LA-6243-MS

Informal Report

C.3

UC-45

Reporting Date: February 1976

Issued: March 1976

Some Properties of Amatex/20K

by

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UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
CONTRACT W-7405-ENG. 36

In the interest of prompt distribution, this report was not edited by the Technical Information staff.

This work was performed for Picatinny Arsenal with funds provided under Order Number M136Z579GGFR. Arthur C. Forsyth, project manager.

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22151
Price: Printed Copy $4.50 Microfiche $2.25

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SOME PROPERTIES OF AMATEX/20K

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ABSTRACT

Some of the properties required for the interim qualification of Amatex/20K for use in ammunition have been determined. Two types of ammonium nitrate (AN) containing 10 wt% potassium nitrate (KN) were used. The properties determined were the detonation velocity as a function of charge diameter, the energy relative to other explosives, and the shock sensitivity as a function of temperature.

The infinite diameter detonation velocity of Amatex/20K, corrected to a density of 1.630 g/cm^3, depends on the type of AN/KN used to prepare the explosive. The values obtained were 6790 m/s for Amatex/20K prepared with solid prills, and 6960 m/s for Amatex/20K prepared with granulated AN/KN prills. Amatex/20K prepared with either AN/KN has a failure diameter greater than 19 mm and less than 25 mm. The relative energy of Amatex/20K prepared with solid prills is about 9% lower than that of Amatex/20. Shock sensitivity seems to be dependent on the type of AN/KN used, the test temperature, and the storage history of the explosive.

I. INTRODUCTION

The use of Amatex, a castable mixture of TNT, RDX, and ammonium nitrate (AN), in ammunition may be restricted because the explosive tends to grow during storage. Most, though not all, of the growth occurs after the explosive has been temperature cycled through the AN III → IV phase transition. To minimize this effect in Minol II, a castable explosive containing AN, the U.S. Navy developed Minol IV in which the AN was replaced with AN containing 10 wt% potassium nitrate (KN) as a solid solution.[1] The addition of 10 wt% KN to AN seemed to eliminate the growth in castings that were temperature cycled between ambient temperature and 73.9°C (165°F). However, no growth studies were conducted in which the explosive was cycled through lower temperatures.

The purpose of the study reported here was to determine some of the properties of Amatex/20K* required for its interim qualification for use in ammunition.

II. RAW MATERIALS USED FOR THE PREPARATION OF AMATEX/20K

A. AN/10 wt% KN

Two types of AN/KN were used in this study. All the Amatex/20K identified in this report as Amatex/20KP was prepared with prills that were

*20 wt% RDX, 40 wt% TNT, 40 wt% AN containing 10 wt% KN.

provided by the Naval Weapons Station, Yorktown, VA. These prills were prepared to a U.S. Navy specification by Ross Thermal Systems, Inc., Englewood, CO. In the Ross process, an unspecified grade of KNO_3 was added to molten AN. The AN used to prepare the molten mixtures was provided by Terra Chemicals International, Inc. The melt was then prilled and the prills were coated with diatomaceous earth. The Ross prills were solid spheres.*

All the Amatex/20K identified as Amatex 20/KG was prepared with ground AN/KN prills. The prills were provided by Picatinny Arsenal (PA). They were manufactured by the Gulf Oil Corporation and were porous or hollow spheres.

The results of our analyses of the Ross prills and the analytical data obtained by PA for the Gulf prills are presented in Table I. The particle size distributions of the prills are shown in Table II. Differential thermal analysis (DTA) and pyrolysis data were obtained for the Ross prills. These data are shown in Fig. 1. The AN III → IV solid-solid phase transition is not present in the DTA curve.

*AN prills per MIL-A-50460 are hollow spheres.

B. TNT

The TNT used in making the castings met the requirements of Military Specification JAN-T-248 Code 1. The acceptance test results are presented in Table III.

C. Composition B, Grade A (Comp B)

The Comp B used in making the castings met the requirements of MIL-C-401C. The acceptance test results are presented in Table IV.

TABLE I

ANALYSIS OF PRILLED AN/KN

Property	Manufacturer: Ross	Manufacturer: Gulf[a]
AN, wt%	87.7	89.44
KN, wt%	10.6	10.56
Water, wt%	0.10	0.18
Water insolubles, wt%	Not run	0.003
Diatomaceous earth, wt%	1.6	0.0
Bulk density, g/cm^3	0.9	0.87
Prill density, g/cm^3	1.57	1.56
Thermal vacuum stability, 48 h at 120°C, ml/g	0.3	-

[a]These data were obtained from A. C. Forsyth, PA, by telephone on January 28, 1975.

TABLE II

PARTICLE SIZE DISTRIBUTIONS OF RAW AN/KN PRILLS

Screen Mesh	Screen Openings (μm)	Ross Prills: Weight Percent Retained	Ross Prills: Cumulative Weight Percent Retained	Gulf Prills: Weight Percent Retained	Gulf Prills: Cumulative Weight Percent Retained
14	1400	94.7	94.7	91.3	91.3
20	840	2.0	96.7	3.5	94.8
25	710	0.8	97.5	0.9	95.7
35	500	0.9	98.4	1.3	97.0
45	350	0.4	98.8	0.7	97.7
60	250	0.3	99.1	0.8	98.5
80	177	0.1	99.2	0.4	98.9
SS		0.8	100	1.1	100

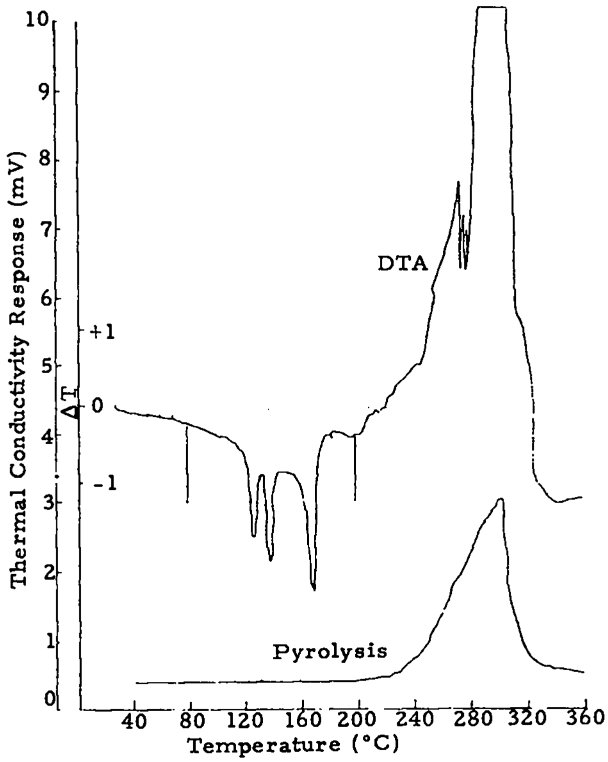


Fig. 1. Differential thermal analysis and pyrolysis of Ross prills.

TABLE III

ACCEPTANCE ANALYSIS OF TNT
Manufacturer - Volunteer Army Ammunition Plant
Lot VOL-10-309

Property	Analysis	Requirements of JAN-T-248
Moisture, %	0	0.1 max
Benzene insolubles, %	Trace	0.05
Melting point, °C	80.0	80.2 min
Nitrogen, %	18.28	NR[a]
Vacuum stability, 48 h at 120°C	0.1 ml/g at STP	NR
DTA, first exotherm, °C	~80	NR
Pyrolysis, first gas evolution, °C	~140	NR

[a]These properties are not required by JAN-T-298.

TABLE IV

ACCEPTANCE ANALYSIS OF COMP B, GRADE A
Manufacturer - Holston Defense Corporation
Lot HOL-050-5815

Property	Analysis	Requirements of MIL-C-401C
Composition, wt%		
RDX	60.50	59.5 ± 2.0
TNT	38.55	39.5 ± 2.3
Wax	0.95	1.0 ± 0.3
Moisture, wt%	0.11	NR
Acetone insolubles, wt%	Trace	NR
Vacuum stability, 48 h at 120°C	0.3 ml/g at STP	NR
DTA, first exotherm, °C	~78	NR
Pyrolysis, first gas evolution, °C	~160	NR

Particle Size in Comp B, Grade A

Screen Size Openings (μm)	Weight Percent Retained
500	0.2
350	4.1
250	32.5
177	21.2
125	16.0
88	5.3
62	4.3
44	1.8
SS	14.6

III. MELT AND CHARGE PREPARATION

A. Amatex/20KP

To determine the casting properties of Amatex/20KP, two 600-g melts were made. The first contained no surface active agent and the second contained 0.15 wt% nitrocellulose (NC).* The NC was added to reduce the possibility of AN prill segregation[2] during the solidification stage, not to reduce the melt viscosity. The flow properties of these melts, as determined with a Stormer

*NC specification: 11.8-12.2 wt% nitrogen, viscosity 18 to 25 cP.

viscometer, are shown in Fig. 2. As expected, the melts have the same apparent viscosity. Small, 25-mm-diam by 50-mm-high castings were poured, and there was no evidence of prill segregation toward the riser portion of the casting in either melt.

Based on this result, a larger (82-kg) Amatex/20KP melt containing 0.15 wt% NC was prepared. When the melt reached 85°C, it was poured into 110-, 52-, and 25.4-mm-diam molds to a height equal to twice the charge diameter. All the castings, except the 25.4-mm-diam charges, were discarded because the within-piece composition spreads were large and the nominal compositions were unacceptable. Typical casting conditions and analytical results for the 110-mm-diam charges are presented in Table V.

These results show that both RDX and AN/KN settled into the main body of the casting. There were no problems with AN/KN segregation to the riser portion of the casting.

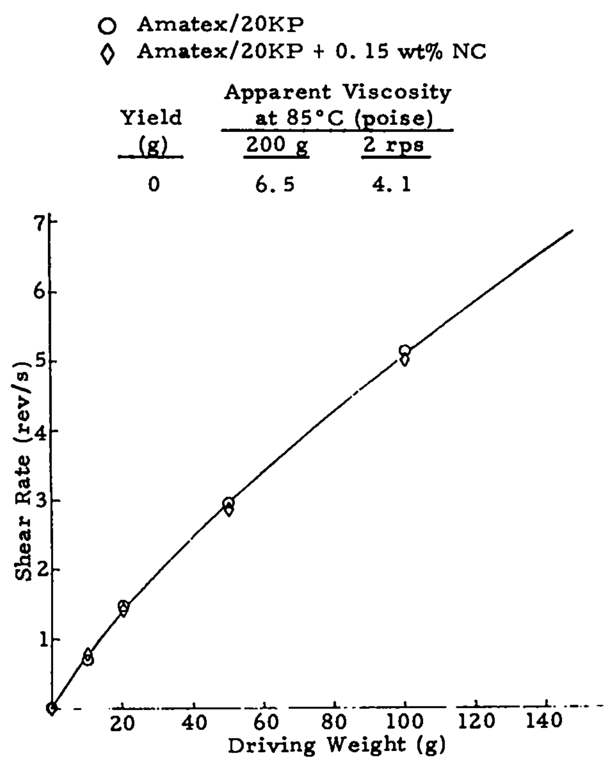


Fig. 2. Amatex/20KP Stormer viscosity measurements.

TABLE V

CHARACTERISTICS OF 110-mm-DIAM CASTINGS AMATEX/20KP

Casting Conditions

Melt viscosity, s efflux	3
Pour temperature, °C	85
Mold temperature at pour, °C	50
Mold temperature 1 h after pour, °C	30
Riser temperature at pour, °C	85
Riser temperature 1 h after pour	Ambient

Analytical Results

	Composition[a] (wt%)		
Sample Location	TNT	RDX	AN/KN
Charge Center Line			
Top	29.2	35.4	35.4
Bottom	29.0	25.6	45.4
Charge Outer Edge			
Top	31.2	25.2	43.6
Bottom	32.2	21.1	46.7
Average	30.4	26.8	42.8
Spread	3.2	14.3	11.3

[a]This is a typical result. In the three castings that were sectioned, composition spreads were reproduced to within a few percent.

A second 82-kg Amatex/20KP melt was prepared without NC. The NC was eliminated in an effort to increase the interfacial contact angle between the AN/KN and the TNT, and because there was no evident difference in AN/KN segregation between small (600-g) melts prepared with NC and without NC.

To increase the viscosity, the melt was "creamed" before pouring, and poured at 79-80°C. The melt viscosity at the time of pour was 9-s efflux. A significant improvement in composition was achieved. Analytical results for the 110-mm-diam charges, and the casting conditions used to achieve these results, are presented in Table VI.

B. Amatex/20KG

A series of small (600-g) melts of Amatex/20KG was prepared to determine the melt flow

TABLE VI

CHARACTERISTICS OF 110-mm-DIAM CASTINGS AMATEX/20KP

Casting Conditions

Melt viscosity (creamed), s efflux	9
Pour temperature, °C	79-80
Mold temperature at pour, °C	30
Mold temperature 1 h after pour	Ambient
Riser temperature at pour, °C	80
Riser temperature 1 h after pour, °C	30

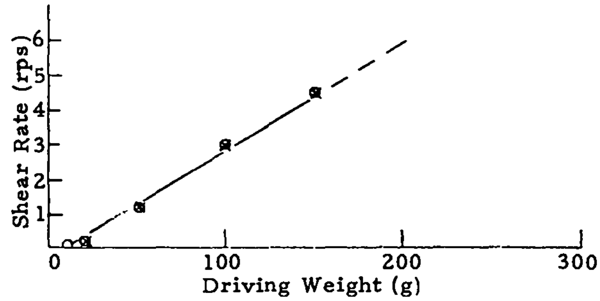
Analytical Results

	Composition (wt%)		
Sample Location	TNT	RDX	AN/KN
Charge Center Line			
Top	37.1	21.5	41.4
Bottom	39.3	19.9	40.8
Charge Outer Edge			
Top	39.9	20.9	39.2
Bottom	38.5	20.9	40.6
Average	38.7	20.8	40.5
Spread	2.8	1.6	2.2

properties as a function of AN/KN granulation. The Gulf AN/KN prills were ground in a Model 5H Mikro Pulverizer hammer mill at a feed rate of 9 kg/h and a hammer speed of 2957 rpm. Two AN/KN granulations were obtained, one with no mill exit screen and the other with an exit screen that had 4.76-mm-diam openings. The flow properties of the Amatex/20KG melts prepared from the two AN/KN granulations and with and without NC are shown in Fig. 3. A free-flowing castable melt with an efflux viscosity of about 4 s at 85°C was obtained, with and without NC, from the AN/KN ground without an exit screen in the hammer mill. However, unsuitable viscosity was obtained in the melts prepared with the AN/KN ground with a 4.76-mm-diam exit screen.

To verify these results, a 57-kg Amatex/20KG melt was prepared with ground AN/KN and without NC. The AN/KN particle size distribution used is listed in Table VII. These prills appear to be

	Yield (g)	Viscosity: Poise at 85°C, 200 g	Viscosity: Poise at 85°C, 2 rps	Viscosity: Efflux (s)	AN/KN[a] $d_m \sim 425\ \mu m$
X	10	9.5	9.6	3.9	No NC
O	10	9.5	9.6	3.9	0.15 wt% NC



	Yield (g)	Viscosity: Poise at 85°C, 200 g	Viscosity: Poise at 85°C, 2 rps	Viscosity: Efflux (s)	AN/KN[b] $d_m \ll 400\ \mu m$
X	50	17.7	20.6	∞	No NC
O	5	15.1	19.3	8.4	0.15 wt% NC

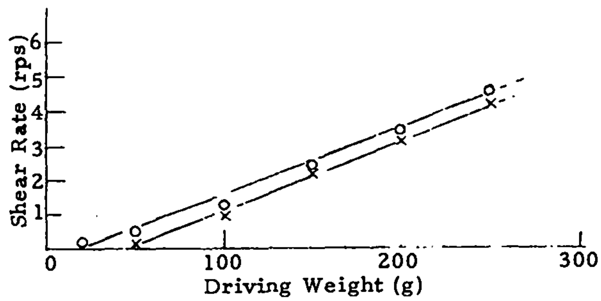


Fig. 3. Apparent viscosity of Amatex/20KG.

[a] AN/KN ground without an exit screen.
[b] AN/KN ground with a 4.76-mm-diam exit screen.

more friable than the Terra Chemicals AN prills used to prepare Amatex/20.[3] This is illustrated in Fig. 4, a comparison between the particle size distributions of the AN/KN prills ground without an exit screen used to prepare the melt, and of the AN prills (Terra Chemicals) ground with a 3.17-mm-diam exit screen.

Acceptable charges 110, 51, and 25 mm in diameter were cast. The casting conditions and analytical results are given in Table VIII.

TABLE VII

PARTICLE SIZE DISTRIBUTION OF GULF AN/KN PRILLS GROUND WITHOUT EXIT SCREEN

Mesh	Openings (μm)	Weight Percent Retained	Cumulative Weight Percent Retained
14	1400	12.6	12.6
20	840	15.8	28.4
35	500	17.9	46.3
60	250	15.9	62.2
80	177	9.5	71.7
100	149	9.1	80.8
120	125	5.4	86.2
170	88	7.5	93.7
230	62	2.6	96.3
325	44	2.6	98.9
SS		1.1	100.0

TABLE VIII

CHARACTERISTICS OF 110-mm-DIAM CASTINGS AMATEX/20KG

Casting Conditions

Melt viscosity, s efflux	13
Pour temperature, °C	85
Mold temperature at pour, °C	30
Mold temperature 1 h after pour	Ambient
Riser temperature at pour, °C	85
Riser temperature 1 h after pour	Ambient

Analytical Results

Sample Location	Composition (wt%) TNT	RDX	AN/KN
Charge Center Line			
Top	38.5	20.6	40.9
Bottom	39.2	20.0	40.8
Charge Outer Edge			
Top	39.0	20.4	40.5
Bottom	40.1	20.0	39.8
Average	39.2	20.2	40.5
Spread	1.6	0.6	1.1

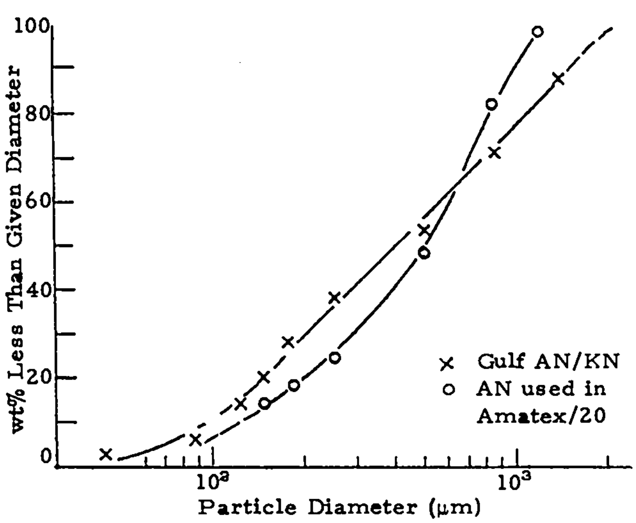


Fig. 4. Particle size distribution of ground AN/KN and AN prills.

IV. CHARGE QUALITY

Roughly 10% of the cast charges prepared under the casting conditions shown in Tables VI and VIII were analyzed to obtain an estimate of their overall composition and the within-piece composition spread. The overall density of each finished piece was determined. A summary of these results is presented in Table IX.

Note that the typical overall density of Amatex/20K is about 1.633 g/cm^3 and is independent of the type of AN/10 KN used. However, the average density of Amatex/20 is 1.614 g/cm^3 when prepared with granular AN.[3] On the assumption that the density of AN IV is 1.725 g/cm^3 and the density of AN/10 KN is 1.703 g/cm^3,[4] the theoretical densities

TABLE IX

COMPOSITION AND DENSITY OF AMATEX/20KP AND AMATEX/20KG

Finished Piece Size (mm)			Overall Density (g/cm^3)		Analytical Composition[a] (wt%)		
Diameter	Height	Type	Density	std dev	RDX	TNT	AN/KN
102	75	Amatex/20KP[b]	1.636	0.003	20.6	39.4	40.0
51	51	"	1.621	0.002	21.0	40.3	38.7
25	37	"	1.639	0.001	20.1	40.8	39.1
102	75	Amatex/20KG[c]	1.634	0.002	20.9	38.2	40.7
51	51	"	1.628	0.002	20.2	39.3	40.5
25	37	"	1.637	0.002	19.8	40.2	40.0

[a]The wax content is about 0.3 wt% and is included in the RDX.
[b]Ross prills.
[c]Gulf granular, $d_m \sim 425$ μm.

of Amatex/20 and Amatex/20K are 1.710 and 1.700 g/cm^3, respectively. This implies that the void content of Amatex/20 at a density of 1.614 g/cm^3 is greater than the void content of Amatex/20K. Nevertheless, the void content for the two materials should be about the same at the time of casting because the flow properties of Amatex/20 and Amatex/20K are not significantly different (Fig. 4). Consequently, the density difference should be attributed to the AN III → IV solid-solid phase transition that occurs during the cooling cycle. At the casting temperature, and until the charge is cooled to about 50°C, the AN is in phase III. As the temperature is lowered, the AN undergoes the III → IV transition and the density of the AN increases from 1.661 to 1.725 g/cm^3. The volume of the AN decreases about 4% and the volume of the voids increases about 1.6%. The net result is that the void content of Amatex/20 at a density of 1.614 g/cm^3 could be about 1.6% greater than the void content of Amatex/20K at a density of 1.633 g/cm^3.

V. RELATIVE ENERGY OF AMATEX/20KP

The relative energy of Amatex/20KP was determined by measuring, as a function of time, the expansion of the wall of a ductile copper tube driven by the detonation products of a closely fitted core of test explosive. Results of this test can be used to compare the efficiency of explosives for imparting kinetic energy to the metal.

To avoid the effects of scaling, and to compare the results of this test with results obtained previously for other related explosives of interest, the test was performed in a copper tube with a nominal i.d. of 101.6 mm and an o.d. of 121.9 mm. The ratio of case weight to charge volume was maintained at 4.033 g of copper per cubic centimeter of explosive.

The results of the cylinder test experiment on Amatex/20KP are presented in Tables X and XI. For comparison we have also included the results previously obtained for Comp B and for Amatex/20 prepared with prilled (hollow) AN and with granular (median particle diameter ~500 μm) AN. These data show that the relative energy of Amatex/20KP is about 9% lower than the relative energy of Amatex/20. These data, in terms of the relative energy as a function of wall expansion, are plotted in Fig. 5.

TABLE X

COPPER CYLINDER TEST RESULTS

Shot No.	C-4374	C-4453	C-4397	C-4321
Explosive	Comp B	Amatex/20KP	Amatex/20[a] (Prilled AN)	Amatex/20[b] (Granular AN)
Charge Density, g/cm^3	1.701	1.636	1.572	1.613
Detonation Velocity, mm/μs	7.915	6.728	6.805	6.951
Cylinder i.d., mm	101.6	101.6	101.6	101.6
Expansion $R-R_o$ (mm)	Wall Velocity (mm/μs)			
5	1.000	0.804	0.871	0.835
10	1.202	0.985	1.048	
15	1.311	1.088	1.150	
20	1.378	1.155	1.217	1.237
25	1.424	1.204	1.265	
30	1.460	1.242	1.302	
35	1.490	1.272	1.333	
40	1.516	1.298	1.359	1.371
45	1.539	1.320	1.381	
50	1.560	1.339	1.400	
55	1.578	1.355	1.417	
60	1.593	1.368	1.432	1.442
65	1.606	1.379	1.444	
70	1.616	1.389	1.456	
75	1.624	1.397	1.466	
80	1.631	1.405	1.476	1.475
85	1.638	1.412	1.484	
90	1.646	1.419	1.493	
95	1.653	1.426	1.502	
100	1.660	1.433	1.509	1.505

[a] AN prills per MIL-A-50460.
[b] Ground AN prills per MIL-A-50460, $d_m \sim 500$ μm.

TABLE XI

RELATIVE KINETIC ENERGY[a]

Explosive	Charge Density (g/cm^3)	Detonation Velocity (mm/μs)	Wall[b] Kinetic Energy Relative to Comp B
Comp B	1.701	7.915	1.000
Amatex/20KP	1.636	6.728	0.741
Amatex/20 (prilled)[c]	1.572	6.805	0.814
Amatex/20 (ground)[d]	1.613	6.951	0.815

[a] 101.6-mm-i.d. copper tube.
[b] At a wall expansion, $R-R_o$, of 80 mm.
[c] Hollow AN prills per MIL-A-50460.
[d] AN per MIL-A-50460 ground to a median particle diameter of ~500 μm.

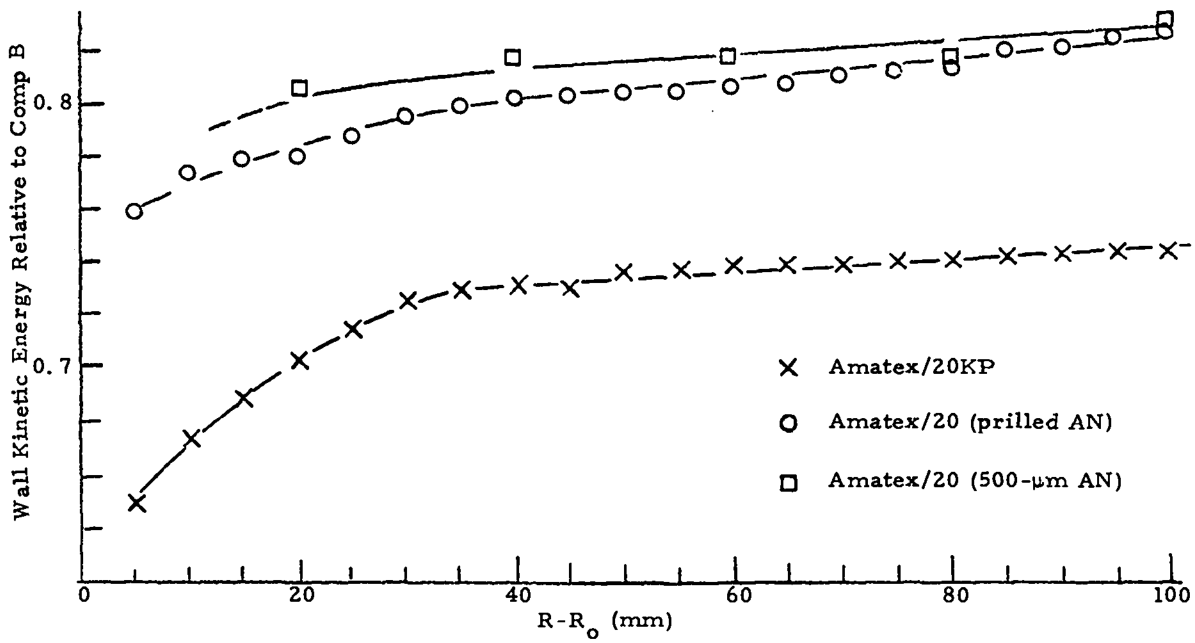


Fig. 5. Cylinder wall kinetic energy relative to Comp B.

VI. DETONATION VELOCITY AND FAILURE DIAMETER OF AMATEX/20KP

The detonation velocity of Amatex/20K was determined as a function of charge diameter and the type of AN/KN. Results of test fires made on Amatex/20K prepared with Ross prills and with ground Gulf prills are presented in Table XII. These data are plotted in Fig. 6 along with the results of previous tests of Amatex/20 prepared with prills and with ground prills.[5] The infinite diameter detonation velocity of Amatex/20K appears to be particle-size dependent, and, within the limits of the tests, the critical or failure diameter is particle-size independent. For Amatex/20, the infinite-diameter detonation velocity is particle-size independent and the critical diameter is particle-size dependent.

TABLE XII

DETONATION VELOCITY OF AMATEX/20K

Material	Charge Diameter (mm)	Average Density (g/cm^3)	Average Composition[a] (wt%) RDX	TNT	AN/KN	Detonation Velocity (mm/μs)	Corrected[b] Detonation Velocity (mm/μs)
Amatex/20KP	101.6	1.636	20.6	39.4	40.0	6.728	6.710[c]
	50.8	1.621	21.0	40.3	38.7	6.548	6.579
	25.4	1.639	20.1	40.8	39.1	6.258	6.231
	19.0	1.639	20.1	40.8	39.1	Failed	
Amatex/20KG	101.6	1.632	20.9	38.2	40.7	6.868	6.862
	50.8	1.628	20.2	39.3	40.5	6.750	6.756
	25.4	1.638	19.8	40.2	40.0	6.509	6.482
	19.0	1.638	19.8	40.2	40.0	Failed	

[a] Based on analysis of samples taken from the same casting lot.
[b] Corrected to a density of 1.630 g/cm^3.
[c] Corrected for the copper confinement.

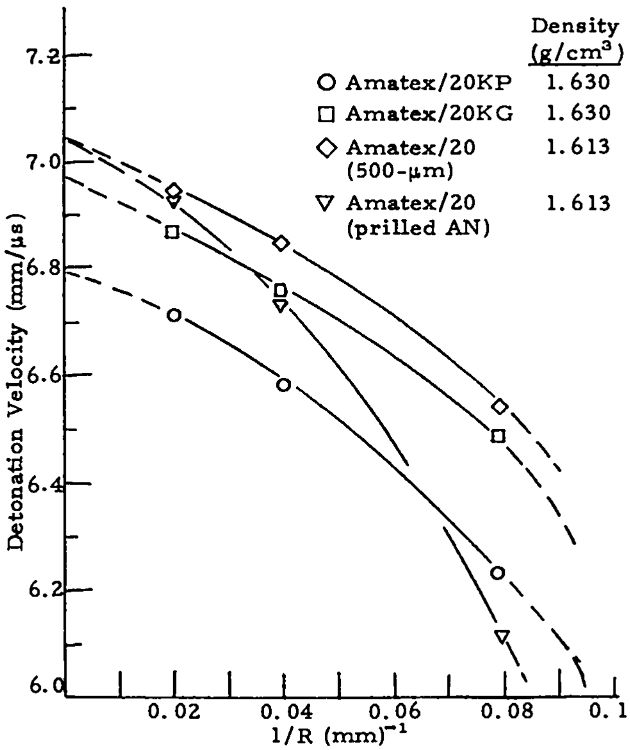


Fig. 6. Detonation velocity of Amatex/20 and Amatex/20K.

The failure diameter of Amatex/20 prepared with ground AN ($d_m \sim 500$ μm) is 17 mm and is dependent upon the AN particle size. The failure diameter of Amatex/20K is greater than 19 mm and less than 25 mm.

An expression that gives a good fit to the experimentally determined relationship between detonation velocity and charge diameter was derived by R. P. Engelke and A. W. Campbell, LASL Group M-3. These data were fitted by least squares to the following equation:

$$D(R) = D_i \left[1 - \frac{A}{R - R_c}\right],$$

where D(R) is the detonation velocity of an unconfined cylinder of explosive of radius R, D_i is the extrapolated value of the detonation velocity for a charge of infinite radius, and A and R_c are fitting parameters. The results of fitting this equation to Amatex/20, Amatex/20K, Comp B, and Cyclotol 75/25 data are listed in Table XIII.

The significance of these analyses is that the values of A and of the failure diameter may be expected to increase with the particle size of the constituents of Amatex. As the values of A and of the failure diameter increase, the energy imparted to metal fragments should decrease and become more dependent on the radius of curvature of the detonation wave.

VII. SHOCK SENSITIVITY OF AMATEX/20K

The effects on the relative shock sensitivity of Amatex/20K, of the type of AN/10 KN used, of the firing temperature, and of storage at low temperature were determined.

A schematic diagram of the experimental technique employed to assess the shock sensitivity of Amatex is shown in Fig. 7. This technique, the same as that used in our previous work,[8] was chosen because data for Amatex/20 prepared with 500-μm AN were available, and thus, the results obtained for Amatex/20K could be compared directly with those for Amatex/20.

TABLE XIII

DETONATION VELOCITY-DIAMETER RELATIONSHIP

Material	ρ	D_i (mm/μs)	A (mm)	R_c (mm)	Failure Diameter (mm)
Amatex/20	1.613	7.031	0.579	4.2	17.0
Amatex/20KP	1.630	6.790	0.634	5.0	$25 > d_f > 19$
Amatex/20KG	1.630	6.949	0.614	3.63	-
Comp B	1.700	7.859	0.0284	1.94	4.28
Cyclotol 75/25	1.740	8.210	0.0489	2.44	6.0

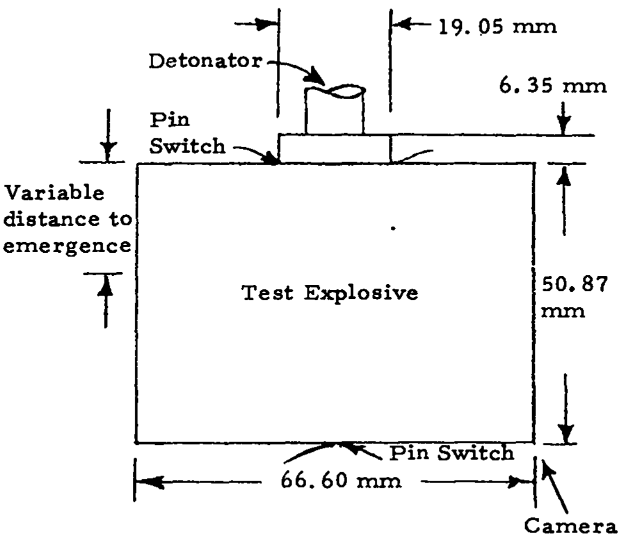


Fig. 7. Booster sensitivity test.

The apparent shock sensitivity is measured in terms of the transit time through the acceptor piece and the position of emergence of the detonation wave on the side of the acceptor. Prompt initiation to detonation may be assumed if the observed detonation velocity through the acceptor explosive is greater than the detonation velocity in a stick of acceptor explosive with a diameter equal to that of the booster explosive. Another indication of prompt initiation to detonation, and of the ability of the detonation wave to diverge, is the location at which the detonation wave emerges from the wall of the cylindrical acceptor charge. Prompt wave divergency is indicated by first emergence of the detonation wave from the side of the acceptor at a place near the surface of shock entry; poor wave divergency is indicated by more distant emergence.

A PBX 9407* booster pellet, 19.05 mm in diameter and 6.36 mm high, pressed to a density of 1.67 g/cm^3, was used to initiate the test explosive. The PBX 9407 booster pellet was initiated with an EBW detonator. Emergence of the detonation wave from the side and face of the acceptor cylinder was observed with a rotating mirror camera. The transit time through the acceptor cylinder was measured with electric switches.

The rotating mirror and still photographs of all the Amatex shots fired for this study are shown in Figs. 8 through 15. Emergence of the detonation wave from the side of the cylinder is indicated by an arrow in the rotating mirror camera photograph. The radius of curvature of the detonation wave can also be used as a measure of initiation efficacy.

The results are summarized in Table XIV and in Figs. 16, 17, and 18.

The data indicate that the addition of 10 wt% KN to the AN decreases the shock sensitivity of Amatex. Amatex/20KP prepared with whole solid prills is less sensitive than Amatex/20KG prepared with ground hollow prills. Prolonged storage at low temperature (-54°C) significantly affects the shock sensitivity of Amatex/20KP. The change in shock sensitivity after prolonged storage at low temperatures could be caused by the solid-solid phase transition[7] that occurs at about 0°C for AN/10 KN.

The experimentally determined transit times for the various Amatex formulations are plotted as a function of temperature in Fig. 16. A plot of the excess transit time as a function of temperature is given in Fig. 17. The excess time is the difference between the experimental transit time and the transit time calculated for the test explosive at the diameter of the booster, corrected for temperature effects, density, and length.

There is an indication that both Amatex/20K formulations are the least shock sensitive at 23.9°C. Amatex/20KP failed at 23.9°C (Shot 4469, Table IX) and fired at both temperature extremes. Since the booster diameter was near the failure diameter, small differences in sensitivity would be amplified. This could also explain the failure in Shot 4469 of the Amatex/20KP at room temperature (Table IX). Although this shot was reported as a failure because neither pin signals nor detonation light was recorded, a significant amount of damage

*94 wt% RDX, 6 wt% Exon.

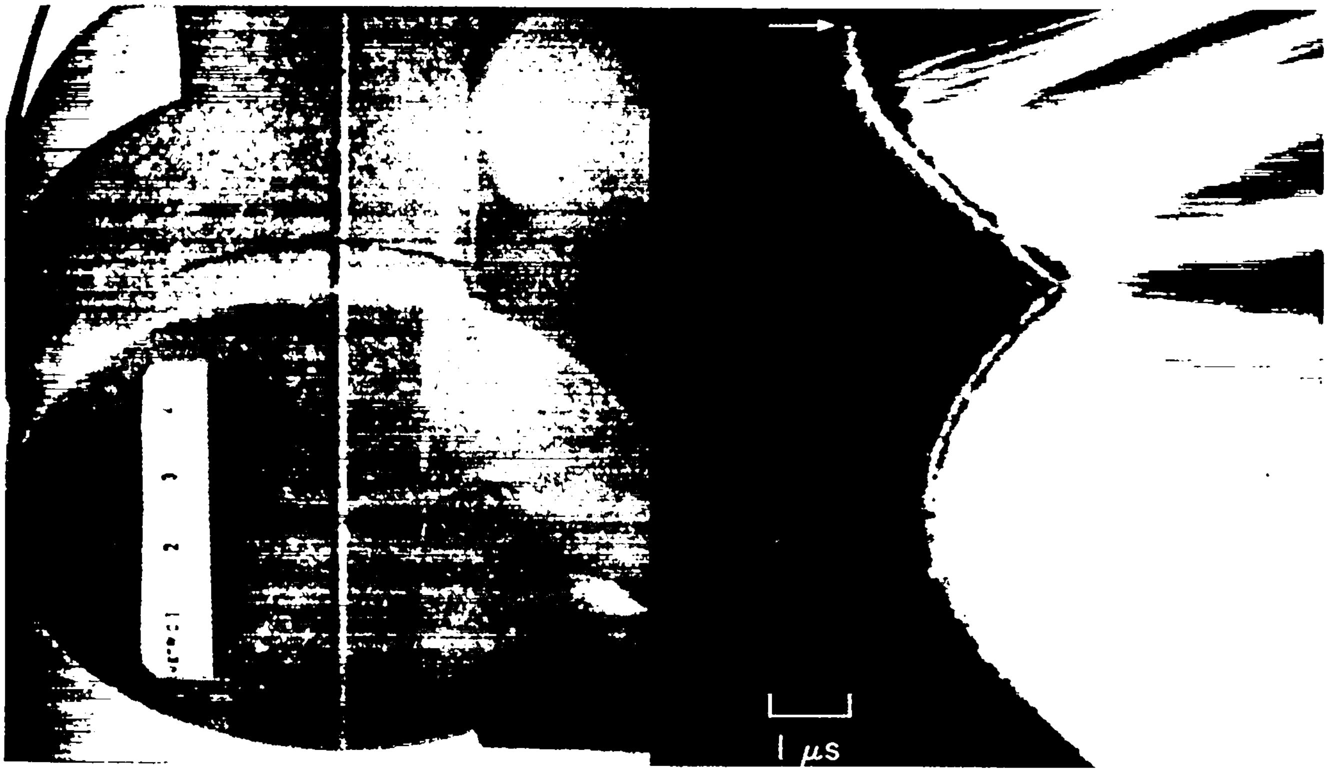


Fig. 8. Shot B-7905, Amatex/20KG at -53.9°C.

Fig. 9. Shot B-7906, Amatex/20KP at -53.9°C.

Fig. 10. Shot C-4470, Amatex/20KG at 23.9°C.

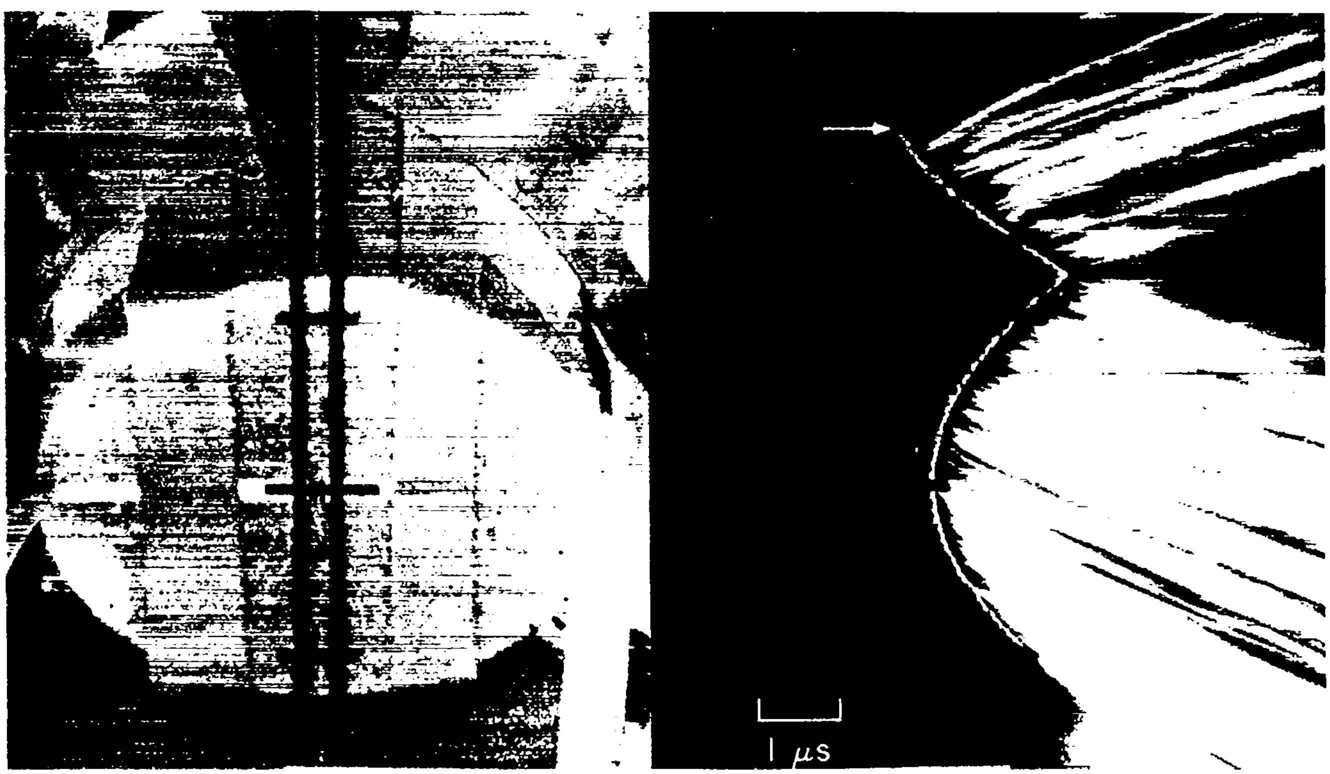


Fig. 11. Shot C-4387, Amatex/20 at 23.9°C.

Fig. 12. Shot B-7901, Amatex/20KG(TC) at 23.9°C.

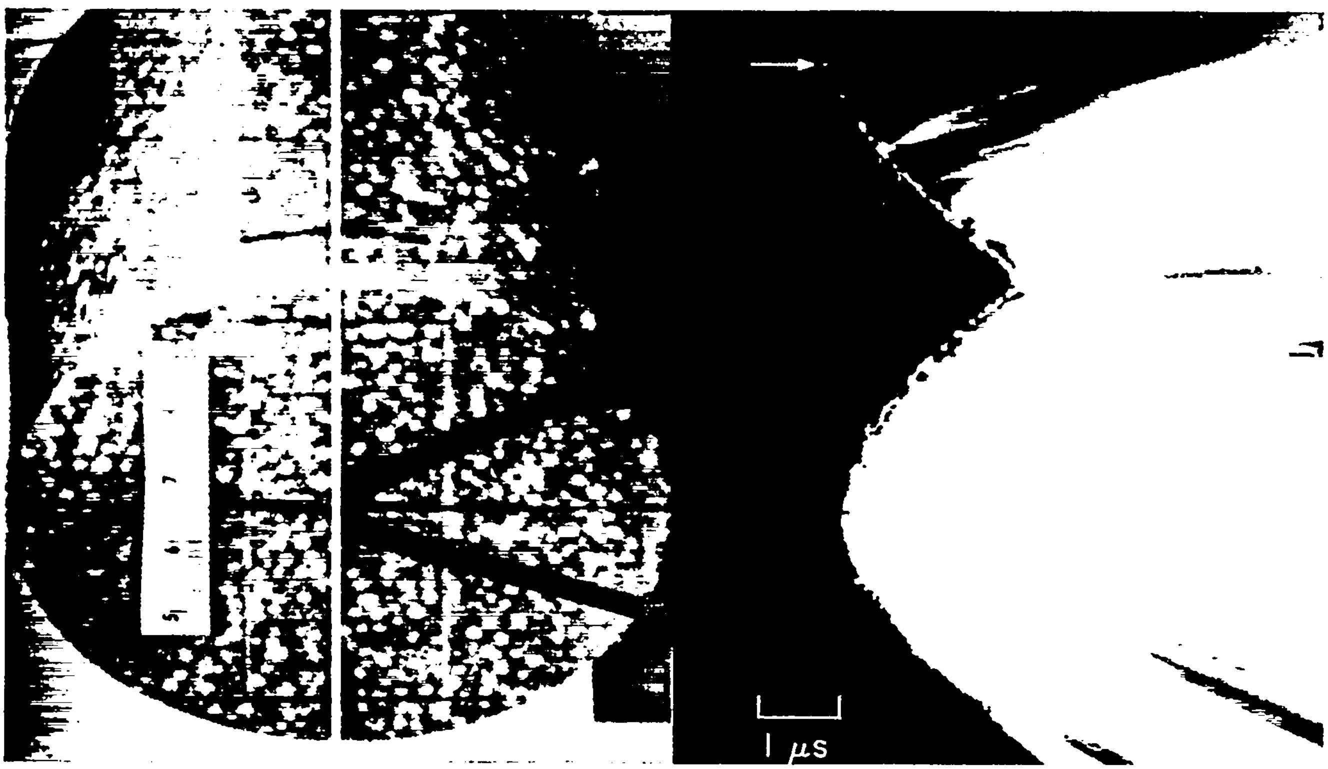


Fig. 13. Shot B-7902, Amatex/20KP(TC) at 23.9°C.

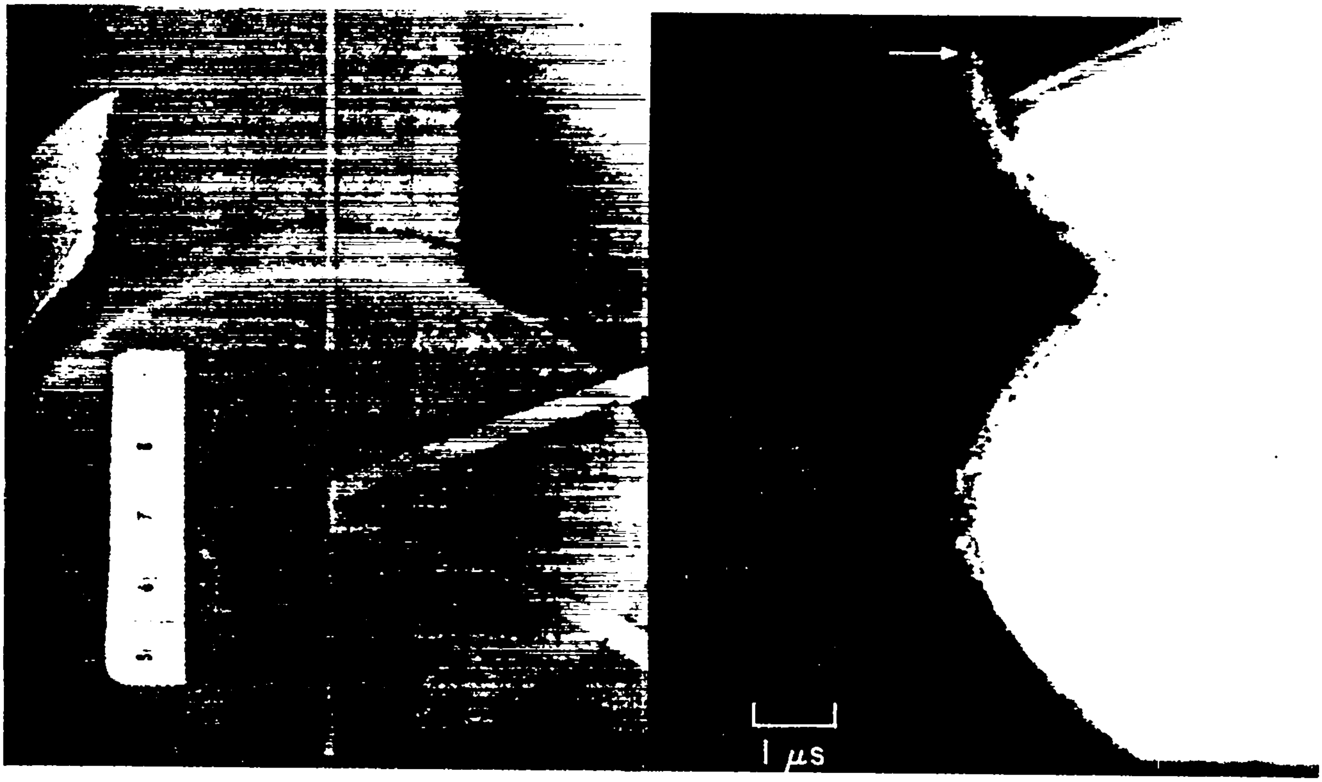


Fig. 14. Shot 7903, Amatex/20KG at 62.8°C.

Fig. 15. Shot B-7904, Amatex/20KP at 62.8°C.

TABLE XIV

RELATIVE SHOCK SENSITIVITY OF AMATEX/20K

Shot	Material	Test Temp (°C)	Charge Density (g/cm^3)	Charge[a] Density at Test Temp (g/cm^3)	Transit Time (μs)	Apparent Detonation Velocity (mm/μs)	Charge Height (mm)	Maximum[b] Prompt Transit Time (μs)	Excess[c] Transit Time (μs)	Distance to Emergence (mm)
B-7905	Amatex/20KG[d]	-53.9	1.634	1.655	8.56	5.92	50.69	8.22	0.34	18.7
B-7906	Amatex/20KP[e]	-53.9	1.632	1.653	9.02	5.62	50.72	8.60	0.42	15.1
C-4470	Amatex/20KG	23.9	1.634	1.634	8.75	5.80	50.77	8.16	0.59	20.7
C-4469	Amatex/20KP	23.9	1.634	1.634	Failed[f]	-	50.75	8.69	-	-
C-4387	Amatex/20	23.9	1.613	1.613	8.35	6.09	50.80	8.11	0.24	20.5
B-7901	Amatex/20KG(TC)[g]	23.9	1.634	1.634	8.32	6.10	50.79	8.16	0.16	17.7
B-7902	Amatex/20KP(TC)[g]	23.9	1.632	1.632	9.24	5.50	50.82	8.70	0.54	15.4
B-7903	Amatex/20KG	62.8	1.634	1.618	8.65	5.88	50.89	8.25	0.40	17
B-7904	Amatex/20KP	62.8	1.630	1.614	9.71	5.24	50.92	8.81	0.90	23

[a] Density corrected to the test fire temperature using linear coefficient of expansion of Comp B.

[b] This was calculated using the data in Table XIII corrected to the test temperature, density, and a charge diameter of 19 mm.

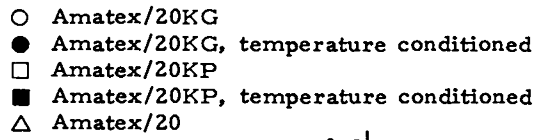
[c] The difference between the observed time and the time calculated for maximum prompt transit time.

[d] Amatex/20K prepared with Gulf prills ground to a median diameter of about 425 μm.

[e] Amatex/20K prepared with whole Ross prills.

[f] Although neither switch nor light signals were recorded, damage at firing site indicated that some explosive reaction occurred.

[g] Before testing, charges were held at -54°C for two weeks, slowly returned to ambient temperature, and fired at 23.9°C.



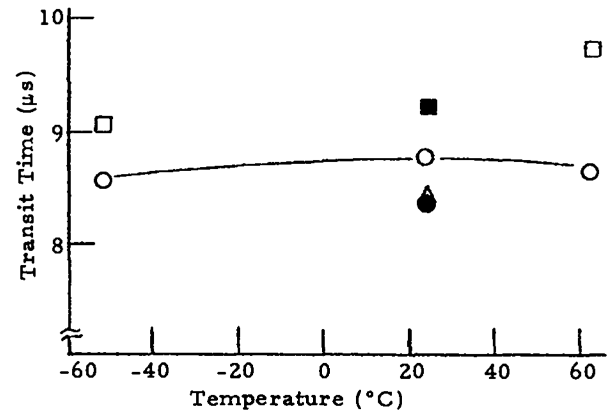


Fig. 16. Booster sensitivity.

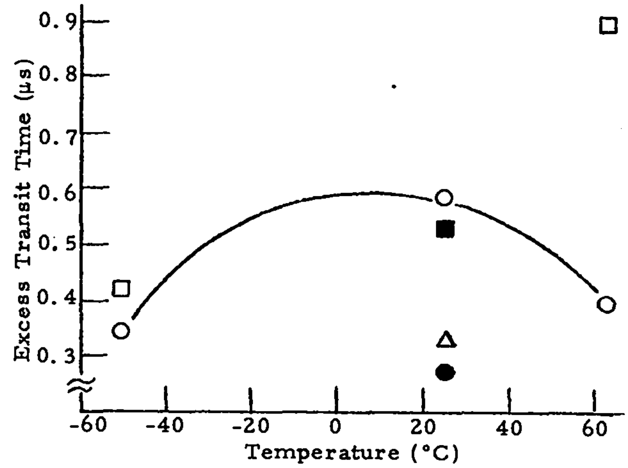


Fig. 17. Excess transit time.

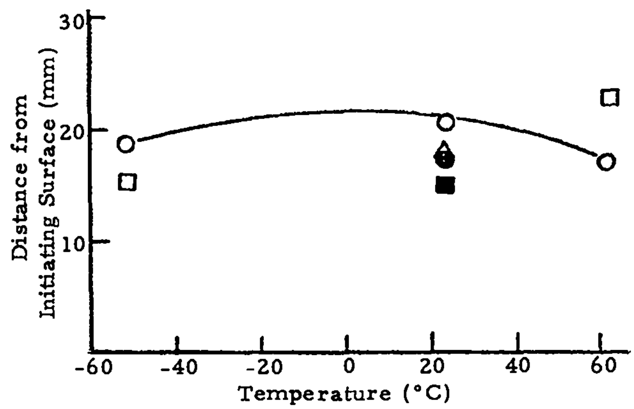


Fig. 18. Detonation wave divergency.

was incurred at the firing site and the wooden firing stand was demolished.

The distance from the surface subjected to the booster shock to the emergence of light at the cylinder wall is shown in Fig. 18 as a function of temperature for various test explosives.

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