT INC MISSILE SYSTEMS GROUP ATTN L WEBER 8433 FALLBROOK AVENUE CANOGA PARK CA 91304-9976	1	ORLANDO TECHNOLOGY INC ATTN T KITCHEN PO BOX 855 SHALIMAR FL 32579	1
KAMAN SCIENCES CORP ATTN TIMOTHY PENDERGRASS 600 BLVD SOUTH SUITE 208 HUNTSVILLE AL 35802	1	RAYTHEON COMPANY ATTN W ZARR HARTWELL ROAD BEDFORD MA 01730	1

IHTR 1821

S CUBED A DIVISION OF MAXWELL LABS INC ATTN R SEDGWICK PO BOX 1620 LAJOLLA CA 92038	1	TELEDYNE BROWN ENGINEERING ATTN L WEBER PO BOX 070007 HUNTSVILLE AL 35807	1
ALLIANT TECHSYSTEMS INC ATTN K L CHRISTIANSON 7225 NORTHLAND DRIVE BROOKLYN PARK MN 55428	1	TELEDYNE BROWN ENGINEERING ATTN J NEWQUIST PO BOX 070007 HUNTSVILLE AL 35807	1
ALLIANT TECHSYSTEMS INC ATTN J L HOULTON 7225 NORTHLAND DRIVE BROOKLYN PARK MN 55428	1	TRW ATTN R CHURCH SAN BERNADINO CA 92401	1
ALLIANT TECHSYSTEMS INC ATTN G JOHNSON 7225 NORTHLAND DRIVE BROOKLYN PARK MN 55428	1	UNIVERSITY OF DENVER COLORADO SEMINARY ATTN G WEEDING PO BOX 10758 DENVER CO 80210	1
SOUTHWEST RESEARCH INSTITUTE ATTN C ANDERSON PO DRAWER 28510 SAN ANTONIO TX 78284	1	VANDERBILT UNIVERSITY ATTN A MELLOR NASHVILLE TN 37235	1
SOUTHWEST RESEARCH INSTITUTE ATTN H GRYTING PO DRAWER 28510 SAN ANTONIO TX 78284	1	ZERNOW TECHNICAL SERVICES INC ATTN L ZERNOW PO BOX 54 SAN DIMAS CA 91773	1
SOUTHWEST RESEARCH INSTITUTE ATTN A WENTZEL PO DRAWER 28510 SAN ANTONIO TX 78284	1	ADVANCED TECH AND RESEARCH INC LAUREL TECHNOLOGY CENTER ATTN J W WATT 14900 SWEITZER LANE LAUREL MD 20707	1
SRI INTERATIONAL ATTN D SHERWOOD 333 RAVENSWOOD AVENUE MENLO PARK CA 94025	1	ADVANCED TECHNOLOGY INC ATTN W SMITH 2121 CRYSTAL DRIVE ARLINGTON VA 22202	1
SRI INTERATIONAL ATTN M COWPERTHAWAITE 333 RAVENSWOOD AVENUE MENLO PARK CA 94025	1	ENIG ASSOCIATES INC SUITE 500 ATTN J ENIG 11120 NEW HAMPSHIRE AVENUE SILVER SPRING MD 20904-2633	1

DISTRIBUTION 16

SHOCK TRANSIENTS INC ATTN D DAVISON PO BOX 5357 HOPKINS MN 55343	1	DEFENSE RESEARCH AGENCY FORT HALSTEAD SEVENOAKS ATTN A CUMMINGS ET BLDG X59 KENT TN14 7BP UNITED KINGDOM	1
SCIENCE APPLICATIONS INTERNATIONAL CORP ATTN S EIDELMAN 1710 GOODRIDGE DRIVE MCLEAN VIRGINIA 22102	1	DEFENSE RESEARCH AGENCY FORT HALSTEAD SEVENOAKS ATTN B HAMMANT KENT TN14 7BP UNITED KINGDOM	1
ORLANDO TECHNOLOGY INC ATTN M GUNGER PO BOX 855 SHALIMAR FL 32579	1	DEFENSE RESEARCH AGENCY FORT HALSTEAD SEVENOAKS ATTN P HASKINS ET1 BLDG X51 KENT TN14 7BP UNITED KINGDOM	1
N M INSTITUTE OF MINING AND TECH ENERGETIC MATERIALS RESEARCH AND TESTING CENTER ATTN P E WILLIAMS SOCORRO NM 87801	1	DEFENSE RESEARCH AGENCY FORT HALSTEAD SEVENOAKS ATTN G HOOPER KENT TN14 7BP UNITED KINGDOM	1
HUGHES AIRCRAFT COMPANY ATTN S W TURNER P O BOX 3310 FULLERTON CA 92634	1	DEFENSE RESEARCH AGENCY FORT HALSTEAD SEVENOAKS ATTN D MULLENGER ET1 BLDG X50 KENT TN14 7BP UNITED KINGDOM	1
HUGHES AIRCRAFT COMPANY ATTN R R RENNER P O BOX 3310 FULLERTON CA 92634	1	ATOMIC WEAPONS ESTABLISHMENT ATTN LIBRARY FOULNESS ISLAND ESSEX SS3 9XE UNITED KINGDOM	1
DEFENSE RESEARCH AGENCY FORT HALSTEAD SEVENOAKS ATTN LIBRARY KENT TN14 7BP UNITED KINGDOM	1	ATOMIC WEAPONS ESTABLISHMENT ATTN H R JAMES FOULNESS ISLAND ESSEX SS3 9XE UNITED KINGDOM	1
DEFENSE RESEARCH AGENCY FORT HALSTEAD SEVENOAKS ATTN M D COOK ET1 BLDG X3 KENT TN14 7BP UNITED KINGDOM	1	MOD(PE) ATOMIC WEAPONS ESTABLISHMENT ATTN J JENKINS ALDERMASTON READING BERKSHIRE RG7 4PR UNITED KINGDOM	1

IHTR 1821

MOD(PE) ATOMIC WEAPONS ESTABLISHMENT ATTN B D LAMBOURN ALDERMASTON READING BERKSHIRE RG7 4PR UNITED KINGDOM	1	ICI EXPLOSIVES ATTN D L KENNEDY GATE 1 BALLARAT ROAD DEER PARK VICTORIA 3023 AUSTRALIA	1
MOD(PE) ATOMIC WEAPONS ESTABLISHMENT ATTN D C SWIFT ALDERMASTON READING BERKSHIRE RG7 4PR UNITED KINGDOM	1	ORDNANCE BOARD ATTN R STENSON (S DIV) EMPRESS STATE BUILDING LILLIE ROAD LONDON SW6 1TR UNITED KINGDOM	1
NEC ATTN W LEEMING ARDEER SITE STEVENSTON AYRESHIRE KA20 3LN SCOTLAND	1	ICI EXPLOSIVES ATTN J COOPER STEVENSTON KA20 3LN UNITED KINGDOM	1
THE BRITISH EMBASSY BRITISH DEFENCE STAFF 3100 MASSACHUSETTS AVENUE NW WASHINGTON DC 20008	1	ICI EXPLOSIVES ATTN G A LEIPER STEVENSTON KA20 3LN UNITED KINGDOM	1
MATERIAL RESEARCH LABORATORY ATTN M CHICK PO BOX 50 ASCOT VALE VICTORIA 3032 AUSTRALIA	1	ICI EXPLOSIVES ATTN I J KIRBY STEVENSTON KA20 3LN UNITED KINGDOM	1
MATERIAL RESEARCH LABORATORY ATTN D D RICHARDSON PO BOX 50 ASCOT VALE VICTORIA 3032 AUSTRALIA	1	ORLANDO TECHNOLOGY INC ATTN M GUNGER PO BOX 855 SHALIMAR FL 32579	1
MATERIAL RESEARCH LABORATORY ATTN D A JONES PO BOX 50 ASCOT VALE VICTORIA 3032 AUSTRALIA	1	CEA CENTRE D'ETUDES DE VAUJOURS-MORONVILLIERS ATTN J N OECONOMOS B P N° 7 77181 COUNTRY FRANCE	1
MATERIAL RESEARCH LABORATORY ATTN M PODLESAK PO BOX 50 ASCOT VALE VICTORIA 3032 AUSTRALIA	1	CEA CENTRE D'ETUDES DE VAUJOURS-MORONVILLIERS ATTN F CHAISSE B P N° 7 77181 COUNTRY FRANCE	1

DISTRIBUTION 18

MESSERSCHMITT-BOLKOW-BLOHM GMBH		450 (O PARRENT)	1
RESEARCH DEPARTMENT		450 (L LIPTON)	1
ATTN M. HELD		460 (J GASPIN)	1
8898 SCHROBENHAUSEN		460 (G HARRIS)	1
GERMANY	1	460 R TUSSING)	1
		460 (R BARASH)	1
DEFENSE RESEARCH ESTABLISHMENT		460 (T FARLEY)	1
VALCARTIER		460 (W MCDONALD)	1
ATTN CONRAD BELANGER		460 (H MAIR)	1
PO BOX 8800		90I	1
COURCELETTE QUEBEC		90H	1
CANADA		90	1
GOA 1R0	1	90E	1
		90D	1
DEFENSE RESEARCH ESTABLISHMENT		90C	1
VALCARTIER		910 (Y TRAN)	1
ATTN ROCCO FARINACCIO		910 (SITZMANN)	1
PO BOX 8800		910	1
COURCELETTE QUEBEC		912 (D CICHRA)	1
CANADA		920	1
GOA 1R0	1	930	1
		940	1
DEFENSE RESEARCH ESTABLISHMENT		941 (A DUONG)	1
VALCARTIER		941 (C GOTZMER)	1
ATTN IRENE HOOTON		941 (L NOCK)	1
PO BOX 8800		941 (E ANDERSON)	1
COURCELETTE QUEBEC		950 (L MONTESI)	1
CANADA		950 (M SWISDAK)	1
GOA 1R0	1	952 (J LAIB)	1
		954 (L DAVIE)	1
DEFENSE RESEARCH ESTABLISHMENT		8510	3
VALCARTIER		8530	3
ATTN GRANT MC INTOSH		920C1(R BERNECKER)	1
PO BOX 8800		920C2 (J FORBES)	9
COURCELETTE QUEBEC		9210 (P MILLER)	1
CANADA		9210 (H JONES)	1
GOA 1R0	1	9210 (C COFFEY)	1
		9210 (R GUIRGUIS)	1
		9210 (F ZERILLI)	1
		9210 (D WOODY)	1
		9220 (W WILSON)	1
		9220 (C RICHMOND)	1
		9220 (D TASKER)	1
		9220 (T LIDDIARD)	1
		9220 (P GUSTAVSON)	1
		9220 (RICHARD LEE)	1
		9220 (R BAKER)	1
		9230 (G SUTHERLAND)	1
<b>Internal:</b>			
TDE (S MITCHELL)	3		
102	1		
40D (E JOHNSON)	1		
40	1		
410 (R GRANDE)	1		
410 (R GARRETT)	1		
410 (W FURR)	1		
410	1		

IHTR 1821

420 (B PARK)	1
420 (W WALKER)	1
420 (A DARE)	1
420 (H CHEN)	1
420 (D BETANCOURT)	1
420	1
9230 (E LEMAR)	1
9230 (J DAVIS)	1
9240 (B GLANCY)	1
9311 (K NEWMAN)	1
9410K (J CHANG)	1
9410 (P DENDOR)	1