

UNCLASSIFIED

AD NUMBER
AD144572
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Controlling DoD Organization: Picatinny Arsenal, Dover, NJ.
AUTHORITY
ARRADCOM ltr dtdd 8 Jul 1982; ARRADCOM ltr dtdd 8 Jul 1982

THIS PAGE IS UNCLASSIFIED

THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOE DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE

DISTRIBUTION UNLIMITED

AD

144572

AUTHORITY:

FRPADCOM

1/12/82



AI44572

Armed Services Technical Information Agency

Reproduced by

DOCUMENT SERVICE CENTER

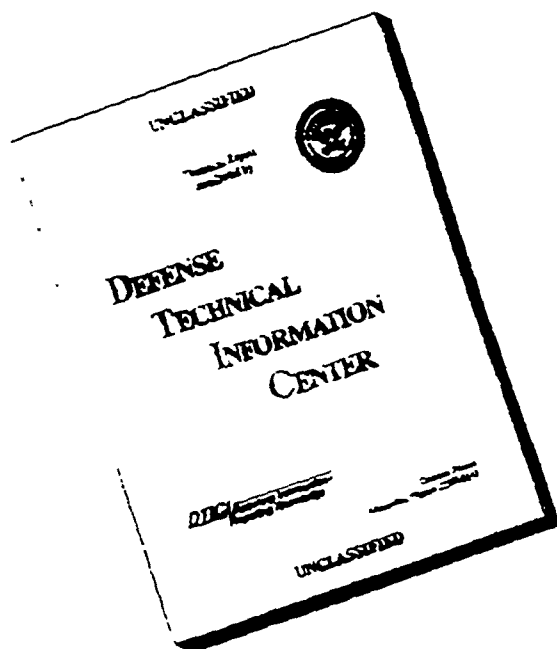
KNOX BUILDING, DAYTON, 2, OHIO

FOR
MICRO-CARD
CONTROL ONLY

1 OF 1

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL, IN ANY WAY BE RELATED THERETO.

DISCLAIMER NOTICE



**THIS DOCUMENT IS BEST
QUALITY AVAILABLE. THE
COPY FURNISHED TO DTIC
CONTAINED A SIGNIFICANT
NUMBER OF PAGES WHICH DO
NOT REPRODUCE LEGIBLY.**

BEST

AVAILABLE

COPY

QUARTERLY REPORT
NNC-Q-2

Contract DAI-19-020-501-ORD-(P)-54

NATIONAL NORTHERN CORPORATION
West Haverford, Massachusetts

**DETONATION VELOCITY DETERMINATIONS
OF VARIED SYSTEMS AND CONDITIONS**

QUARTERLY PROGRESS REPORT 2005-2

Contract DAI-19-020-501-ORD-(P)-58

NINTH QUARTERLY REPORT

NNC-Q-2

June, July, August 1957

Copy No. 117

NATIONAL NORTHERN CORPORATION

West Hanover, Massachusetts

A Subsidiary of American Potash and Chemical Corporation

NATIONAL NORTHERN CORPORATION

West Hanover, Massachusetts

DETONATION VELOCITY DETERMINATIONS

OF VARIED SYSTEMS AND CONDITIONS

QUARTERLY PROGRESS REPORT 2005-2

Contract DAI-19-020-5C1-ORD-(P)-58

NINTH QUARTERLY REPORT

NNC-Q-2

June, July, August 1957

Submitted by:

**Arthur W. O'Brien, Jr.
Chas W. Plummer**

Approved by:

**C. M. Saffer, Jr.
Technical Director**

Approved by:

**S. J. Porter
Vice President and
General Manager**

NOTICE: This document contains information affecting the National Defense of the United States within the meaning of the Espionage Laws, Title 18, U. S. Code, Sections 793 and 794. Its transmission or the revelation of its contents in any manner to unauthorized persons is prohibited by law.

A Subsidiary of American Potash and Chemical Corporation

This document is the property of the United States Government. It is furnished for the duration of the contract and shall be returned when no longer required, or upon recall by ASTIA to the following address:
Armed Services Technical Information Agency, Document Service Center,
Knott Building, Dayton 2, Ohio.

**NOTICE: THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE
NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING
OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 and 794.
THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN
ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW**

1.0 INTRODUCTION

This is a Quarterly Report of testing accomplished during the period 10 June 1957 through 9 September 1957 for Picatinny Arsenal under supplemented Contract DAI-19-020-501-ORD-(P)-58 and is designated NNC-Q-2. The first four Quarterly Reports under this contract, NN-Q-1 through NN-Q-4, dealt with free-air blast testing and are summarized in National's Summary Report NN-P-34. The fifth and sixth Quarterly Reports described the work on various RDX systems. This work is summarized in the sixth report for September, October, November 1956, NN-Q-7. The seventh and eighth Quarterly Reports describe preliminary determinations for our current investigation of velocity of detonation in varied explosive systems.

National Northern Corporation gratefully acknowledges the guidance and assistance of Picatinny Arsenal engineers in this investigation.

2.0 OBJECT OF TESTS

The task assigned under this contract, as supplemented, is a survey of varied explosive systems for the purpose of determining any change in detonation velocity with changes in altitude, charge diameter, and degree of confinement.

3.0 CHARGE DATA

3.1 To survey possible changes in behavior of varied explosive systems with changes in altitude, diameter of explosive column and confinement of explosive column, a number of specific conditions have been taken as starting points. In each combination of conditions, five measurements of the detonation velocity of the explosive system will be made.

3.2 The explosive systems included in these tests are TNT, H-6, 70/30 RDX/TNT, 70/30 HMX/TNT and MOX-25

3.3 These systems are measured at ground, 30,000, 60,000, and 90,000 feet (simulated altitude).

3.4 These systems are tested in cylindrical columns, one and two inches in diameter, eighteen and seven inches long, respectively. These represent our estimates for the maximum explosive weights that can be tolerated in our altitude chamber.

3.5 These explosives, with the exception of MOX-2B, are measured for detonation velocities in two conditions of confinement. In one case, no confinement is used, and in the other, one-quarter-inch-thick steel tubing of appropriate inside diameter. MOX-2B will not sustain detonation in unconfined columns of the two selected diameters and an increase in diameter is not considered feasible. To increase diameter would require reduction in length of column to maintain maximum charge weight allowed in our chamber. Columns shorter than those now used would cause our experimental error to be too large.

3.6 Subsequent to initiation of our firing program, we found that we were not able to detonate unconfined TNT completely in the two selected diameters. This is noted in the data tables, following.

4.0 TEST EQUIPMENT

4.1 The measurement of detonation velocity is accomplished by insertion of electrical probes at measured points in the explosive column. These probes, with associated circuits, generate a sharp, high-voltage pulse (rising to approximately 300 volts in 0.1 microsecond). These pulses are used to operate start/stop circuits on an electronic counter-chronograph. The electronic counter-chronograph used is the Potter Model 471 operating at 8 megacycles.

4.2 Tests at simulated altitude are accomplished in our chamber. The chamber has approximate inside dimensions of 12x14x8 feet and may be evacuated

to approximately 120 000 feet 3 mm. Hg.) by a Kinney KD-780 vacuum pump run by a forty horsepower electric motor. These tests run at zero altitude ("ground") were accomplished at our Halls Testing Range.

5.0 TEST RESULTS

5.1 The tables following include all of the data obtained to date. In these tables, density is determined by dividing the net weight of charge by the calculated volumes of the two sizes-of-charge. The 15"x1" cylinder is calculated to have a volume of 232 cubic centimeters and the 7"x2" cylinder a volume of 360 cubic centimeters.

Altitude (feet)	Average Charge Density (gms./cc)	Measured Segment (meters)	Measured Time (micro- seconds)	Velocity of Detonation (meters/second)
--------------------	---	---------------------------------	---	---

H-6, unconfined. in one-inch diameter column.

Ground	1.80	.302	41.1	7350
(760-764	1.78	.295	41.1	7180
mm. Hg.)	1.79	.303	40.9	7410
	1.81	.305	40.9	7460
	1.80	.303	41.1	7370

Average Velocity 7350

30,000				
(226 mm. Hg.)	1.81	.305	40.4	7550
	1.79	.302	41.3	7310
	1.80	.302	40.9	7380
	1.81	.305	40.9	7460
	1.80	.305	41.6	7330

Average Velocity 7410

60,000				
(60 mm. Hg.)	1.80	.302	39.3	7680
	1.79	.305	40.6	7510
	1.79	.302	40.4	7480
	1.80	.303	41.1	7370
	1.79	.300	40.5	7410

Average Velocity 7490

<u>Altitude</u> <u>(feet)</u>	<u>Average</u> <u>Charge</u> <u>Density</u> <u>(gms/cc)</u>	<u>Measured</u> <u>Segment</u> <u>(meters)</u>	<u>Measured</u> <u>Time</u> <u>(micro-</u> <u>seconds)</u>	<u>Velocity</u> <u>of</u> <u>Detonation</u> <u>(meters/second)</u>
----------------------------------	--	--	---	---

H-6, unconfined, in one-inch diameter column. (Cont'd)

90,000	1.78	.302	41.0	7370
(13 mm. Hg.)	1.78	.302	41.0	7370
	1.80	.302	42.1	7170
	1.79	.303	40.6	7460
	1.80	.299	41.4	6980

Average Velocity 7270

Average Velocity of 20 tests 7380

H-6, unconfined, in two-inch diameter column.

Ground	1.83	.099	14.0	7070
(760-764	1.77	.100	14.5	6900
mm. Hg.)	1.84	.102	14.8	6890
	1.75	.102	15.1	6750
	1.81	.100	14.8	6760

Average Velocity 6870

H-6, confined in $\frac{1}{4}$ -inch-thick steel tubing, one inch diameter explosive column.

Ground	1.72	.305	42.0	7260
(760-764	1.72	.305	42.0	7260
mm. Hg.)	1.72	.303	42.0	7210

H-6, confined in $\frac{1}{4}$ -inch-thick steel tubing, two-inch diameter explosive column.

Ground	1.78	.102	13.9	7340
(760-764	1.78	.102	13.9	7340
mm. Hg.)	1.78	.102	14.4	7080
	1.77	.102	13.6	7500
	1.78	.102	13.7	7450

Average Velocity 7340

TNT, unconfined, was not successfully detonated in either charge-diameter or at any ambient pressure.

TNT, confined in $\frac{1}{4}$ -inch-thick steel tubing, one-inch diameter explosive column.

Ground	1.55	.305	44.7	6820
(760-764	1.59	.305	44.5	6850
mm. Hg.)	1.61	.303	44.7	6780
	1.60	.304	44.7	6800
	1.62	.305	44.5	6850

Average Velocity 6820

RD7, TNT, 70/30, unconfined in one-inch diameter column

Altitude (feet)	Average Charge Density (gms/cc)	Measured Segment (meters)	Measured Time (micro- seconds)	Velocity of Detonation (meters/second)
Ground	1.79	305	35.1	8010
760-764	1.72	302	36.1	8370
mm. Hg.	1.58	305	37.6	8110
	1.75	302	32.9	7950
	1.76	303	37.6	8060

Average Velocity 8100

90,000				
60 mm Hg.)	1.71	301	37.5	8030
	1.72	305	37.8	8070

90,000				
13 mm Hg.)	1.73	305	38.1	8010
	1.71	305	38.0	8030
	1.82	302	37.9	7970
	1.82	305	38.4	7940
	1.73	302	37.8	7990

Average Velocity 7990

RD7, TNT, 70/30 confined in 1.4 inch-thick steel tubing one-inch diameter explosive column

Ground	1.72	305	38.3	7960
760-764	1.74	305	38.5	7920
mm. Hg.)	1.57	305	38.0	8030
	1.71	305	38.5	7920
	1.73	305	36.4	7940
	1.81	305	38.1	8010
	1.82	305	38.0	8030

Average Velocity 7970

90,000				
(13 mm Hg.)	1.62	305	37.9	8070

5.0 DISCUSSION OF RESULTS

6.1 The table shows detonation velocity determinations for sixty-two samples. In addition to these we have determined that TNT, unconfined, cannot

be completely detonated in one or two-inch diameter columns at ambient pressures of one atmosphere or less. This reduces our program to 320 samples, eliminating MOX-2B and TNT, unconfined, at four altitudes and two diameters of charge.

6.2 We have estimated our experimental error to be $\pm 3\%$, maximum, due to the following probable sources of error:

- (a.) Non-uniform density in charges.
- (b.) Non-linear velocities over measured segment.
- (c.) Precision in measurement of linear distances and elapsed times.

6.3 Density variations within a single column are not readily detected. We are proceeding with the testing only after each sample is inspected by X-Ray photography for major flaws. Minor variations in density along the explosive column are not readily detectable.

6.4 Non-linear velocities of detonation occur where steady-state reaction is not established. This is usually corrected by allowing ample "run-up" explosive column ahead of the measured segment. In our experiments, the weight limit imposed by our altitude chamber prohibits ample "run-up" column with the diameters-of-charge specified. This is probably the explanation for the low velocity of detonation obtained with the two-inch diameter, H-6 samples.

6.5 Precision of measurement has been estimated at less than $\pm 1\%$ maximum. Linear distances are precise within one millimeter and time is precise within one-tenth microsecond.

6.6 The series completed on H-6, unconfined, in one-inch columns gives the following average velocities:

Ground	7350
30,000 feet	7410
60,000 feet	7490
90,000 feet	7270

Average for series : 7380

The maximum variation, 220 meters per second, is only 3% and within our estimated experimental error.

6.7 Investigations of detonation velocities have been extensively reported by the Naval Ordnance Laboratories. A few of the results reported by Liddiard and Coleburn, NAVORD 2611, and by Donna Price, NAVORD 4510, have been selected for comparison with our results. NAVORD 2611, September 1952, is designated Reference B in the following table. NAVORD 4510, April 1957, is designated Reference A in the following table.

Explosive	Velocity of Detonation (meter/second)	Charge Density (gms/cc)	Charge Diameter (inches)	Confinement (inches of steel)	Source of Data
R-6	7240 (3)	1.72	1.00	.250	NNC
	7380 (20)	1.79	1.00	none	NNC
	7440	1.74	1.625	.037	Ref. A.
	7163 (3)	1.659	2.491	none	Ref. B.
TNT	6820 (5)	1.59	1.00	.025	NNC
	6820	1.58	----	----	Ref. A.
RDX/TNT 70/30	7990 (5)	1.69	1.00	none	NNC
	7970 (7)	1.67	1.00	.025	NNC
	8017	1.69	----	----	Ref. A.

7.0 FUTURE WORK

7.1 In general, the experiments will go ahead as planned, with minor changes in technique and the addition of one series of tests.

7.2 Our technique has been modified, for the rest of the program, to include X-Ray examination of all samples before they are fired. In this way, we

Intend to eliminate samples with flaws and bring about better control of density.

7.3 We intend to add a series of control samples at varied ambient pressures. These samples will be RDX primacord in sufficient length to bring us up to our weight limit. The added length of explosive column and the necessary "run-up" column should provide better than 1% precision for these samples.

8.0 MAN-HOURS

A total of $1319 \frac{1}{2}$ man-hours has been expended on this contract during this report period.

QUARTERLY DISTRIBUTION LIST

Copy No.

Addressee

Commanding Officer
Picatinny Arsenal
Dover, New Jersey
Attn: Samuel Feltman Amm. Labs.
Contract Section 1, 2, 3

Contracting Officer
Boston Ordnance District
Army Base
Boston 10, Massachusetts. 4

Chief of Ordnance
Dept. of the Army
Washington 25. D C
Attn: ORDTA 5

Director, Armed Services Technical Information Agency (ASTIA)
Document Service Center
Knott Building
Dayton 2. Ohio. 6, 7

Commanding Officer
Picatinny Arsenal
Dover, N J
Attn: Samuel Feltman Ammunition Laboratories
High Explosives section, Mr. P B. Tweed.. 8